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Quantitative Methods

2015 CFA一级知识框架图

Framework

Time Value Calculation	R5 The Time Value of Money
	R6 Discounted Cash Flow Applications
Probability & Descriptive Statistics	R7 Statistical Concepts and Market Returns
	R8 Probability Concepts
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Time Value of Money

Interest rate

含义	构成
① Required rate of return ② Discount rate ③ Opportunity cost	① Nominal risk-free rate = real risk-free rate + expected inflation rate ② Required interest rate on a security = nominal risk-free rate + default risk premium + liquidity risk premium + maturity risk premium

EAR ★

计算	$\left(1+\frac{r}{m}\right)^m = 1+EAR \rightarrow \lim_{n\to\infty}\left(1+\frac{r}{m}\right)^m = e^r = 1+EAR$
性质	The greater the compounding frequency, ✓ the greater the EAR will be in comparison to the stated rate ✓ the greater the difference between EAR and the stated rate

TVM计算 ★

① $FV=PV(1+r/m)^m$

② Annuity：
- ordinary annuities
- annuity due

③ perpetuity

Reading 6

Discounted Cash Flow Applications

NPV & IRR ★

计算	$NPV = CF_0 + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \ldots + \frac{CF_N}{(1+r)^N} = \sum_{t=0}^{N} \frac{CF_t}{(1+r)^t}$ $NPV = 0 = CF_0 + \frac{CF_1}{(1+IRR)^1} + \frac{CF_2}{(1+IRR)^2} + \ldots + \frac{CF_N}{(1+IRR)^N} = \sum_{t=0}^{N} \frac{CF_t}{(1+IRR)^t}$
Decision Rule	① Independent Projects： • Accept it if NPV>0 • Accept it if IRR>r (required rate of return) ② Mutually Exclusive Projects： • NPV method: Choose the one with higher NPV • IRR method: Choose the one with higher IRR • NPV and IRR methods may conflict with each other，以NPV判断为准
IRR的特点	✓ When NPV= 0, the discount rate. ✓ IRR method assumes the project's cash flows will be reinvested at the IRR. ✓ Multiple solutions Problem of the IRR calculation (sign changes)

收益率计算 ★

折价率 → $r_{BD} = \frac{(F - P_0)}{F} \times \frac{360}{t}$

收益率 → $HPY = \frac{P_1 - P_0 + CF_1}{P_0}$

- 单利年化 → $r_{MM} = HPY \times \frac{360}{t}$
- 复利年化 → $EAY = (1 + HPY)^{\frac{365}{t}} - 1$ ⟺ $(1 + \frac{BEY}{2})^2 = 1 + EAR$

TWRR &MWRR ★★

	TWRR	MWRR
定义	几何平均，相当于给每个收益率相同的权重	以现金流作为权重，现金流越多的一期，收益率给的权重越大
计算	① 找到每一期的HPR； ② n期HPR的几何平均	① 找到每一期的现金流； ② MWRR = 计算IRR
性质	✓ 不会受到现金流流入流出的影响； ✓ 衡量基金经理业绩更准确	✓ 会受到现金流改变的影响，所以客户的决策对MWRR会造成影响； ✓ 如果客户投资的越来越多，相当于给后期的收益率一个更高的权重

Reading 7

Statistical Concepts and Market Return

Descriptive statistic： 描述一组数据的基本特征

Types of measurement scales ★

	Nominal scales	Ordinal scales	Interval scales	Ratio scales
含义	定性区分	排序(>, <)	(>, <, +, -)	(>, <, +, -, *, /)
性质	只能求mode	Mode、median	没有绝对零点	Most refined

中心位置

Frequency	① Relative frequency ② Cumulative frequency ③ Cumulative Relative Frequency
Mean	计算：arithmetic mean、weighted mean、geometric mean、harmonic mean 注意：geometric mean=$[(1+HPR_1)\ldots\ldots(1+HPR_n)]^{1/n}$
	结论：harmonic mean<= geometric mean<=arithmetic mean
Quantiles ★	定义：Quartile /Quintile/Deciles/Percentile
	计算：$L_y = (n+1)y/100$
	性质：比如The third quartile > mean

