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Market Risk Management

FRM二级知识框架图

Market
Risk
Management

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Framework of Market Risk Management

VAR and Other Risk Measures

- Parametric And Non-parametric Methods Of Estimation
- Backtesting VAR
- VAR Mapping
- Correlation Risk Modeling and Management
- Academic Literature On Risk Measuring

Risk Management Of Fixed Income and Option

- The Science Of Term Structure Models
- LIBOR VS. OIS
- Empirical Approaches To Risk Metrics And Hedging
- Volatility Smiles

Section 1

PARAMETRIC AND NON-PARAMETRIC METHODS OF ESTIMATION

Non-parametric Methods

Historical Simulation Approach

(数据权重1/n)

basic HS approach: ★

two steps

- **Order** (sort) the daily profit/loss observations
- Locate the loss **corresponding to the specified confidence level**
- 95% VAR is the (n*5% + 1)th highest observation. →结论与一级不同

Expected Shortfall (Conditional VAR)

- expected value of the loss when it exceeds VAR
- ***average of the tail loss / average of tail VARs***
- as a subadditive risk measure
- **VAR定义模糊，ES定义清晰，有唯一答案**

bootstrap historical simulation (数据有限)

- draw a sample, records the VAR→repeat over and over→multiple sample VARs→average of them
- Empirical analysis: provides more precise estimates than historical simulation on raw data alone

Weighted Historic Simulation Approaches
(数据权重不同)

Age-weighted HS ★
(hybrid of EWMA & HS)

$$w_{(i)}=\frac{\lambda^{i-1}(1-\lambda)}{1-\lambda^{n}}$$

计算

advantages

- Generalizes historical simulation (HS) (λ →1)
- more responsive to large losses & handling clusters of large losses
- reduce ghost effects
- option of letting our sample size grow over time

Volatility-weighted HS → weight returns by relative volatility

$$r_{t,i}^{*}=\left(\frac{\sigma_{T,i}}{\sigma_{t,i}}\right)\times r_{t,i}$$

advantages

- Directly accounts for volatility changes
- Allows us to incorporate GARCH forecasts
- Can obtain estimates exceed maximum loss in actual datasets
- Empirical evidence to support superiority of estimates

Correlation-weighted HS → major generalization of the volatility-weighted approach

Filtered HS

- bootstrapping + traditional HS with conditional volatility modeling (GARCH)
- Semi-Parametric Bootstrap

do not make strong assumptions about the distribution

优缺点 定性了解★

Advantages	Disadvantages
• Intuitive • Handle non-normal returns (skew, kurtosis) • handle any position type including derivatives • Popular among risk practitioners • Relatively easy to implement (e.g., spreadsheet) • No "curse of dimensionality" • Uses readily available data (returns, volatility) • Easy to report and communicate results • Easy to generate confidence intervals • Can be combined with parametric "add-ons"	• If history is a "quiet period," VAR (or ES) estimates will be too low • Difficulty handling in-sample shifts (or regime changes) • Can be dominated by extreme losses (not helpful if unlikely to occur) • Most are subject to ghost effect (shadow effect) • Generally make no allowance for plausible events that might occur but did not occur • To an extent constrained by largest loss in historical dataset

Parametric Estimation Approaches

Normal VAR ★计算

•returns that follows a normal distribution

$$\mathrm{VAR}(\alpha\%) = -\mu_{\mathrm{P/L}} + \sigma_{\mathrm{P/L}} \times z_{\alpha}$$

Lognormal VAR ★计算

•returns that follow a lognormal distribution

$$\mathrm{VAR}(\alpha\%) = \mathrm{P}_{\mathrm{t-1}} \times (1 - e^{\mu_{\mathrm{R}} - \sigma_{\mathrm{R}} \times z_{\alpha}})$$

Other Issues

Coherent Risk Measures ★★

- Monotonicity: if X1 ≤ X2, ρ(X1) ≥ ρ(X2)
- Translation Invariance: ρ(X+ k) = ρ(X) − k
- Homogeneity: ρ(bX) = bρ(X)
- Subadditivity: ρ(X1 + X2) ≤ ρ(X1) + ρ(X2)

not coherent risk measure

- ***Standard deviation*** violates
  - the monotonicity
  - translation invariance condition
- ***VAR*** is not
  - sub-additive

coherent risk measure

- ***Spectral*** measures are coherent:
  - weighted average of the quantiles
  - (所有数据点加权;越往左,权重越大)
- ***ES***(special case)
  - (只有尾部等权重加权,其余部分权重为0)

