CAA Dictionary

For Manual A1, A3, and A5

First Edition

Sun Life Financial

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Chinese Term	English Translation	Exam	Chapter
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Chinese Term	English Translation	Exam	Chapter
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Chinese Term	English Translation	Exam	Chapter
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Chinese Term	English Translation	Exam	Chapter

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Chinese Term	English Translation	Exam	Chapter
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Chinese Term	English Translation	Exam	Chapter
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隐含波动率	Implied Volatility	A2	Ch9
一年定期全缴费期修正法（FPF法）	Full Preliminary Term Method	A5	Ch6

Chinese Term	English Translation	Exam	Chapter
伊藤公式	Ito's Lemma	A1	Ch12
伊藤积分	Ito's Calculus	A1	Ch12
一元回归	Simple Regression	A1	Ch8
一致性预期假定	Homogeneous Expectation Assumption	A2	Ch10
永续年金	Perpetuity	A2	Ch2
右截断	Right Truncation	A3	Ch4
右截断数据	Right-Truncated Data	A3	Ch8
右删失数据	Right-Censored Data	A3	Ch8
右删失	Right Censoring	A3	Ch4
有限波动信度	Limiting Fluctuation Credibility	A3	Ch12
有限差分法	Finite Difference Method	A2	Ch7
优先股	Preferred Stock	A2	Ch2
有限期望函数	Limited Expected Function	A3	Ch4
有限时间破产概率	Finite Time Ruin Probability	A3	Ch7
有效久期	Effective Duration	A2	Ch6
有效凸度	Effective Convexity	A2	Ch6
有效资产组合	Efficient Portfolio	A2	Ch10
原假设	Null Hypothesis	A1	Ch7
远期单利	Simple Forward Rate	A2	Ch7
远期复利	Compounded Forward Rate	A2	Ch7
远期合约	Forward Contract	A2	Ch8
远期价格	Forward Price	A2	Ch8
远期利率	Forward Interest Rate	A2	Ch6
远期利率协议	Forward Rate Agreement (FRA)	A2	Ch8
（纯粹）预期理论	Pure Expectation Theory	A2	Ch6
预期值	Expected Value	A2	Ch7
余弦	Cosine	A1	Ch9

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再投资收益率	Reinvestment Rate of Return	A2	Ch3
责任准备金（准备金）	Reserve	A5	Ch5
债券	Bond	A2	Ch5
债券持有人	Bond Holder	A2	Ch5
债券发行人	Bond Issuer	A2	Ch5
债券价格	Purchase Price of a Bond	A2	Ch5
债券面值	Face Value of a Bond	A2	Ch5
债权人	Bondholder	A2	Ch5
债券赎回值	Redemption Value of a Bond	A2	Ch5
债务偿还	Loan Repayment	A2	Ch4
账面值	Book Value	A2	Ch5
展期保险	Extended Insurance	A5	Ch16
占优策略	Dominant Strategy	A2	Ch9
折价（发行）	(Issued at) Discount	A2	Ch5
折价积累	Accumulation of Discount	A2	Ch5
正交矩阵	Orthogonal Matrix	A1	Ch5
证券化	Securitization	A2	Ch5
证券市场线	Security Market Line (SML)	A2	Ch11
正态分布	Normal Distribution	A1	Ch2
正弦	Sine	A1	Ch9
整值平均余寿	Expected Curtate Future Lifetime	A5	Ch1

Chinese Term	English Translation	Exam	Chapter
折现因子	Discount factor	A2	Ch1
秩	Rank	A2	Ch9
直方图	Histogram	A3	Ch8
支付	Payoff	A2	Ch9
芝加哥商品交易所	Chicago Mercantile Exchange	A2	Ch8
指数	Exponential	A2	Ch1
指数保费	Exponential Premium	A5	Ch4
指数保费原则	Exponential Premium principle	A5	Ch4
指数分布	Exponential Distribution	A1	Ch2
（指数分布的）无记忆性	Memoryless Property (of Exponential Distribution)	A3	Ch2
指数分布族	Exponential Distribution Family	A3	Ch9
指数假设（常力假设）	Constant Force of Mortality Assumption	A5	Ch1
指数平滑	Exponential Smoothing	A1	Ch9
指数准备金	Exponential Reserve	A5	Ch5
执行	Exercise	A2	Ch8
执行价格	Exercise Price	A2	Ch8
置信区间	Confidence Interval	A1	Ch6
置信上限	Upper Bound of Confidence Interval	A1	Ch6
置信水平	Confidence Level	A1	Ch6
置信下限	Lower Bound of Confidence Interval	A1	Ch6
终极破产概率	Ruin Probability	A3	Ch7
终极生存概率	Survival Probability	A3	Ch7
终极生命表	Ultimate Life Table	A3	Ch3
终身生命年金	Whole Life Annuity	A5	Ch3
终生寿险	Whole Life Insurance	A5	Ch2
众数	Mode	A1	Ch3
中位数	Median	A1	Ch3
中心极限定理	Central Limit Theorem	A1	Ch4
中心死亡率	Central Death Rate	A3	Ch2
中心终止率	Central Death Rate	A5	Ch8
终值	Accumulated Value	A2	Ch1
终止力	Force of Decrement	A5	Ch8
种子	Seed	A3	Ch13
状态变量	Status Variables	A2	Ch7
状态价格向量	State-Price Vector	A2	Ch9
转换比率	Conversion Ratio	A2	Ch5
转换因子	Conversion Factor	A2	Ch8
转移概率	Transition Probability	A1	Ch11
转移概率矩阵	Transition Probability Matrix	A5	Ch10
逐日盯市	Marking to Market	A2	Ch8
主要变量	Primary Random Variable	A3	Ch2
资本市场线	Capital Market Line (CML)	A2	Ch10
资本收益	Capital Income	A2	Ch5
资本预算	Capital Budgeting	A2	Ch3
资本增益税	Capital Gains Tax	A2	Ch5
资本资产定价模型	Capital Asset Pricing Model	A2	Ch11
自变量	Explanatory Variable	A1	Ch8
资产	Asset	A3	Ch7
资产池	Asset Pool	A2	Ch5
资产份额	Assets Share	A5	Ch14

Chinese Term	English Translation	Exam	Chapter
资产负债管理	Asset Liability Management	A2	Ch6
资产负债匹配	Asset Liability Matching	A2	Ch6
资产管理	Asset Management	A2	Ch6
资产估值	Asset Valuation	A2	Ch11
资产配置	Asset Allocation	A2	Ch11
资产配置线	Capital Allocation Line (CAL)	A2	Ch10
资产证券化	Asset Securitization	A2	Ch5
资产组合	Portfolio	A2	Ch10
自回归模型(AR)	Autoregressive Model	A1	Ch9
自回归移动平均模型(ARMA)	Auto Regressive Moving Average Model (ARMA)	A1	Ch9
自融资	Self-Financing	A2	Ch9
自相关系数	Autocorrelation Coefficient	A1	Ch9
自协方差函数	Autocovariance Function	A1	Ch9
自由度	Degree of Freedom	A1	Ch7
总量函数	Accumulation function	A2	Ch1
总理赔过程	Aggregate Claim Process	A3	Ch7
总平方和	Sum Square of Total(SST)	A1	Ch8
总体	Population	A1	Ch5
最大精算信度模型	Greatest Accuracy Credibility Model	A3	Ch12
最大损失随机变量	Maximal Aggregate Loss Random Variable	A3	Ch7
最低保证年金	Guaranteed Minimum Annuity	A5	Ch12
最后生存状态	Last Survivor Status	A5	Ch7
最廉价交割债券	Cheapest to Deliver	A2	Ch8
最小二乘估计	Least Squares Estimation	A1	Ch8
最优化问题	Optimization	A2	Ch6
最优资产组合	Optimal Portfolio	A2	Ch10
左截断	Left Truncation	A3	Ch4
左截断数据	Left-Truncated Data	A3	Ch8
左删失	Left Censoring	A3	Ch4
左删失数据	Left-Censored Data	A3	Ch8