离散程度

计算	**Range = maximum value – minimum value**
	$MAD = \frac{\sum_{i=1}^{N} \lvert X_i - \bar{X} \rvert}{n}$
	For population: $\sigma^2 = \frac{\sum_{i=1}^{N} (X_i - \mu)^2}{N}$ For sample: $s^2 = \frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}$
性质	MAD < σ
CV ★★	$CV = \frac{s_x}{\bar{X}} \times 100\%$ relative dispersion, free of scale (or free of unit)

$$\text{Sharp ratio} = \frac{R_P - R_f}{\sigma_P}$$

性质：越大越好

Chebyshev inequality ★

计算：

1. regardless of the shape of the distribution;
2. the proportion of the values that lie within k standard deviations of the mean is at least $1 - 1/k^2$

Skewness

★★掌握性质

Positive skewed	✓ Mode<median<mean ✓ right fat tail ✓ frequent small losses and a few extreme gains (mean＝0时) ✓ 投资者更加prefer positive skewness
Negative skewed	✓ Mode>media>mean ✓ left fat tail ✓ frequent small gains and a few extreme losses. (mean＝0时)

kurtosis

★ 掌握性质

Leptokurtic	✓ Sample kurtosis>3； Excess kurtosis>0 ✓ 相同σ，尖峰肥尾(more frequent extremely large deviations from the mean than a normal distribution.)
Platykurtic	Sample kurtosis<3； Excess kurtosis<0
Normal distribution	Sample kurtosis=3； Excess kurtosis=0

t分布：和z分布比，低峰肥尾。所以t分布更加分散一些，σ更大。

Reading 8

Probability Concepts

概率和事件(event)

Properties of Probability	✓ $0 \le P(E) \le 1$ ✓ $P(E_1)+P(E_2)+......+P(E_n)=1$ • $E_1......E_n$: Mutually exclusive and Exhaustive	
概率分类	Empirical probability: 分析过去，得到将来	
	Priori probability: 分析过去，得到过去的推理	
	Subjective probability: 主观	
Event分类	Mutually exclusive	$P(AB)=P(A \mid B)=P(B \mid A)=0$
	Exhaustive events	include all possible outcomes
	Independence ★★	✓ $P(AB)=P(A)\times P(B)$ ✓ If exclusive, must not independence ✓ Independence →$\rho=0$; 反之不对

概率计算 ★

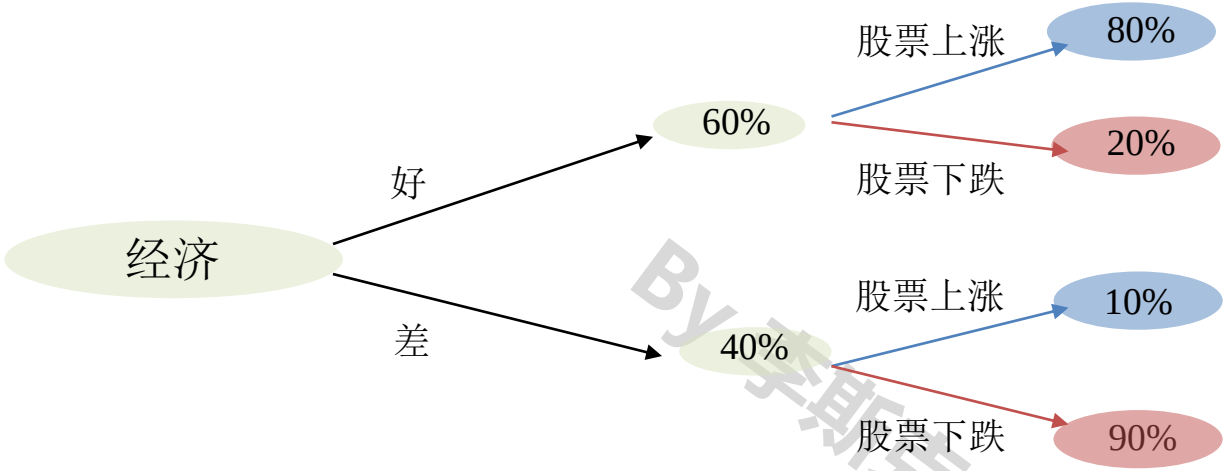
Odds	Odds for an event： P(E)/(1-P(E))
	Odds against an event： (1-P(E))/P(E)
Joint probability	P(AB)=P(A|B)×P(B)= P(B|A)×P(A)
Addition rule	at least one of two events will occur P(A or B)=P(A)+P(B)-P(AB)