Standard Errors Of Coherent Risk Measures

- ***sensitive to the choice of n (sample size)*** : n ↑, the quantiles will be further into the tails where more extreme values of the distribution are located
- tails became heavier, ***ES*** estimators became ***more prone to the effects of large but infrequent losses***
- presence of heavy tails might make ***ES*** estimators in general ***less accurate*** than VAR estimators

QQ plot ★

- predicted quantile against the empirical quantile
- ***linear*** QQ plot indicates a ***good fit*** to the distribution
- departures from linearity can tell whether the tails of empirical distribution are fatter, or thinner

Other Issues

★ Extreme Value Theory(EVT)

- central limit theorems do not apply to extremes
- extremes are governed by extreme-value theorems

Block Maxima Method →Generalized Extreme Value Distribution (GEV)

params: location(μ), scale(σ), shape/tail(ξ) + select threshold(u)

Fisher-Tippett theorem: sample size(n) ↑, distribution of extremes converges to the GEV distribution

- same goal and general principles of EVT
- same shape/tail parameter: ξ

tradeoff of the threshold
- high enough so that the GPD applies
- low enough so that there are sufficient observations

Peaks over Threshold →Generalized Pareto Distribution(GPD)

params: positive scale(β), shape/tail(ξ) + select threshold(u)

distribution of excess loss over u: $F_u(x)=P\{X-u<=x|X>u\}$

extreme events are not independent

Multivariate EVT →相关性

ρ: 线性, normal (elliptical) distribution

copulas: 非线性, not normal

POT相比GEV

POT Advantages	POT Disadvantages
• GEV involves an additional parameter • and involves some loss of useful data	• problem of choosing the threshold

Section 2

BACKTESTING VAR

Backtesting VAR

Backtesting VAR

process of comparing losses predicted by the VAR model to those actually experienced over the testing period

Difficulties in backtesting a VAR model

- statistical decision(not 100% confidence)
- assumes a static portfolio →
  - contamination minimized in short horizons
  - track both actual and hypothetical return
  - cleaned-return (consider Transaction fee)

Process Of Model Verification

★ 计算

- ***failure rate(Bernoulli trials)*** →binomial probability distribution(x: number of exceptions)

$$f(x)=\binom{T}{x}p^{x}(1-p)^{T-x}$$

- ***假设检验***: central limit theorem(binomial distribution →normal distribution)

$$z=\frac{x-pT}{\sqrt{p(1-p)T}}\sim N(0,1)$$

- H_0: accurate model
- H_a: inaccurate model

Other Issues

Type I And Type II Errors

- ***Probability of Type I error*** (mistakenly reject null) = α = level of significance
- ***Probability of Type II error*** (mistakenly accept null) =β(difficult to calculate)

Null: Model is correctly calibrated		
Decision	Null is correct	Null is incorrect
Accept *	Good decision!	Type 2 Error
Reject	Type 1 Error	Good decision!

* Technically, “accept” = “Do not reject”
(as a jury finds defendant “not guilty” instead of “innocent”)

Unconditional Coverage Model: ignores time variation(reflects “independence” in the i.i.d. assumption)

Conditional coverage models: analyze exceptions conditional on current condition

Backtesting Exceptions

Using Failure Rates in Model Verification

- H_0: accurate model
- H_a: inaccurate model

★ 重要数字

- Test statistic(LR)
- If LR>**3.84**, we would reject the hypothesis(the model is correct)

The Basel Rules For Backtesting

Basel internal approach(market risk) : 10-day 99.0% VAR model ★ ★

Over 250 observations in one year, the excpected number of exceptions is 0.01 * 250 = 2.5

Four categories of causes for exceptions:

- The basic integrity of the model is lacking.
  The ***penalty*** should ***apply***.
- Model accuracy needs improvement.
  The ***penalty*** should ***apply***.
- Intraday trading activity.
  The penalty should be ***considered***.
- Bad luck. The market significantly varied.