A1 Manual

§2 A1 Manual

§2.1 第一章：随机事件与概率 Chapter One: Random Events and Probabilities

- 贝叶斯公式
  Bayes' Law: Given Event A and Event B, Bayes' Law provides a formula to calculate conditional probabilities:
  $$P(A|B) = \frac{P(B|A)P(A)}{P(B)}.$$
- 必然事件
  Certain Event: A certain event is the event occurs with probability equal to 1.
- 伯努里试验
  Bernoulli Trial: A Bernoulli Trial is an experiment whose outcome is random and can be either of two possible outcomes, "success" and "failure".
- 不可能事件
  Impossible Event: An impossible event is the event with no possibility to occur.
- 对立事件（逆事件）
  Complementary Event: A complementary event of any event A is the event that A does not occur. Note $P(A) + P(\text{not } A) = 1$.
- （集合的）对偶律
  De Morgan's laws: De Morgan's laws are rules relating to logical operators "and" and "or" in terms of each other via negation. In set theory, it is often stated as "Union and intersubsection interchange under implementation", namely:
  $$\begin{aligned}\overline{A \cap B} &= \overline{A} \cup \overline{B},\\ \overline{A \cup B} &= \overline{A} \cap \overline{B}.\end{aligned}$$
- 独立试验序列概型
  Bernoulli Probability: Bernoulli probability describes probabilities associating with an event in Bernoulli trial.
- 独立性
  Independence: In probability theory, if two random events are independent, the occurrence of one event does not influent the probability of the occurrence of the other event. Mathematically,
  $$P(A|B) = P(A), P(B|A) = P(B).$$
- （集合的）分配律
  Distributivity: In the context of set theory, distributivity refers to following properties for some arbitrary sets:
  $$\begin{aligned}A \cup (B \cap C) &= (A \cup B) \cap (A \cup C)\\ A \cap (B \cup C) &= (A \cap B) \cup (A \cap C).\end{aligned}$$
- 概率
  Probability: The probability of an event A is a measure of how likely the event will happen, mathematically, denote as: $P(A)$.
- 概率论
  Probability Theory: Probability theory is a branch of mathematics concerned with analysis of random phenomena. The central objects of probability theory are random variables, stochastic processes and events.
- 古典概型
  Classic Probability: The classic probability describes an experiment with a sample space having equally occurring sample points. In other words, Events in such an experiment have same probabilities.
- （集合的）交换律
  Commutavity: In the context of set theory, the commutavity names following relationship between sets:
  $$A \cup B = B \cup A, A \cap B = B \cap A.$$
- 基本事件
  Elementary Event: If the outcome set of an Event only contains one single element, such an event is called the elementary event.
- （集合的）结合律
  Associativity: In the context of set theory, associativity relates to following properties of some arbitrary sets:
  $$\begin{aligned}A \cap (B \cap C) &= (A \cap B) \cap C,\\ A \cup (B \cup C) &= (A \cup B) \cup C.\end{aligned}$$
- 集合（集）
  Set: A set is a collection of distinct objects, considered as an object in its own right.
- 几何概型
  Geometric Probability: Geometric probability is a general topic studying probability associated with probability problems in geometric sense. In late 20th century, the topic has split to subtopics with different emphases. Integral geometry sprang from the principle that the mathematically natural probability models are those that are invariant under certain transformation groups. Stochastic geometry emphasizes the random geometrical objects themselves.

- 两两独立

  Pair Wise Independency: Let A, B, C be three random events, then if A and B, B and C, A and C are all independent, these three events are pair wise independent.

- 离散概率空间

  Discrete Probability Space: A probability space with elements that are countable in discrete sense is called discrete probability space.

- 全概率公式

  Partition Rule: Let A, B, C be three subsets of a sample space, then

  $$P(A) = P(A|B)P(B) + P(A|C)P(C)$$

  is called the partition rule.

- 随机事件（事件）

  Random Event (Event): In probability theory, an event is a set of outcomes (a subset of the sample s-pace) to which a probability is assigned.

- 随机试验

  Random Trial (Random Experiment): A random experiment of an event assigns random probabilities to outcomes.

- 条件概率

  Conditional Probability: The probability associates to an event A given another event B happens is named the conditional probability of A given B. Mathematically, denote as $P(A|B)$.

- 样本点

  Sample Point: The outcomes that make up the sample space are called sample points.

- 样本空间

  Sample Space: A sample space is a set of distinct outcomes for an experiment or process, with the property that in a single trial, one and only one of these outcomes occurs.

§2.2 第二章：随机变量与分布函数 Chapter Two:Random Variables and Distribution Functions

- 边缘分布

  Marginal Distribution: For the discrete case, the marginal distribution of bivariate random variables (X,Y) with the joint distribution $p_{ij} = P\{X = x_i, Y = y_j\}$ is defined as:

  $$P\{X = x_i\} = \sum_j p_{ij},\ P\{Y = y_j\} = \sum_i p_{ij}.$$

  For the continuous case, the corresponding marginal distribution of (X,Y) with bivariate density $f(x,y)$, then

  $$f_X(x) = \int f(x,y)dy,\ f_Y(y) = \int f(x,y)dy$$

  are called marginal distributions of variables X and Y.

- 泊松定理

  Poisson Theorem: Let $\lambda > 0$ and $n \in \mathbb{Z}_+$, then if $np_n = \lambda$, we have

  $$\lim_{n\to\infty} C_n^k p_n^k (1-p_n)^{n-k} = \frac{\lambda^k e^{-\lambda}}{k!},$$

  for some $k \in \mathbb{N}$. This theorem is usually applied to approximate the probability of binomial random variable X with large n and small p.

- 参数

  Parameter: In mathematics, statistics, and the mathematical sciences, a parameter is a quantity that serves to relate functions and variables using a common variable when such a relationship would be difficult to explicate with an equation. For example, a binomial random variable, $X \sim Bin(n,p)$, then n and p are parameters.

- 二维均匀分布

  Bivariate Uniform Distribution: Let D be a bounded field with area equal to A, then a pair of random variables, (X,Y), are uniformly distributed in D if

  $$f(x,y) = \begin{cases} \frac{1}{A}, (x,y) \in D \\ 0, \text{otherwise} \end{cases}.$$

- 二维正态分布

  Bivariate Normal Distribution: If bivariate random variables, (X,Y), have joint probability density function with the form of

  $$\begin{aligned} f(x,y) &= \frac{1}{2\pi\sigma_1\sigma_2\sqrt{1-\rho^2}} \exp\{-\frac{1}{2(1-\rho^2)} \\ &* [\frac{(x-\mu_1)^2}{\sigma_1^2} - 2\rho\frac{(x-mu_1)(y-mu_2)}{\sigma_1\sigma_2} \\ &+ \frac{(y-\mu_2)^2}{\sigma_2^2}]\}, \end{aligned}$$

  where $\sigma_1 > 0, \sigma_2 > 0, |\rho| < 1$, then (X,Y) is following bivariate normal distribution, denote as $(X,Y) \sim N(\mu_1,\mu_2,\sigma_1^2,\sigma_2^2,\rho)$.

- 二项分布

  Binomial Distribution: The discrete random variable Y has a binomial distribution if its probability mass function is of the form

  $$f_Y(y) = \binom{n}{y} p^y (1-p)^{n-y},$$

  where $y = 0, 1, ..., n$, and p is another parameter with $0 < p < 1$. This model arises in connection with repeated independent trials, where each trial results in either an outcome "S"(with probability p) or

"F" (with probability $1-p$). If Y equals the number of S outcomes in a sequence of n trials, it has the probability mass function given above. We write $Y \sim Bin(n,p)$.

- 反函数
Inverse Function:In mathematics, if ? is a function from a set A to a set B, then an inverse function for $f$is a function from B to A, with the property that a round trip (a composition) from A to B to A (or from B to A to B) returns each element of the initial set to itself. A function f that has an inverse is called invertible; the inverse function is then uniquely determined by f and is denoted by f^{-1}.

- 概率分布列(分布列)
Probability Mass Function(pmf):For a discrete random variable the probability mass function $f_Y(y)$ is defined as
$$f_Y(y) = Pr(Y=y), y \in \mathbb{R},$$
where $\mathbb{R} = \{r_1, r_2, ...\}$ is the range of Y.