Covariance & Correlation ★★

计算		性质
Covariance	$COV = E[(X-E(X))(Y-E(Y))]$	✓ how one random variable moves with another random variable ✓ The covariance of X with itself is equal to the variance of X ✓ Covariance ranges from negative infinity to positive infinity
Correlation	$\rho_{XY} = \frac{COV(X,Y)}{\sqrt{Var(X)Var(Y)}}$	✓ Correlation measures the linear relationship between two random variables ✓ Correlation has no units, ranges from –1 to +1, standardization of covariance ✓ If ρ=0, this doesn‘t indicates independence.

Bayes' Formula

★计算，用二叉树图形，不用记公式



注意：把非条件概率画在第一支

$$P(A|B)=\frac{P(B|A)}{P(B)}*P(A)$$

排列组合

了解

Multiplication rule	$n_1\times n_2\times\ldots\ldots\times n_k$
Factorial	n !
Labeling (or Multinomial)	$\frac{n!}{n_1!\times n_2!\times\ldots\times n_k!}$
Combination	${}_nC_r$ (用计算器算)
Permutation	${}_nP_r$ (用计算器算)

Reading 9

Common Probability Distributions

Probability Distribution分类

分类	定义	性质
Discrete	the number of outcomes is counted	measurable and positive probability
Continuous	the number of outcomes is infinite	P (x)=0 even though x can occur
注意：Cumulative probability function F(x)=P(X<=x)		

Discrete Probability Distribution

类型	性质&计算
Discrete uniform	例：X={1,2,3,4,5}, p(x)=0.2
Bernoulli random variable	P(Y=1)=p， P(Y=0)=1-p Expectation=p, Variance=p(1-p)
Binomial random variable ★★	$p(x)=P(X=x)={}_nC_x p^x(1-p)^{n-x}$ Expectation=np, Variance=np(1-p)

Continuous Probability Distribution

类型		性质&计算
Uniform Distribution		取值区间：(a, b) $P(x_1 \le X \le x_2) = (x_2 - x_1)/(b-a)$
Normal distribution ★★	Properties	✓ X~N(μ , σ²); 取值区间：(-∞, +∞) ✓ Symmetrical distribution: skewness=0; kurtosis=3 ✓ A linear combination of normally distributed is also normally distributed. ✓ The tails get thin and go to zero but extend infinitely.
	confidence intervals	68% confidence interval is $[\mu-\sigma, \mu+\sigma]$ 90% confidence interval is $[\mu-1.65\sigma, \mu+1.65\sigma]$ 95% confidence interval is $[\mu-1.96\sigma, \mu+1.96\sigma]$ 99% confidence interval is $[\mu-2.58\sigma, \mu+2.58\sigma]$
	Standard, Z分布	$Z = \frac{X-\mu}{\sigma}$
	safety-first Ratio	$[E(R_P) - R_L]/\sigma_P$; Maximize SFR <=> Minimize P (Rp< R_L)
Lognormal distribution ★★		✓ If lnX is normal, then X is lognormal. ✓ Lognormal →the price of asset; normal →the return of asset ✓ Right skewed; Bounded from below by zero (取值不能小于0)