The Basel Committee decided ★ ★

Three Zones

Zone	# of Exceptions	Increase in Scaling Factor (k)
Green	0-4	0
Yellow	5	0.40
	6	0.50
	7	0.65
	8	0.75
	9	0.85
Red	10 or more	1.00

Section 3

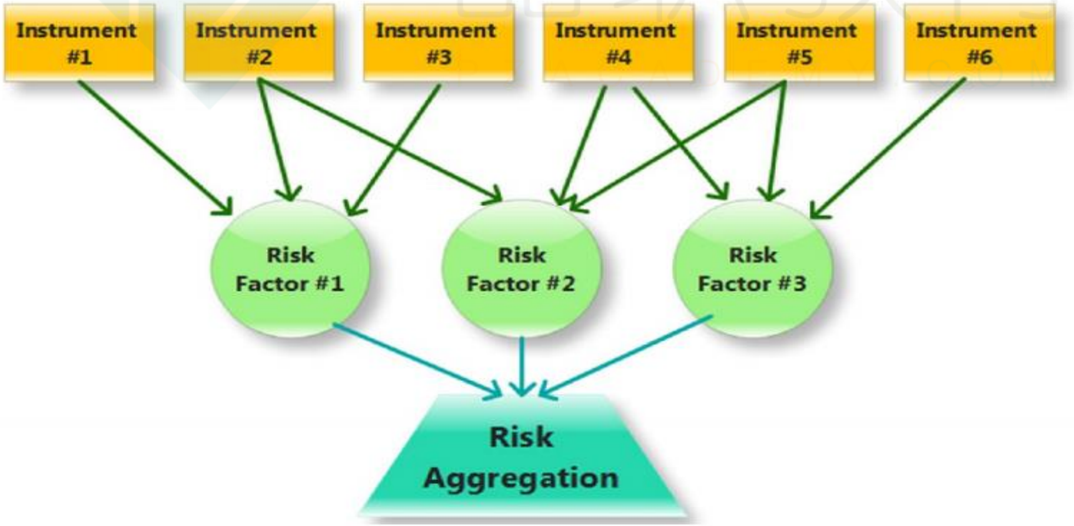
VAR MAPPING

VAR Mapping

Mapping replaces current portfolio position values with exposures to risk factors.

Mapping Principles

- positions can be simplified to smaller number of positions on set of risk factors
- when instrument characteristics change over time.
- only solution to data (shortage) problem



Mapping Portfolios Of Fixed Income Securities

★ **Mapping Approaches to fixed-income portfolios** → 掌握基础班讲义例题★

Principal mapping	Duration mapping	Cash flow mapping
•One risk factor (portfolio principal) •Bond risk = average portfolio maturity	•One risk factor •(portfolio duration) •Bond risk = zero-coupon bond with maturity equal to the bond duration	•Several risk factors •Bond risk = decomposed into risk of each of the bond cash flows

linear Derivatives → *Delta-normal method*

$$VAR(dP) = |{-D^*P}| \times VAR(dy)$$

$$VAR(dc) = |\Delta| \times VAR(dS)$$

nonlinear Derivatives → *Delta-Gamma method*

$$VAR(dP) = |{-D^*P}| \times VAR(dy) - (1/2)(C \times P) \times VAR(dy)^2$$

$$VAR(dc) = |\Delta| \times VAR(dS) - (1/2)\,\Gamma \times VAR(dS)^2$$

★记忆方法: 凸性的好处→降低风险

Other Issues

Stress Testing

- This stress test generates a distribution of present value factors that can be used to re-price the portfolio

VAR Relative To A Benchmark Portfolio

- Benchmarking a portfolio: measuring VAR relative to a benchmark portfolio
- $\text{Tracking Error VAR} = \alpha\sqrt{(x-x_o)'\sum(x-x_o)}$

Section 4

CORRELATION RISK MODELING AND MANAGEMENT

Some Correlation Basics

通常假设ρ不变 $\xrightarrow{\text{correlation change}}$ Financial Correlation Risk

the risk of financial loss due to adverse movements in correlation between two or more (financial) variables

Eg. Wrong-way risk: adverse correlation between a bond issuer and the bond insurer

危机时的ρ变化规律

During a severe systemic **crisis**, an **increase in correlation** is typical

High diversification is related to low correlation

影响ρ因素 — **nonfinancial variables**

- Sovereign debt and currency value
- Geopolitical tensions
- Correlated markets and economies

Trading And Correlation

hedge

Multi-Asset Options

correlation↓, option price↑, except Option on the worse of two

- **Option on the better of two**. Payoff = max(S1, S2).
- **Option on the worse of two**. Payoff = min(S1, S2).
- **Call on the maximum of two**. Payoff = max[0, max(S1,S2) – K].
- **Exchange option (as a convertible bond)**. Payoff = max(0, S2−S1).
- **Spread call option**. Payoff = max[0,(S2−S1) −K].
- **Option on the better of two or cash**. Payoff = max(S1, S2, cash).
- **Dual-strike call option**. Payoff = max(0,S1−K1, S2−K2).