- 概率密度函数(密度函数,密度)
Probability Density Function(pdf): For a continuous random variable the probability density function is such that for any interval (a,b) contained in $\mathbb{R}$,
$$Pr(a \leq Y \leq b) = \int_a^b f_Y(y)dy.$$

- 高斯分布
Gaussian Distribution: The continuous random variable Y has a Gaussian distribution if its probability density function is of the form
$$f(y) = \frac{1}{\sqrt{2\pi\sigma}} \exp\left\{-\frac{(y-\mu)^2}{2\sigma^2}\right\},$$
where $-\infty < y < \infty$, $-\infty < \mu < \infty$ and $\sigma > 0$. We write $Y \sim G(\mu, \sigma)$.

- 函数
Function: The mathematical concept of a function expresses the intuitive idea that one quantity (the argument of the function, also known as the input) completely determines another quantity (the value, or the output).

- 伽马分布
Gamma Distribution: The continuous random variable Y has a gamma distribution if its probability density function is of the form
$$f(y) = y^{\alpha-1}\frac{e^{-x/\theta}}{\theta^\alpha \Gamma(\alpha)},$$
where $\alpha, \beta > 0$, and we write $Y \sim Gamma(\alpha, \beta)$.

- 几何分布
Geometric Distribution: For a discrete random variable Y, it follows a geometric distribution if its density function takes the form of
$$Pr(Y=k) = (1-p)^{k-1}p,$$
where $k \in \mathbb{N}$.

- 积累概率分布函数(分布函数)
Cumulative Distribution Function(cdf): The cumulative distribution function is defined for a random variable Y as
$$F_Y(y) = Pr(Y \leq y).$$
If Y is discrete then $F_Y(y) = \sum_{x \leq y} f_Y(x)$; if Y is continuous then $F_Y(y) = \int_{x \leq y} f_Y(x)dx$.

- 卷积
Convolution:In mathematics and, in particular, functional analysis, convolution is a mathematical operation on two functions f and g, producing a third function that is typically viewed as a modified version of one of the original functions.

- 均匀分布
Uniform Distribution: For a continuous random variable Y has a uniform distribution on (a,b) if its probability density function is of form
$$f(y) = \begin{cases} \frac{1}{b-a}, x \in (a,b) \\ 0, \text{otherwise} \end{cases}.$$
We write $X \sim U(a,b)$.

- 联合分布函数
Joint Cumulative Distribution: Joint cumulative distribution is the cumulative density function in multivariate cases.

- 连续型随机变量
Continuous Random Variable: The random variable of a continuous distribution is called continuous random variable.

- 离散型随机变量
Discrete Random Variable: The random variable of a discrete distribution is called discrete random variable.

- 帕斯卡分布
Negative Binomial Distribution: For a discrete random variable Y has a negative binomial distribution if its probability mass function takes the form of
$$Pr(Y=y) = \binom{r-1}{k-1} p^r (1-p)^{k-r}, r \in \mathbb{Z}_+$$
where $k = r, r+1, ...$ and $0 < p < 1$. We write $Y \sim NB(p,k,r)$. When $r = 1$, Y is following geometric distribution.

- 随机变量

  Random Variable:A random variable is a function from the sample space of a random experiment to the real numbers. We use the notation that Y refers to the random variable, while y a particular realization, i.e. the result of a particular experiment. If have multiple independent experiments use $y_1, ..., y_n$ as the realisations. Random variables are usually discrete or continuous. A discrete random variable Y is one for which the range R (set of possible values) of Y is countable. A continuous random variable is one whole range R consists of one or more continuous intervals of real numbers.

- 条件分布

  Conditional Distribution:For the discrete case, the conditional probability of event A given event B is defined to be

  $$Pr(A|B) = \frac{Pr(A \cap B)}{Pr(B)}.$$

  In the continuous case the conditional density is given by

  $$f(x|Y = y) = \frac{f(x, y)}{f(y)}.$$

- 严格单调函数

  Strictly monotonic function:In mathematics, a monotonic function (or monotone function) is a function which preserves the given order. Moreover, given a pair of arbitrary numbers in the range R, $f(x) \neq f(y)$ if $x \neq y$.

- 严减函数

  Strictly Decreasing Function: A function f defined on a subset of the real numbers with real values is called strictly decreasing, if for all x and y such that $x < y$ one has $f(x) < f(y)$.

- 严增函数

  Strictly Increasing Function:A function f defined on a subset of the real numbers with real values is called strictly increasing, if for all x and y such that $x > y$ one has $f(x) > f(y)$.

- 正态分布

  Normal Distribution:The continuous random variable Y has a Gaussian distribution if its probability density function is of the form

  $$f(y) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left\{-\frac{(y-\mu)^2}{2\sigma^2}\right\},$$

  where $-\infty < y < \infty$, $-\infty < \mu < \infty$ and $\sigma > 0$. We write $Y \sim N(\mu, \sigma^2)$.

- 指数分布

  Exponential Distribution: The continuous random variable Y has an exponential distribution if its probability density function is of the form

  $$f(y) = \frac{1}{\theta} e^{-y/\theta},$$

  where $\theta > 0$ and $y > 0$, and we write $Y \sim Exp(\theta)$.

§2.3 第三章：随机变量的数字特征 Chapter Three: Numerical Characteristics of Random Variables

- 变异系数

  Coefficient of Variation:Coefficient of Variation of a random variable Y is defined as

  $$CV(Y) = \frac{\sqrt{Var(Y)}}{E(Y)}, E(Y) \neq 0,$$

  where $VAR(Y)$ is the variance of Y and $E(Y)$ is the expectation of Y.

- 标准差

  Standard Deviation: The standard deviation of a random variable Y is defined as

  $$SD(Y) = \sqrt{E([Y - E(Y)]^2)}.$$

  Also, it is denoted as σ_Y or $\sigma(Y)$.

- 常数

  Constant:

- 方差

  Variance: The variance of a random variable Y is defined as

  $$Var(Y) = E([X - E(X)]^2).$$

- 分位数

  Quartile: Let $F(y)$ be the cumulative distribution function of a random variable Y, we say x_α is $\alpha(0 < \alpha < 1)$-th quartile of X if

  $$F(x_\alpha) = \alpha.$$

- 加权平均

  Weighted Average: An average in which each quantity to be averaged is assigned a weight. These weightings determine the relative importance of each quantity on the average. Weightings are the equivalent of having that many like items with the same value involved in the average.

- 矩

  Moments:Let $k \in \mathbb{Z}$, we say $E(Y^k)$ is the k-th moment of a random variable Y.

- 柯西-施瓦茨不等式

  Cauchy-Schwarz Inequality: Assume the first and the second moments of random variables X, Y exist, then

  $$[E(XY)]^2 \leq E(X^2)E(Y^2)$$

  holds if and only if there is a real number C that $P(Y = CX) = 1$.

- 切比雪夫不等式

  Chebyshev Inequality: For any random variable Y with $Var(Y) < \infty$, we have

  $$P\{|Y - E(Y)| \geq \epsilon\} \leq \frac{Var(Y)}{\epsilon^2},$$

  where ϵ is a positive number.

- 期望向量

  Expectation Vector: In bivariate case, we say $\binom{E(X)}{E(Y)}$ is the expectation vector for a random vector (X, Y).

- 全期望公式

  Double Expectation Formula: For all random variables X and Y, we have

  $$E(X) = E(E(X|Y)).$$

  If Y is discrete, the above formula can be expanded to

  $$E(X) = \sum_y E(X|Y = y)P(Y = y).$$

  If Y is continuous with density $f_Y(y)$, then

  $$E(X) = \int_{-\infty}^{\infty} E(X|Y = y)f_Y(y)dy.$$

- 数学期望(均值)

  Expectation(Mean): The expectation for a random variable Y is defined as

  $$E(Y) = \begin{cases} \sum_y yPr(Y = y), \text{for discrete case,} \\ \int yf_Y(y)dy\text{for continuous case.} \end{cases}$$

  Moreover, the expectation of a function of Y is defined in a similar way.