Monte Carlo simulation & Historical simulation

了解

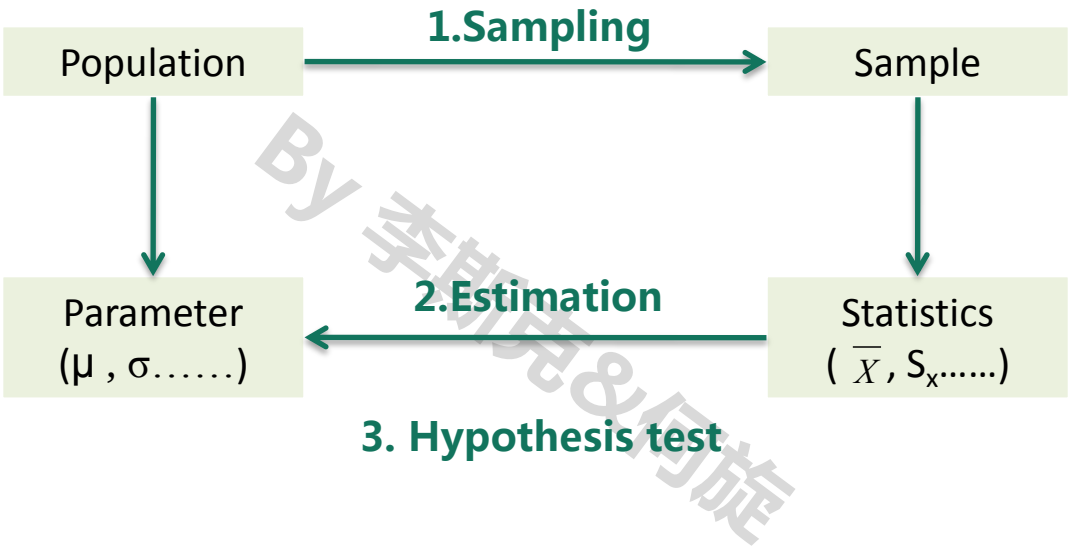
Monte Carlo simulation	✓ based on their assumed distributions, to produce a distribution of possible security values； ✓ It is fairly complex and will assume a parameter distribution； ✓ It is not an analytic method but a statistical one.
Historical simulation	✓ Selected historical data to generate a distribution; ✓ the past can not indicate the future; ✓ historical simulation cannot address the sort of “what if ” questions that Monte Carlo simulation can.

Reading 10 & 11

Sampling and Estimation、Hypothesis Testing

难点

Framework



1. Sampling

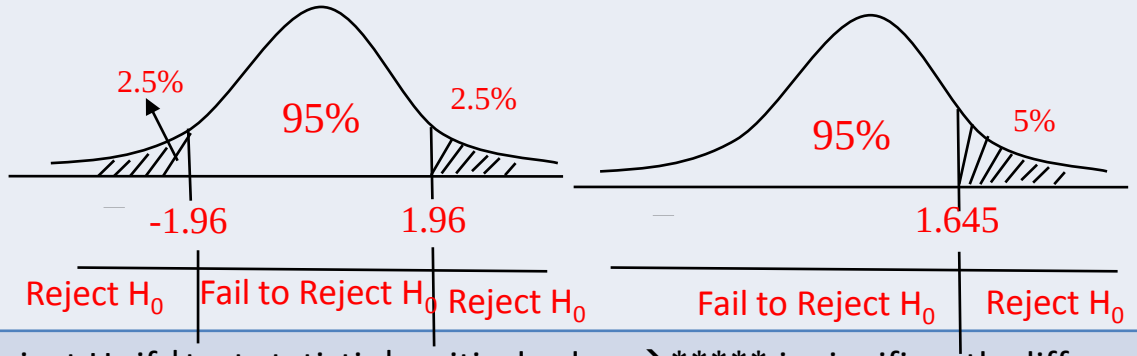
抽样方法	✓ Simple random sampling ✓ Stratified random sampling: to separate the population into smaller groups
Data	✓ Time-series data: data taken over a period of time ✓ Cross-sectional data: data taken at a single point of time
Sample statistic特点 ★★	✓ sampling error of the mean= sample mean- population mean ✓ The sample statistic itself is a random variable ✓ Central Limit Theory： n>=30 → sample mean ~$\underline{N(\mu , \sigma^2/n)}$ ✓ Standard error =$s / \sqrt{n}$ or $s / \sqrt{n}$