Quanto option(protects an investor against currency risk)

know two things

- how deep in the money
- exchange rate

Tools to Hedge Correlation Risk

直接hedge ρ

Correlation Swap* ★ *: fixed correlation ←→ realized/stochastic correlation

$$\rho_{\text{realized}} = \frac{\sum_{i>j} \rho i, j}{\frac{n \times (n-1)}{2}}$$

- payer→long correlation→correlation ↑ gain
- receiver→short correlation→correlation ↓ gain

间接hedge σ

→positive relationship between correlation and volatility

Buy Call On Index And Sell Call On Individual

- Long Index Call
- Short Component Call

Variance Swap

- pay fixed in a variance swap on an index and
- to receive fixed in variance swaps on individual components of the index.

If correlation increases, so will the variance. ★

Correlation And Financial Crisis Of 2007 To 2009

了解

Causes Of The Crisis

- Increased speculation fueled by loose credit
- Complex credit products
- Model risk
- Moral hazards
- Increased risk appetite

First correlation-related crisis

- May 2005
- the correlations of the assets in the CDO decreased, the hedge funds lost on both positions

Correlation Risk and Risk Management

结论

- ***Market risk*** (comprised of equity risk, interest rate risk, currency risk, and commodity risk)
  - *Market risk implicitly incorporates correlation risk*
- ***Credit risk***
  - 构成 →
    - •Migration risk
    - •Default risk
    - ← the higher the correlation, the higher the probability of total loss
  - 事实 →
    - period 1981 to 2001 →
      - •Default correlations between industries are mostly positive with the exception of the energy sector
      - •The default correlation within sectors is higher than between sectors
    - sector-diversified loan portfolio to reduce default correlation risk
    - term structure of defaults →
      - •most investment grade bonds, the term structure of default probabilities increases in time
      - •bonds in distress, the default term structure is typically inverse
- ***Systemic risk*** → Systemic risk and correlation risk are highly dependent
- ***Concentration risk*** → High sector diversification reduces default risk

How Do Correlations Behave in the Real World

结论

Equity Correlation Behaviors

- Correlation levels are lowest in strong economic growth times.
- In recessions, correlation levels typically increase.

- Correlation volatility is lowest in an economic expansion and highest in worse economic states.
- Positive relationship between correlation level and correlation volatility

Mean reversion

- Fixed coupon bonds exhibit strong mean reversion
- Interest rates are assumed to be mean reverting

经济周期

Autocorrelation

Time **lag 2** autocorrelation is highest★

the autocorrelation of 22.49% and the strong mean reversion of 77.51% sum to 1.0

Statistical Correlation Models

limitation of financial model

- random models better replicate human behavior
- need to be stress-tested
- limitations were ignored in the crisis of 2007 to 2009

线性

parametric → *Pearson Correlation* → *5 Limitation*

$$\rho(X,Y)=\frac{Cov(X,Y)}{\sigma(X)\sigma(Y)}$$

- Linear dependencies
- Zero correlation derived in equations does not mean independence
- natural dependence measures only if the joint distribution is elliptical
- variances of the sets X and Y have to be finite
- not invariant to transformations

nonparametric (ordinal measure)

Spearman's Rank Correlation

$$\rho_S=1-\frac{6\sum_{i=1}^{n}d_i^2}{n(n^2-1)}$$

Kendall's τ

$$\tau=\frac{n_c-n_d}{n(n-1)/2}$$

- concordant pair
- discordant data pair
- pair is neither concordant nor discordant

Problems ★

- ordinal correlation are less sensitive to outliers
- Kendall τ: many non-concordant and many non-discordant pairs may occur

Copula Functions

非线性

- ***Purpose Of Copula Functions***
  - simplify statistical problems
  - multiple univariate distributions → single multivariate distribution
  - n-dimensional function → unit-dimensional one
- ***Gaussian Copula***(correlation)
  - most applied copulas in finance

$$C_g[G_1(u_1), \ldots, G_n(u_n)] = M_n[N^{-1}(G_1(u_1)), \ldots, N^{-1}(G_n(u_n)); \rho_M]$$

Section 5

ACADEMIC LITERATURE ON RISK MEASURING

Academic Literature on Risk Measuring

- no unique solution
- square-root-of-time ("square root rule") →inaccurate approximation

Time Horizon

proper time horizon →取决于 portfolio liquidity and purpose for risk measurement

incorporate time-varying volatility into VAR models→否则会**underestimation of risk**

accuracy of simple VAR measures diminish as time horizon lengthens

Backtesting VAR

less effective over longer time horizons

conditional backtests improve power of backtests

Liquidity Risk

Exogenous liquidity → transaction costs→ "liquidity-adjusted VAR" approach

Endogenous liquidity → price impact → depends on trade size(move market prices)