- 条件方差

  Conditional Variance: Given $Y = y$, the conditional variance of a random variable X is defined as

  $$Var(X|Y = y) = E[(X - E(X|Y = y))^2|Y = y].$$

  Also the condition variance can be calculated in another way, that is

  $$Var(X|Y = y) = E(X^2|Y = y) - (E(X|Y = y))^2.$$

- 条件方差公式

  Conditional Variance Formula: For all random variables X and Y, we have the following relation

  $$Var(X) = E[Var(X|Y)] + Var[E(X|Y)].$$

- 条件期望

  Conditional Expectation: For discrete random variables X, Y, given $Y = y$ the conditional expectation of X is defined as

  $$E(X|Y = y) = \sum_x xP[X = x|Y = y].$$

  If X, Y both are continuous random variables, then the conditional expectation given $Y = y$ is defined as

  $$E(X|Y = y) = \int_{-\infty}^{\infty} xf_{X|Y}(x|y)dy.$$

- 无量纲

  zero dimension: A quantity is non-dimension or dimensionless if it has no units. For example, the correlation coefficient is dimensionless.

- 相关系数

  Correlation Coefficient: For random variable X, Y with $Var(X) > 0 and Var(Y) > 0$, then

  $$\frac{Cov(X, Y)}{\sqrt{Var(X)Var(Y)}}$$

  is the correlation coefficient of X and Y, denoted as ρ or ρ_{xy}.

- 协方差

  Covariance: If random variables X and Y's variance exist, then the covariance of X and Y is defined as

  $$Cov(X, Y) = E[(X - E(X))(Y - E(Y))].$$

  For the case $X = Y$, then $Cov(X, X) = Var(X)$. In practise, the covariance is calculated by

  $$Cov(X, Y) = E(XY) - E(X)E(Y).$$

- 协方差矩阵

  Covariance Matrix: For the multivariate case, we defined the covariance matrix in the form of

  $$\begin{bmatrix} Cov(X_1, X_1) & ... & Cov(X_1, X_n) \\ ... & ... & ... \\ Cov(X_n, X_1) & ... & Cov(X_n, X_n) \end{bmatrix}$$

  .

- 众数

  Mode: Let X be a random variable, then the $mod(X)$ denotes that x makes corresponding probability mass function or probability density function reaches the maximum value.

- 中位数

  Median: Median essentially is the 50 percent quartile.

§2.4 第四章：大数定律与中心极限定理 Chapter Four: Law of Large Numbers and Central Limit Theorem

- 伯努利大数定理
  Bernoulli's Law of Large Numbers: In case of Bernoulli distribution, f_A is the frequency of occurrences of event A in n-times independent experiments, p is the probability of event A in each trial, then for any positive number $\epsilon > 0$, we have
  $$\lim_{n\to\infty} P\{|f_A/n - p| < \epsilon\} = 1.$$
  Bernoulli's Law of Large Numbers is a special case of Khinchine's Law of Large Numbers.

- 大数定理
  Law of Large Numbers: In probability theory, the law of large numbers (LLN) is a theorem that describes the result of performing the same experiment a large number of times. According to the law, the average of the results obtained from a large number of trials should be close to the expected value, and will tend to become closer as more trials are performed. There are several expressions to formularies LLN, among which two most common ways are Khinchine's Law of Large Numbers and Bernoulli's Law of Large Numbers.

- 德莫弗-拉普拉斯中心极限定理
  De Moivre-Laplace's Central Limit Theorem: Let $\{X_1, X_2, ..., X_n\}$ be a sequence of i.i.d random variables and $X_i \sim Bin(1,p)$ for all $i \leq n$, then for any x, $-\infty < x < \infty$, we have
  $$\lim_{n\to\infty} P\left(\frac{\sum_i X_i - np}{\sqrt{np(1-p)}} \leq x\right) = \Phi(x),$$
  where $\Phi(.)$ is the cumulative density function of standard normal distribution.

- 独立同分布
  Independent Identical Distributed (I.I.D.): We say a sequence of random variables are independent identical distributed (i.i.d.) if each random variable has the same probability distribution as the others and all are mutually independent.

- 独立同分布情况下的中心极限定理
  Central Limit Theorem for i.i.d Random Variables: Let $\{X_1, X_2, ...\}$ be a sequence of i.i.d random variables and $E(X_i) = \mu, Var(X_i) = \sigma^2 > 0$, for $i = 1, 2, ...$, then for any x, $-\infty < x < \infty$, we have
  $$\lim_{x\to\infty} P\left(\frac{\sum_i X_i - n\mu}{\sqrt{n}\sigma} \leq x\right) = \Phi(x),$$
  where $\Phi(.)$ is the cumulative distribution function of $N(0,1)$. This central limit theorem is also known as Lindberg-Levy's Central Limit Theorem.

- 极限
  Limits: In mathematics, the concept of a "limit" is used to describe the value that a function or sequence "approaches" as the input or index approaches some value.

- 林德泊格-列维中心极限定理
  Lindberg-Levy's Central Limit Theorem: See 独立同分布情况下的中心极限定理(Central Limit Theorem for i.i.d Random Variables).

- 蒙特卡洛方法
  Monte Carlo Methods: Monte Carlo methods are a class of computational algorithms that rely on repeated random sampling to compute their results.

- 辛钦大数定理
  Khinchine's Law of Large Numbers: A sequence of i.i.d random variables $\{X_1, X_2, ...\}$ have expectation of $E(X_k) = \mu, k = 1, 2, ...$, then for any $\epsilon > 0$ we have
  $$\lim_{n\to\infty} \left\{|\frac{1}{n}\sum_k X_k - \mu| < \epsilon\right\} = 1.$$

- 算数平均值
  Arithmetic Average: The arithmetic average of a sequence of numbers, $\{x_1, x_2, x_3, ..., x_n\}$, is defined as
  $$\frac{\sum_{i=1}^n x_i}{n}.$$

- 中心极限定理
  Central Limit Theorem: The term central limit theorem is a generic name used to designate any theorem that asserts that the sums of large numbers of random variables, after standardization(i.i, subtraction of the mean and division by standard deviation), have approximately a standard normal distribution.

§2.5 第五章：统计量及其分布 Chapter Five: Statistical Quantities and Corresponding Distributions

- 0-1分布
  0-1 Distribution: Refers to 伯努利分布(Bernoulli Distribution).

- 抽样分布
  Sampling Distribution: The distribution of a statistic is called a sampling distribution.

- 次序统计量
  Order Statistic: In statistics, the k-th order statistic of a sample is equal to its k-th smallest value.

- 峰态
  Kurtosis: In probability theory and statistics, kurtosis is a measure of the "peakedness" of the probability distribution of a real-valued random variable,

although some sources are insistent that heavy tails, and not peakedness, is what is really being measured by kurtosis.

- 个体
  Unit: A population consists of units.
- 简单随机抽样
  Simple Random Sampling: If elements in a random sample is independently and identically distributed, the we say such sampling process the simple random sampling. The sample is called i.i.d sample.
- 渐进分布
  Asymptotic Distribution: In mathematics and statistics, an asymptotic distribution is a hypothetical distribution that is in s sense the "limiting" distribution of a sequence of distributions.
- 阶梯函数
  Step Function: In mathematics, a function on the real numbers is called a step function if it can be written as a finite linear combination of indicator functions of intervals.
- 经验分布函数
  Empirical Distribution Function: Let $\{X_1, ..., X_n\}$ be i.i.d real random variables with the common cdf $F(t)$. Then the empirical distribution function is defined as