2. Estimation

Desirable properties ★★	✓ Unbiasedness: expected value of the estimator is equal to parameter that estimate ✓ Efficiency: dispersion is smaller ✓ Consistency: the accuracy increases as n increases.
Estimation	1. Point estimate: 2. Confidence interval estimate★★ $\bar{x} \pm z_{a/2} \frac{s}{\sqrt{n}}$ or $\bar{x} \pm t_{a/2} \frac{s}{\sqrt{n}}$
选择哪一个分布？	✓ 方差已知用z，方差未知用t，非正态总体小样本不可估计； ✓ 如果n>=30，都可以用z.
T分布 ★★	✓ Symmetrical ✓ Degrees of freedom (df): n-1 ✓ Less peaked than a normal distribution (“fatter tails”) ✓ As the degrees of freedom gets larger, the shape of t-distribution approaches standard normal distribution
估计的bias	1. Data-mining bias 2. Sample selection bias 3. Survivorship bias 4. Look-ahead bias 5. Time-period bias

3. Hypothesis test

步骤：检验μ ★★

1. 提出假设	**Two-tailed** $H_0: m = m_0 \quad H_a: m \neq m_0$ **One-tailed** $H_0: m \geq m_0 \; H_a: m < m_0 \; or, H_0: m \leq m_0 \; H_a: m > m_0$ H_0 is what we want to reject
2. 计算test statistic	$Test\ Statistic = \dfrac{\overline{X} - \mu_0}{s/\sqrt{n}}$
3. 画分布找到critical value	
4. 判断	Reject H_0 if |test statistic|>critical value →***** is significantly different from ****** Fail to reject H_0 if |test statistic|<critical value →***is not significantly different from ***

P – value ★★

P – value <α →reject H_0

Type I error and Type II error ★★

Decision	True condition	
	H_0 ✔	H_0 ✖
Do not reject H_0	Correct Decision	Incorrect Decision Type II error
Reject H_0	Incorrect Decision Significance level =P (Type I error)	Correct Decision Power of test = 1- P (Type II error)

1. Type I error ↑→ Type II error ↓
2. Increase the Sample Size →Type I error & Type II error ↓

其他检验 ★★

Test type	Assumptions	H_0	Test-statistic
Mean	Independent populations	$\mu_1-\mu_2=0$	t
	Paired comparisons test	$\mu_d=0$	$t=\bar{d}/s_{\bar{d}}$
Variance	Normally distributed population	$\sigma^2=\sigma_0^2$	C^2
	Two independent populations	$\sigma_1^2=\sigma_2^2$	F test

Nonparametric tests 了解

Parametric tests	specific to population parameters
Nonparametric tests	Nonparametric tests are used: ✓ The assumptions that support a parametric test are not met. ✓ When data are ranks (ordinal measurement scale) rather than values. ✓ The hypothesis does not involve the parameters of the distribution, such as testing whether a variable is normally distributed.

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Technical Analysis

了解

Principles	1. Prices are determined by the interaction of supply and demand. 2. Only participants who actually trade affect prices. 3. Price and volume reflect the collective behavior of buyers and sellers.
Assumptions	1. Investor behavior is reflected in trends and patterns that trend to repeat. 2. Efficient markets hypothesis dose not hold.
和基本面分析的区别	Fundamentalists believe that prices react quickly to changing stock values, while technicians believe that the reaction is slow.
Advantages	1. Actual price and volume data are observable. 2. Technical analysis itself is objective, while much of the data used in fundamental analysis is subject to assumptions or restatements. 3. It can be applied to the prices of assets that do not produce future cash flows, such as commodities. 4. It can also be useful when financial statement fraud occurs.
Disadvantage	illiquid markets不能用
重要图形和指标	✓ ***Head-and-shoulders pattern***:**Price target = Neckline – (Head – Neckline)** ✓ ***Inverse head and shoulders***: **price target = neckline + (neckline – head)** ✓ ***Prevailing up trend***: upward moves in prices consist of 5 waves and downward moves occur in 3 waves ✓ ***Prevailing down trend***: downward moves in prices consist of 5 waves and upward moves occur in 3 waves

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