Endogenous liquidity effects are important when

- underlying asset is not very liquid
- size of the position
- small investors follow the same hedging strategy
- asymmetric information→magnifies the sensitivity of prices to clusters of similar trade

Practical Issues

Compare Risk Measures Methods

- Value at Risk (VAR)→not subadditive
- Expected Shortfall→ subadditive
- Spectral risk measures→ generalization of expected shortfall

Leverage

- procyclical
- inversely related to the market value of total assets
- cyclical feedback loop
- amplify boom and bust cycles

Within bank's risk assessment framework

- ***compartmentalized approach***: sum measured risks separately
- ***unified approach***: consider the interaction among various risk factors
- calculating individual risks and adding them together is not an accurate measure of true risk due to risk diversification

The Basel approach is a non-integrated approach to risk measurement

Top-down vs. Bottom-up

- ***top-down approach***: risks are separable and can be aggregated in some way
- ***bottom-up approach*** : better account for the interaction among risk factors

Section 6

THE SCIENCE OF TERM STRUCTURE MODELS

Bond Valuation

Discounted Future CF $P=\sum_{t=1}^{n}\frac{\text{cash flow}_t}{(1+\text{discount rate})^t}$

Interest rate risk → Duration: bond's interest rate risk or sensitivity of a bond's full price to a change in its yield

★ **Macaulay Duration:** the average time to wait for each payment, weighted by PV of cash flow

$$Macaulay\ duration=\sum_{t=1}^{n}[t\times(PVCF_t/P_0)]$$

Yield-Based DV01 DV01=Duration × Bond Value ×0.0001=D* ×P × 0.0001 $DV01=-\frac{1}{10,000}\times\frac{dP}{dy}$

Yield-Based Convexity

- Convexity is always positive for regular coupon-paying bonds
- Greater convexity is beneficial both for falling and rising yields

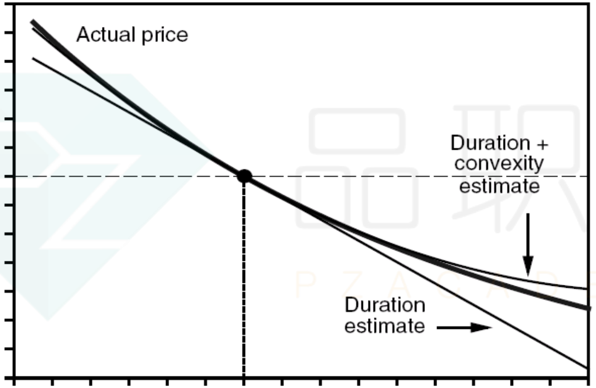
All else equal, duration and convexity both increase for ★

- longer maturities(夜长梦多)
- lower coupons(财大气粗)
- lower yields(看斜率)

Bond Valuation

Bond Price and Yield

- Using Duration only: $\Delta P = -D^* \times P \times \Delta y$
- Using Duration and Convexity: $\Delta P = -D^* \times P \times \Delta y + \frac{1}{2} \times C \times P \times (\Delta y)^2$



The Barbell vs. The Bullet

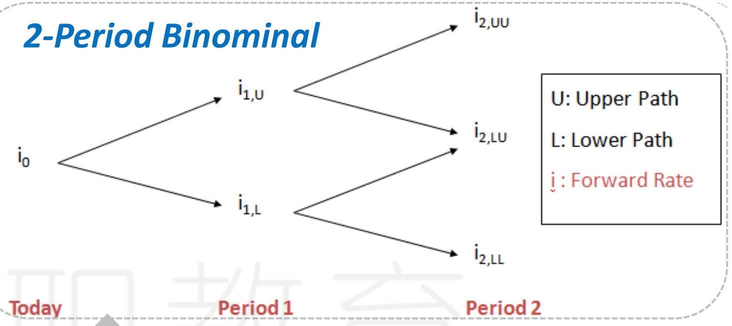
- ***barbell bond portfolio***: short maturities (low duration) + long maturities (high duration)
- ***bullet bond portfolio*** : concentrates in medium-term maturities