$$\hat{F}_n(t) = \frac{\text{number of elements in the sample} \leq t}{n}.$$

- 偏态
  Skewness: In probability theory and statistics, skewness is a measure of the asymmetry of the probability distribution of a real-valued random variable. The skewness value can be positive or negative, or even undefined. Qualitatively, a negative skew indicates that the tail on the left side of the probability density function is longer that the right side and the bulk of the values(including the median) lie to the right of the mean.
- 频率
  Relative Frequency: Relative frequency of an event is the normalized ratio of frequency over the total number of events occurred in the experiment or the study.
- 频数
  Frequency: In statistics the frequency of an event is the number of times the event occurred in the experiment or the study.
- 统计量
  Statistic: A statistic, $T = T(X) = T(X_1, ..., X_n)$, is a function of the data which does not depend on any unknown parameter(s). For example, suppose $\{X1, ..., X_n\}$ is a random sample from a distribution. Then the sample mean $\bar{X}$ and the sample variance S^2 are statistics.
- 样本
  Sample: The sample is the set of units actually selected in the investigation.
- 样本方差和标准差
  Sample Variance and Standard Deviation: If the sample data is $\{x_1, x_2, ..., x_n\}$ then the sample variance is given by

$$\sigma_{n-1}^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}.$$

  The sample deviation is defined as $\sigma_{n-1} = \sqrt{\sigma_{n-1}^2}$.
- 样本极差
  Sample Range:Give a sample data, the range of the sample is defined as the *maximum value - minimum value* in the data.
- 样本四分位差
  Sample Interquartile Range: Let $Q1, Q3$ be the 25-th and 75-th quartiles of a sample data accordingly. The difference $Q_3 - Q_1$ is called the interquartile range.
- 样本均值
  Sample Mean: Given a sample data $\{x_1, x_2, ..., x_n\}$, the sample mean is defined by

$$\bar{X} = \frac{\sum_{i=1}^n x_i}{n}.$$

- 样本容量
  Sample Size: The number of units in the sample is called the sample size.
- 样本众数
  Sample Mode: Given a sample data $\{x_1, x_2, ...x_n\}$, the sample mode is the x_i with the highest frequency.
- 样本中位数
  Sample Median: Given a sample data $\{x_1, x_2, ..., x_n\}$, the sample median is x such that

$$number of x_i < x = number of x_i > x.$$

- 正交矩阵
  Orthogonal Matrix: Let M be a n by n matrix, we say M is an orthogonal matrix if

$$M^T M = I,$$

  where I is an identity matrix.
- 总体
  Population: In statistics, population is a set of units in investigation.

§2.6 第六章：参数估计 Chapter Six: Parameter Estimation

- 参数估计
  Parameter Estimation: In statistics, parameter estimation is the process that sample statistics are employed to estimate the population parameters. It includes point estimation and interval estimation.
- 点估计
  Point Estimation: In statistics, point estimation involves the use of sample data to calculate a single value (known as a statistic) which is to serve as a "best guess" for an unknown (fixed or random) population parameter.
- 极大似然估计
  Maximum Likelihood Estimation: Maximum likelihood estimation (MLE) is a popular statistical method used for fitting a statistical model to data, and providing estimates for the model's parameters. To use the method of maximum likelihood, one first specifies the joint density function or joint probability mass function for all observations. For example, in continuous case, we have

$$L(\theta) = f(x_1, x_2, x_3, ..., x_n|\theta),$$

  where θ is a set of unknown parameters for a given distribution $f(.)$, and $\{x_1, x_2, ..., x_n\}$ is the set of sample data. Moreover, $L(\theta)$ is called the likelihood function. The maximum likelihood function estimates for θ, $\hat{\theta}$, is a set of values that maximize $L(\theta)$.
- 似然函数
  Likelihood Function: In statistics, likelihood function for a specific distribution is the joint distribution of a sample data given unknown parameters. For more details, please see 极大似然估计(Maximum Likelihood Estimation).
- 矩估计
  Moment Estimation: In statistics, the method of moments is a method of estimation of population parameters such as mean, variance, median, etc. by equating sample moments with unobservable population moments and then solving those equations for the quantities to be estimated.
  For example, suppose $\{X_1, X_2, ..., X_n\}$ is a sample from an exponentially distributed population, $f(x) = \frac{1}{\theta}e^{-x/\theta}, x > 0$, then the moment estimate of unknown parameter is

$$\begin{aligned} \hat{\theta} &= E(\hat{X}) = \hat{\mu} = \bar{X} \\ &= \frac{X_1 + X_2 + ... + X_n}{n}. \end{aligned}$$

- 均方误差
  Mean Square Error: The mean square error (MSE) of parameter estimator $\hat{\theta}$ with respect to the estimated parameter θ is defined as

$$MSE(\hat{\theta}) = E[(\hat{\theta} - \theta)^2] = Var(\hat{\theta}) + bias^2(\hat{\theta}).$$

- 偏差平方
  Square of Bias: Suppose an unknown parameter θ of a certain distribution has an estimator $\hat{\theta}$, then the square of bias of $\hat{\theta}$ is defined as

$$bias^2(\hat{\theta}) = E[E(\hat{\theta} - \theta)]^2 = [E(\hat{\theta}) - \theta]^2.$$

- 区间估计
  Interval Estimation: In statistics, interval estimation is the use of sample data to calculate an interval of possible values of an unknown population parameter. Suppose θ is a parameter of a population with its parameter space Θ, and $\{X_1, X_2, ..., X_n\}$ is a random sample, then for a given α $(0 < \alpha < 1)$, we have two statistics $\hat{\theta}_L$ and $\hat{\theta}_U$ such that

$$P(\hat{\theta}_L \leq \theta \leq \hat{\theta}_U) \geq 1 - \alpha, \text{for all } \theta \in \Theta.$$

  Then we call $(\hat{\theta}_L, \hat{\theta}_U)$ is the confidence interval for a confidence level $1 - \alpha$, where $\hat{\theta}_L$ is called the lower bound and $\hat{\theta}_U)$ is called the upper bound of the confidence interval.
- 无偏估计
  Unbiased Estimation: Let $\hat{\theta}$ is an estimator of the parameter θ, if

$$E(\hat{\theta}) = \theta, \text{for all} \theta \in \Theta,$$

  where Θ is the parameter space. Then $\hat{\theta}$ is a unbiased estimator of θ.
- 置信区间
  Confidence Interval: For detail, please see 区间估计(interval estimation).
- 置信上限
  Upper Bound of Confidence Interval: For detail, please see 区间估计(interval estimation).
- 置信水平
  Confidence Level: For detail, please see 区间估计(interval estimation).
- 置信下限
  Lower Bound of Confidence Interval: For detail, please see 区间估计(interval estimation).

§2.7 第七章：假设检验 Chapter Seven: Hypothesis Testing

- 单边检验
  One-sided Test: A hypothesis testing with null hypothesis in form of $\theta \leq h$ or $\theta \geq h$ is a one-sided test.

- 备择假设
  Alternative Hypothesis: The complementary hypothesis to null hypothesis is called alternative hypothesis, denoted as H_1.
- 检验统计量
  Test Statistic: In hypothesis testing, a hypothesis is typically specified in terms of a test statistic, which is a function of the sample; it is considered as a numerical summary of a set of data that reduces the data to one or a small number of values that can be used to perform a hypothesis test.
- 假设
  Hypothesis: In hypothesis testing, a hypothesis is a statement that θ belongs to Θ_0 and the statement that θ does not belong to Θ_0 are called hypothesis, where θ is a random variable of a model's parameter and θ belongs to some special subset Θ_0. For example, suppose μ is a parameter of normal distribution $N(\mu, \sigma^2)$, then the statement $\mu = 1$ or $\mu > 4$ are both hypotheses.
- 假设检验
  Hypothesis Testing: A hypothesis test is the use of statistics to determine the probability that a given hypothesis is true. The usual process of hypothesis testing consist of four steps.