With the same duration, barbell bond has larger convexity than bullet bond

The Science of Term Structure Models

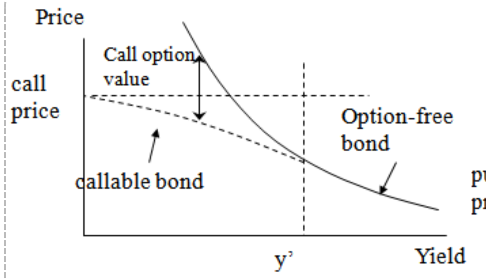
★
- *不含权债定价*
- *含权债*
  - callable bond
  - putable bond
- *不含权债期权*
  - 欧式
  - 美式
  - → •call on bond
  - → •put on bond

2-Period Binominal



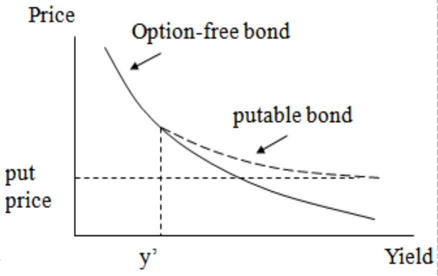
Interest Rate Tree (Binominal) Model: to value bonds with embedded options ← **No Arbitrage Rule**

Callable Bonds



Negative Convexity

Puttable Bonds



More Convexity

Black-Scholes-Merton model not appropriate to value derivatives on fixed-income securities. It assumes:

- no upper limit to the price of the underlying asset. However, bond prices do have a maximum value.
- risk-free rate is constant. However, changes in short-term rates do occur.
- volatility is constant. However, price volatility decreases as bond approaches maturity.

The Shape of The Term Structure

Theory	Details
Pure Expectation	forward rates are solely a function of expected future spot rates 不足: fail to consider the riskiness of bond investing
Liquidity Preference	forward rates are biased estimates of the market's expectation of future rates include liquidity premium
Market Segmentation	• shape of the yield curve→ preferences of borrowers and lenders • Yield at each maturity is determined independently
Preferred habitat	• forward rates represent expected future spot rates plus a premium(not related to maturity) • explain almost any yield curve shape

Interest Rate Volatility: volatility of expected rates causes the future spot rates to be lower

★ Convexity Effect(Jensen's inequality) $E\left[\frac{1}{(1+r)}\right] > \frac{1}{E[1+r]}$

the value of convexity increases with maturity and volatility

The Art of Term Structure Models: Drift

★ 计算

Model 1 (no Drift) $dr = \varepsilon\sigma\sqrt{dt}$

Trend

- **Model 2 (with Drift)** $dr = \lambda dt + \varepsilon\sigma\sqrt{dt}$
- **Ho-Lee Model (with time-dependent drift)** $dr = \lambda(t)dt + \varepsilon\sigma\sqrt{dt}$

mean reverting → **Vasicek Model** ★ $dr = k(\theta - r)dt + \varepsilon\sigma\sqrt{dt}$ →

- k=a parameter that measures the speed of reversion adjustment
- θ=long-run value of the short-term rate assuming risk neutrality
- r=current interest rate level

Assuming a long-run interest rate of r_L, then long-run mean reverting level is: $\theta \approx r_L + \frac{\lambda}{k}$

Model 3 (with time-dependent volatility) $dr = \lambda(t) + \varepsilon\sigma e^{-\alpha t}\sqrt{dt}$

Cox-Ingersoll-Ross (CIR) Model $dr = k(\theta - r)dt + \sigma\sqrt{r}\varepsilon\sqrt{dt}$ σ与r相关

Model 4 (Lognormal) $dr = ardt + \sigma r\varepsilon\sqrt{dt}$ →

$$d\left[\ln(r)\right] = a(t)dt + \sigma\varepsilon\sqrt{dt}$$

$$d\left[\ln(r)\right] = k(t)\left[\ln\theta(t) - \ln(r)\right]dt + \sigma(t)\varepsilon\sqrt{dt}$$

结论★

- Ho-Lee model, the drift terms are ***additive***
- Lognormal model, the drift terms are ***multiplicative***

Section 7

LIBOR VS. OIS

LIBOR VS. OIS

衍生品定价要用到rf

常见Rf

Rf

Treasury bills → artificially low → 原因

- regulatory requirements
- capital of a bank, required
- favorable tax treatment

LIBOR → not totally risk-free → 3-month LIBOR-OIS spread →

- normal market conditions: 10 bps
- October 2008: high of 364 bps

overnight indexed swap (OIS) rate →

- a swap: fixed rate→geometric average of overnight rates
- OIS rate: fixed rate in an OIS
- OIS: short lives
- OIS longer than 1 year is divided into 3-month subperiods
- OIS rate: continually refreshed overnight rate
- might be a default on an overnight loan
- might be a default on the OIS swap itself