  1. Formulate the null hypothesis (H_0) and the alternative hypothesis (H_1).
  2. Identify the test statistic.
  3. Compute the p-value, which is the probability that a test statistic at least as significant as the one observed would be obtained assuming the null hypothesis is true. The small the p-value, the stronger evidence against the null hypothesis.
  4. Compare p-value to a pre-determined significant level. If $p < \alpha$, the null hypothesis is rejected.
- 接受域
  Non-critical Region: In hypothesis testing, the non-critical region is a complementary region to the critical region.
- 拒绝域
  Critical Region: In hypothesis testing, if the p-value corresponding to the test statistic falls into the critical region, the null hypothesis is rejected.
- 临界值
  Critical Value: In hypothesis testing, a critical value is the edge value between the critical region and the non-critical region.
- 拟合优度检验
  Chi-square Goodness of Fit Test: A test of goodness of fit establishes whether or not an observed frequency distribution differs from a theoretical distribution. The test statistic is followed chi-square distribution.
- 双边检验
  Two-sided Test: In hypothesis testing, a test with null hypothesis in form of $\theta = h$ is a two-sided test.
- 显著性水平
  Significance Level: In hypothesis testing, the amount of evidence required to accept that an event is unlikely to have arisen by chance is known as the significance level. The significance level is predetermined, and usually denoted as α.
- 原假设
  Null Hypothesis: In hypothesis testing, a hypothesis with equal signs is a null hypothesis. For example, suppose θ is the parameter of exponential distribution $Exp(\theta)$, then following statements, $\theta = 0.5, \theta \leq 3$, and $\theta \geq 6$, are all null hypothesis, while $\theta \neq 0.5, \theta < 3$, and $\theta > 6$ are not null hypothesis. Usually, null hypothesis is written as H_0.
- 自由度
  Degrees of Freedom: In statistics, the number of degrees of freedom is the number of values in the final calculation of a statistic that are to vary.

§2.8 第八章：常用统计方法 Chapter Eight: Common Statistical Analysis Method

- 回归分析
  Regression Analysis: In statistic, regression analysis includes any techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables.
- 回归模型
  Regression Model: In regression analysis, regression models involve the following variables:

  1. The unknown parameters denoted as βl this may be a scalar or a vector.
  2. The independent variables, X.
  3. the dependent variable, Y.

  A regression model relates Y to a function of X and β

  $$Y \approx f(X, \beta).$$

  The approximation is usually formalized as

  $$E(Y|X) = f(X, \beta).$$

- 回归平方和

  Sum Square of Regression (SSR): In regression analysis, let $\{y_1, y_2, ..., y_n\}$ be a sample of the response random variable, then $\hat{y}_i$ $(i = 1, ..., n)$ is the fitted value by the regression model and $\bar{y}$ is the sample mean. The sum square of regression (SSR) is defined as

  $$SSR = \sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2.$$

- 回归预测

  Regression Forecasting:

- 模型拟合值

  Fitted Value: In regression analysis, the regression model is in form of $Y = f(X, \beta)$, where X and Y are explanatory variable and response variable accordingly, and β is a set of parameters. Then estimates of regression parameters β are essentially a function of observed values, i.e.,$\hat{\beta} = g(X, Y)$. The fitted values of Y is defined as

  $$\hat{Y} = f(X, \hat{\beta}).$$

- 偏差

  Residual: In regression analysis, residuals of the model is defined as

  $$R = Y - \hat{Y},$$

  where Y and $\hat{Y}$ are a sample of response variable and corresponding fitted values.

- 误差平方和

  Sum Square of Error(SSE): In regression analysis, let $\{y_1, y_2, ..., y_n\}$ be a sample of the response random variable, then $\hat{y}_i$ $(i = 1, ..., n)$ is the fitted value by the regression model. The sum square of Error (SSE) is defined as

  $$SSE = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2.$$

- 线性回归

  Linear Regression: In statistic, linear regression is an approach to modeling the relationship between a scalar variable y and one or more variables denoted X. In linear regression, data is modeled using linear functions, and unknown model parameters are estimated from the data. A generalized linear regression model is in form of

  $$Y \sim \beta_0 + \sum_{i=1}^{n} \beta_i X_i.$$

- 因变量

  Response Variable: Also known as the dependent variable.

- 一元回归

  Simple Regression: In linear regression, the simple regression model is defined as

  $$Y \sim \alpha + \beta X.$$

- 自变量

  Explanatory Variable: Also known as the independent variable.

- 总平方和

  Sum Square of Total(SST): In regression analysis, let $\{y_1, y_2, ..., y_n\}$ be a sample of the response random variable, then $\bar{y}$ is the sample mean. The sum square of Error (SST) is defined as

  $$SSE = \sum_{i=1}^{n} (y_i - \bar{y}_i)^2.$$

- 最小二乘估计

  Least Squares Estimation: In regression analysis, the least squares methods finds the regression model parameters β minimize sum of the squared residuals

  $$S = \sum_i r_i^2.$$

  The estimates of parameters using the least squares method is called the least squares estimates.

§2.9 第九章：时间序列分析 Chapter Nine: Time Series Analysis

- **AIC准则**

  AIC Criterion: The Akaike information criterion (AIC) is a measure of the goodness of fit a statistical model. It was developed by Hirotsugu Akaike. In general case, the AIC is

  $$AIC = 2k - 2\ln(L),$$

  where k is the number of parameters in the statistical model, and L is the maximized value of the likelihood function for the estimated model.

- 求和自回归移动模型(**ARIMA**)

  Autoregressive Integrated Moving Average Model: In statistics and econometrics, and in particular in time series analysis, an autoregressive integrated moving average (ARIMA) model is a generalization of an autoregressive moving average (ARMA) model with non-stationarity added.

- 自回归模型(**AR**)

  Autoregressive Model: In statistics, an autoregressive (AR) model is a type of random process which is often used to predict various types of natural and social phenomena. The notation $AR(p)$ refers to the autoregressive model of order p. The $AR(p)$ model is defined as

  $$X_t = c + \sum_{i=1}^{p} \varphi_i X_{t-i} + \epsilon_t,$$

  where $\varphi_1, ..., \varphi_p$ are the parameters of the model, c is a constant and ϵ is the white noise.

- 白噪音
White Noise: A random vector W is a white noise vector if and only if its mean vector and autocorrelation matrix are the following:
$$\begin{aligned} \mu_w &= E(w) = 0 \\ R_{ww} &= E(ww^T) = \sigma^2 I \end{aligned}$$
where I is the identity matrix.

- 残差平方和
Sum Squares of Residual Errors: In time series study, the sum squares of residual errors is defined as
$$\sum_{i=1}^{n} \epsilon_t^2,$$
where ϵ_t is the residual error at Time t.

- 残差项
Residual Errors: In ARIMA process, let $\tilde{\beta}$ be the set of parameters and $F_t(\tilde{\beta})$ be the fitted value at Time t using ARIMA model. Then the residual error at Time t is defined as
$$\epsilon_t = x_t - F_t(\tilde{\beta}),$$
where x_t is the observed value at Time t.

- 复根
Complex Roots

- LB检验统计量
Ljung-Box Test Statistic: The Ljung-Box test is a type of statistical test of whether any of a group of autocorrelations of a time series are different from zero. Instead of testing randomness at each distinct lag, it tests the "overall" randomness based on a number of lags, and is therefore a portmanteau test.
The hypothesis can be defined as follows:
  - H_0: The data is random.
  - H_1: The data is not random.

  The test statistic is
$$Q = n(n+2)\sum_{k=1}^{h} \frac{\hat{\rho}_k^2}{n-k},$$
where n is the sample size, $\hat{\rho}_k$ is the sample autocorrelation at lag k, and h is the number of lags being tested.

- 移动平均模型(MA)
Moving Average Model (MA): In time series analysis, the moving average (MA) model is a common approach for modeling univariate time series models. The notation $MA(q)$ refers to the moving average model of order q.
$$X_t = \mu + \epsilon_t + \theta_1 \epsilon_{t-1} + \theta_q \epsilon_{t-q},$$
where μ is the mean of the series, the $\theta_1, ..., \theta_q$ are parameters of the model, and $\epsilon_t, \epsilon_{t-1}, ...$ are white noise terms.

- 拟和模型
Fitted Model

- 平稳时间序列
Stationary Time Series: For a series of random variables $\{X_t\}$, if it satisfies following three conditions, then $\{X_t\}$ is stationary.
  1. For any $t \in T$, $E(X_t) = \mu$, where μ is a constant;
  2. For any $t \in T$, $E(X_t^2) < \infty$;
  3. For any $t, s, k \in T$, and $k + s - t \in T$, $\gamma(t, s) = \gamma(k, k+s-t)$, where $\gamma(t, s)$ is the autocovariance function of $\{X_t\}$.