应用

- non-collateralized derivatives→LIBOR
- collateralized derivatives→OIS rate

- The OIS zero curve is as close to risk-free.
- It should be used for discounting regardless of whether the transaction is collateralized

Section 8

EMPIRICAL APPROACHES TO RISK METRICS AND HEDGING

Empirical Approaches To Risk Metrics And Hedging

Drawback with a DV01-neutral

- "parallel" assumption → but "twists" in the curve → "curve risk"
- not necessarily a realistic hedge

improve

- empirical data → not co-dependent
- Advantage: estimate how much nominal yield changes given a change in TIPS yield
- Advantage: estimate of the volatility of the hedged portfolio

Regression hedge

$$Portfolio = Bond + Hedge \Rightarrow \begin{cases} \Delta P = \Delta B + \Delta H = BD_B \Delta y_B + HD_H \Delta y_H = 0 \\ \Delta y_B = \beta \Delta y_H \end{cases}$$

正负号表示long/short

★计算

Two variable regression

$$P = B_{20} + H_{10} + H_{30} \Rightarrow \begin{cases} \Delta P = \Delta B_{20} + \Delta H_{10} + \Delta H_{30} \\ \quad = B_{20} D_{20} \Delta y_{20} + H_{10} D_{10} \Delta y_{10} + H_{30} D_{30} \Delta y_{30} = 0 \\ \Delta y_{20} = \beta_{10} \Delta y_{10} + \beta_{30} \Delta y_{30} \end{cases}$$

Principal Component Analysis(PCA)

- sum of the variances of the principal components equals the sum of the variances of the individual rates
- principal components are uncorrelated with one another
- principal components are chosen to have the maximum possible variance

Section 9

VOLATILITY SMILES

What Is Volatility Smiles

Volatility smile : a plot of the ***implied volatility*** of an option as a function of its ***strike price***

Put-Call Parity(whatever pricing model is used): $p+S_0e^{-qT}=c+Xe^{-rT}$

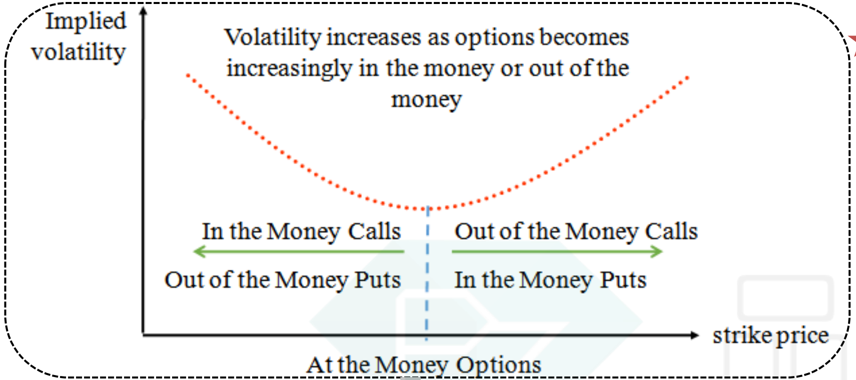
★ The implied volatility of a European call option is always the same as the implied volatility of a European put option
(when the two have the same strike price and maturity date)

了解

Alternative ways of characterizing the volatility smile

- strike price(K)→K/S_0→ K/F_0 (F_0: the forward pirce of the asset)
- strike price(K)→delta of the option

Volatility Smile For Foreign Currency Options

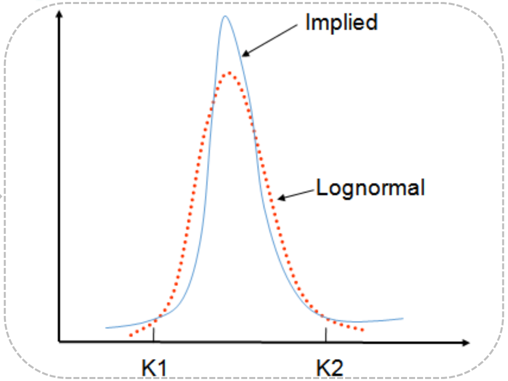


Contidions for an asset price to have a lognormal distribution

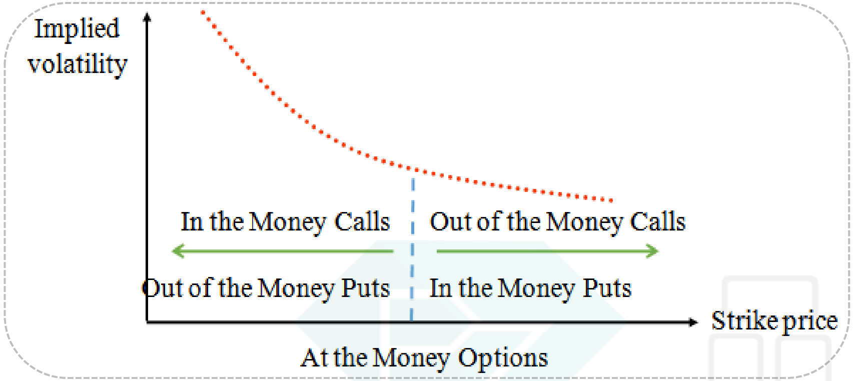
- The volatility of the asset is constant
- The price of the asset changes smoothly with no jumps

Exchange rate is not lognormally distributed

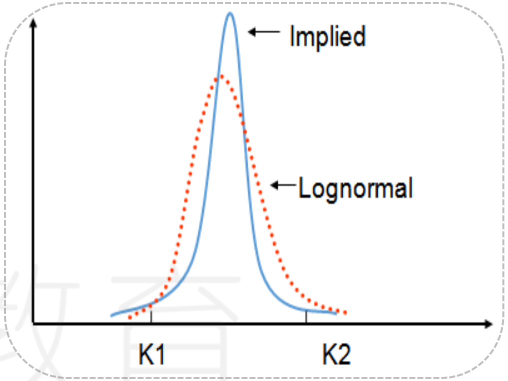
- In practice, neither of these conditions is satisfied for an exchange rate.
- The volatility of an exchange rate is far from constant, and exchange rates frequently exhibit jumps



Volatility Smiles (Skew) For Equity Options



★左高右低



Reasons For The Smile In Equity Options

- ***Leverage***: firm's equity value decreases→leverage increases→increases the riskness/volatility of the underlying assets
- ***Crashophobia***: 1987 stock market crash→higher premiums for put prices when the strike prices lower

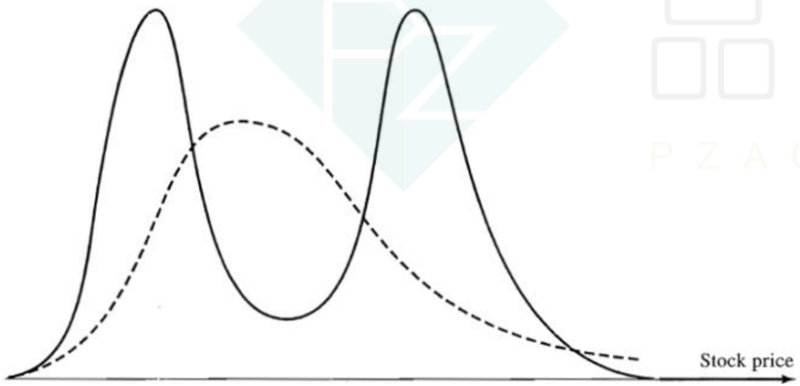
The implied distribution has a heavier left tail and a less heavy right tail than the lognormal distribution.

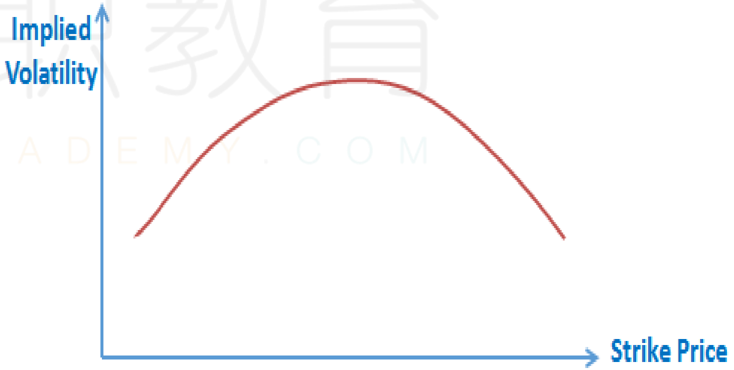
- Traders allow the implied volatility to depend on time to maturity as well as strike price.
- Volatility surfaces combine volatility smiles with the time to maturity and K/S0.

The Impact Of Large Asset Price Jumps

Implied volatility is affected by price jumps and the probabilities assumed for either a large up or down movement

- ***At-the-money options*** tend to have a higher implied volatility than either out-of-the-money or in-the-money options
- Away-from-the-money options exhibit a lower implied volatility than at-the-money options





Thank You!