  If the series does not satisfy any above condition, it is the non-stationary time series.

- SBC准则
SBC Criteria: In statistic, the Baysian information criterion (BIC) is a criterion for model selection among a class of parametric models with different numbers of parameters. The formula for the BIC is
$$-2 \cdot \ln(L) + k \ln(n),$$
where L is the maximized value of the likelihood function for the estimated model, k is the number of parameters to be estimated, and n is the number of observations.

- 实根
Real Roots

- 时间序列
Time Series: In statistics, a sequence of random variables in time order
$$..., X_1, X_2, ..., X_t, ...$$
are called the time series of a random event, denoted as $\{X_t, t \in T\}$ or $\{X_t\}$.

- 随机游走
Random Walk: In ARIMA process, ARIMA(0,1,0) model is formulated as
$$\begin{cases} x_t = x_{t-1} + \epsilon_t \\ E(\epsilon_t) = 0, Var(\epsilon_t) = \sigma_\epsilon^2, E(\epsilon_t \epsilon_s) = 0, s \neq t \\ E(x_t \epsilon_t) = 0, \text{ for all } s < t \end{cases}.$$
This model is also called Random Walk model.

- 自相关系数
Autocorrelation Coefficient: Refer to 自协方差函数(Autocovariance).

- 自协方差函数

  Autocovariance Function: Given a stationary time series $\{X_t, t \in T\}$, for any $t, t+k \in T$, the autocovariance function with Lag k, $\gamma(k)$, is defined as

  $$\gamma(k) = \gamma(t, t+k).$$

  Also we can extend autocovariance function to the concept of autocorrelation coefficient, which takes the form of

  $$\rho_k = \frac{\gamma(k)}{\gamma(0)}.$$

- 偏自相关系数

  Partial Correlation Coefficient: In time series study, the partial correlation coefficient with lag k is defined as

  $$\rho_{x_t, x_{t-k}} = \frac{E[(x_t - \hat{Ex_t})(x_{t-k} - \hat{Ex_{t-k}})]}{E[(x_{t-k} - \hat{Ex_{t-k}}},$$

  where $\hat{Ex_t} = E[x_t|x_{t-1}, ..., x_{t-k+1}]$, and $\hat{Ex_{t-k}} = E[x_{t-k}|x_{t-1}, ..., x_{t-k+1}]$.

- 余弦

  Cosine

- 正弦

  Sine

- 指数平滑

  Exponential Smoothing: Exponential smoothing is a technique that can be applied to time series data. When the sequence of observations $\{x_0, x_1, ...,\}$ begins at time $t = 0$, the simplest form of exponential smoothing is given by the formulas

  $$\begin{aligned} s_1 &= x_0 \\ s_t &= \alpha x_{t-1} + (1-\alpha)s_{t-1}, t > 1 \end{aligned}$$

  where α is the smoothing factor, and $0 < \alpha < 1$.

- 自回归移动平均模型（**ARMA**）

  Auto Regression Moving Average Model (ARMA): In time series study, autoregressive moving average models are typically applied to autocorrelated time series data. The notation $ARMA(p, q)$ refers to the model with p autoregressive terms and q moving average terms. This model contains the $AR(p)$ and $MA(q)$ models,

  $$X_t = c + \epsilon_t + \sum_{i=1}^{p} \varphi_i X_{t-i} + \sum_{i=1}^{q} \theta_i \epsilon_{t-i},$$

  where ϵ_t is a white noise.

§2.10 第十章：随机过程的基本概念和基本类型 Chapter Ten: Fundamental Concepts and Classification of Stochastic Processes

- 布朗运动

  Brownian Motion: In mathematics, Brownian motion is described by the Wiener process, a continuous-time stochastic process. The Brownian motion B_t us characterized by three facts:

  1. $B_0 = 0$
  2. B_t is almost surely continuous
  3. B_t has independent increment with distribution $W_t - W_s \sim N(0, t-s)$ for $0 \leq s \leq t$.

- 点过程

  Counting Process: Counting process is a stochastic process $\{N(t)\}_{t \geq 0}$ that possesses the following properties:

  1. $N(t) \geq 0$
  2. $N(t)$ is an integer
  3. if $s \leq t$, then $N(s) \leq N(t)$.

  Poisson process is an example of counting process.

- 独立增量过程

  Independent Increment Process

- 更新过程

  Renewal Process: Let $R_1, R_2, ...$ be a sequence of positive i.i.d random variables such that

  $$0 < E[S_i] < \infty.$$

  We refer to the random variable S_i as the "i-th" holding time. Define for each $n > 0$:

  $$J_n = \sum_{i=1}^{n} S_i,$$

  each J_n referred to as the "n-th" jump time and the intervals $[J_n, J_{n+1}]$ being called renewal intervals. Then the random variable $\{X_t\}_{t \geq 0}$ given by

  $$X_t = \sum_{n=1}^{\infty} 1_{\{J_n \leq t\}} = \sup\{n : J_n \leq t\}$$

  is called a renewal process.

- 宽平稳过程

  Weak Stationary Process: A continuous-time random process X_t which is weak stationary process has the following restrictions on its mean function

  $$EX_t = m_x(t) = m_x(t+\tau), \text{for all} \tau \in \mathbb{R}$$

  and autocorrelation function

  $$\begin{aligned} E[X_{t_1} X_{t_2}] &= R_x(t_1, t_2) = R_x(t_1 + \tau, t_2 + \tau) \\ &= R_x(t_1 - t_2, 0) \text{for all} \tau \in \mathbb{R}. \end{aligned}$$

- 马尔可夫过程

  Markov Process: Let $\{X_t\}_{t\geq 0}$ be a set of stochastic random variables, then the process is called Markov process if the condition

$$\begin{aligned} Pr[X_t &= x_t|X_s = x_s, X_{p_1} = x_{p_1}, X_{p_2} = x_{p_2}, ...] \\ &= Pr[X_t = x_t|X_s = x_s] \end{aligned}$$

  holds for all $t > s > p_1 > p_2 > ....$

- 随机过程

  Random Process: In probability theory, a stochastic process, or sometimes random process, is the counterpart to a deterministic process (or deterministic system). Instead of dealing with only one possible reality of how the process might evolve under time, in a stochastic or random process there is some indeterminacy in its future evolution described by probability distributions. This means that even if the initial condition (or starting point) is known, there are many possibilities the process might go to, but some paths may be more probable and others less so.

- 随机游动

  Random Walks: In stochastic process, the random walk is the most elementary process. Let $\{X_t\}$ be a time series of mutually independent random variables, then the process is called random walks if

$$S_t = X_1 + X_2 + ... + X_t.$$

- 鞅

  Martingale: A discrete-time martingale is a discrete-time stochastic process $\{X_t\}_{t\geq 0}$ that satisfies for all n

$$E(X_{n+1}|X_1, X_2, ..., X_n) = X_n.$$

  And a continuous-time martingale is a stochastic process such that for all t

$$E(X_t|\{X_\tau, \tau < s\}) = X_s, \text{for all} s < t.$$

- 严平稳过程

  Strong Stationary Process: In the mathematical sciences, a stationary process (or strong stationary process) is a stochastic process whose joint probability distribution does not change when shifted in time or space. Formally, let $\{X_t\}$ be a stochastic process and let $F_X(x_{t_1+\tau}, ..., x_{t_k+\tau})$ represent the cumulative distribution function of joint distribution of $\{X_t\}$ at times $t_1+\tau, ..., t_k+\tau$. Then $\{X_t\}$ is a strong stationary process if for all k, τ and t_i,

$$F_X(x_{t_1+\tau}, ..., x_{t_k+\tau}) = F_X(t_1, ..., t_k).$$

  So $F_X(.)$ is not a function of time.

§2.11 第十一章：几种常用的随机过程 Chapter Eleven: Several Widely-used Stochastic Process

- 泊松过程

  Poisson Process: Poisson process is a continuous-time counting process$\{N_t\}_{t\geq 0}$ that possesses the following properties:

  - $N_0 = 0$
  - Independent increments(the numbers of occurrences counted in disjoint intervals are independent from each other)
  - Stationary increments(the probability distribution of the number of occurrences counted in any time interval only depends on the length of the interval)
  - No counted occurrences are simultaneous.

  Poisson process includes homogeneous Poisson process, non-homogeneous Poisson process, compound Poisson process, and conditional Poisson process.

- 布朗桥

  Brownian Bridge: Brownian bridge is a continuous-time stochastic process built on Brownian motion. Suppose $\{B_t\}_{t\geq 0}$ is a Brownian motion, let

$$B_t^* = B_t - tB_1, 0 \leq t \leq 1,$$

  then $\{B_t^*\}_{0\leq t\leq 1}$ is called Brownian bridge.

- 常返态

  Recurrent State: If a state i is not transient, then it is said to be recurrent.

- **Chapman-Kolmogorov 方程**

  Chapman-Kolmogorov Equation: Let $P_{ab}^{(c)}$ be c-step transition probability from State a to State b, then Chapman-Kolmogorov equation is defined as

  1. $P_{ij}^{(m+n)} = \sum_{k\in S} P_{ik}^{(m)} P_{kj}^{(n)}$;
  2. $P^{(n)} = P \cdot P^{(n-1)} = P \cdot P \cdot P^{(n-2)} = ... = P^n$,

  for all $n, m \geq 0$, $i, j \in S$, where S is the set of states.

- 非齐次泊松过程

  Non-homogenous Poisson Process: In Poisson process, if the rate parameter for event arriving may change over time, we call such a Poisson process non-homogeneous Poisson process.

- 复合泊松过程

  Compound Poisson Process:A compound Poisson process with rate $\lambda > 0$ and jump size distribution G is a continuous-time stochastic process $\{Y_t\}_{t\geq 0}$ given by

$$Y_t = \sum_{i=1}^{N_t} X_i$$

where $\{N_t\}_{t\geq 0}$ is a Poisson process with rate λ, and $\{X_i\}_{i\geq 1}$ are i.i.d random variables with distribution function G, which are also independent of $\{N_t\}_{t\geq 0}$.

- 高斯过程
  Gaussian Process: In probability theory and statistics, a Gaussian process is a stochastic process whose realizations consist of random values associated with every point in a range of times such that random variables has a normal distribution.
- 更新方程
  Renewal Equation: The renewal equation satisfies
  $$K(t) = H(t) + \int_0^t k(t-s)dF(s),$$
  where $H(t)$ and $F(t)$ are known, and $H(t), F(t)$ equal 0 if and only if $t < 0$.
- 更新回报过程
  Renewal-reward Process: Let $W_1, W_2, ...$ be a sequence of i.i.d random variables satisfying
  $$E|W_i| < \infty.$$
  Then the random variable
  $$Y_t = \sum_{i=1}^{X_t} W_i$$
  is called a renewal-reward process. Note each W_i may take negative values as well as positive values.
- 马尔可夫链
  Markov Chain: A Markov chain is a sequence of random variable $X_1, X_2, X_3, ...$ with the Markov property, namely that, given the present state, the future and past states are independent. Formally,
  $$\begin{aligned} & Pr(X_{n+1} = x|X_1 = x_1, ..., X_n = x_n) \\ = \quad & Pr(X_{n+1}|X_n = x_n). \end{aligned}$$
- 时齐马尔可夫链
  Homogeneous Markov Chain: If the transition probability of a Markov chain $P\{X_{n+1} = j|X_n = i\}$ only relates to State i, j not n, then we call such a Markov chain the homogeneous Markov chain.
- 瞬态
  Transient State: A state i is said to be transient if, given that we start in state i, there is non-zero probability that we will never return to i.
- 条件泊松过程
  Conditional Poisson Process: Let $\Lambda > 0$ be a random variable, under the condition $\Lambda = \lambda$, the counting process $\{N_t\}_{t\geq 0}$ is a process process with parameter λ, then such a counting process is called conditional Poisson process.
- **Wald** 等式
  Wald's Equation: In probability theory, Wald's equation is an important identity that simplifies the calculation of the expected value of the sum of a random number of random quantities.
  Suppose $E(X_i) < \infty, i = 1, 2, ...$, then
  $$E(T_{N(t)+1}) = E(X_1 + ... + X_{N(t)+1}) = E(X_1)E[N(t)+1].$$
- 转移概率
  Transition Probability: In Markov process, the conditional probabilities associated with various state-changes are called transition probabilities.

§2.12 第十二章：随机微积分

Chapter Twelve: Stochastic Calculus

- 二次变差
  Quadratic Variation: Let $\{X_t\}_{t\geq 0}$ be a stochastic process, its quadratic variation at t is defined as
  $$\lim_{n\to\infty} \sum_{k=1}^{n} (X_{t_k} - X_{t_{k-1}})^2,$$
  where n is the number of partitions in time interval $[0, t]$.
- **Fubini** 定理
  Fubini's Theorem: In mathematical analysis Fubini's theorem is a result which gives conditions under which it is possible to compute a double integral using iterated integrals. Suppose A and B are complete measure spaces. Suppose $f(x, y)$ is $A \times B$ measurable. If
  $$\int_{A\times B} |f(x,y)| d(x,y) < \infty,$$
  where the integral is taken with respect to a product measure on the space over $A \times B$, then
  $$\begin{aligned} \int_A \left(\int_B f(x,y)dy \right) dx &= \int_B \left(\int_A f(x,y)dx \right) dy \\ &= \int_{A\times B} f(x,y)d(x,y). \end{aligned}$$
- 随机微积分
  Stochastic Calculus: Stochastic calculus is a branch of mathematics that operates on stochastic processes.
- 伊藤公式
  Ito's Lemma: Ito's lemma is the version of the chain rule or change of variables formula which applies to the Ito's integral. Let $Y(t) = f(t, S(t))$, then
  $$\begin{aligned} dY(t) &= f_t(t, S(t))dt + f_S(t, S(t))dS(t) \\ &+ \frac{1}{2} f_{SS}(t, S(t))(dS(t))^2 \end{aligned}$$
- 伊藤积分
  Ito Calculus: Ito calculus extends the methods of calculus to stochastic processes such as Brownian motion. The usual notation for the Ito stochastic integral is:
  $$Y_t = \int_0^t H_s dX_s = \lim_{n\to\infty} \sum_{[t_{i-1}, t_i]\in\pi_n} H_{t_{i-1}}(X_{t_i} - X_{t_{i-1}})$$
  where π_n is a sequence of partitions of $[0, t]$ with mesh going to zero and X_t is a Brownian motion.

A3 Manual

§3 A3 Manual

§3.1 第一章：绪论 Chapter One: Introduction

This chapter contains reading materials, and most of technique terms can be found in previous context.

§3.2 第二章：生存分析的基本函数及生存模型 Chapter Two: Basic Functions of Survival Analysis and Survival Models

- 伴随变量
  Adjoint Random Variable

- 初始事件
  Initial Event: The event or status at the beginning of the period $t = 0$ is called the initial event.

- 独立终止率
  Independent Rate of Decrement: In associated single decrement model, ${}_tq_x^{\prime(j)}$ is called independent rate of decrement, because cause j does not complete with other causes in determining ${}_tq_x^{\prime(j)}$. It is also named as net probability of decrement and absolute rate of decrement.

- **Gompertz分布**
  Gompertz Distribution: In survival analysis and mortality modeling, Gompertz distribution for hazard rate is defined as

$$h(x) = Bc^x, x \geq 0, B > 0, c > 1.$$

  with survival function

$$S(x) = \exp(\frac{B}{\ln c}(1 - c^x)).$$

- 伽玛函数
  Gamma Function: Gamma function is an important function in mathematics, which is defined in integral form

$$\Gamma(z) = \int_0^\infty t^{z-1}e^{-t}dt.$$

  If z is a positive integer, gamma function also can be simplified as

$$\Gamma(z) = (z - 1)!.$$

- 截尾分布
  Mean Excess Loss Distribution: Mean excess loss random variable is defined as $X|X > y$, and its corresponding distribution is called the mean excess loss distribution.

- 联合单减因模型
  Associated Single Decrement Model: In mortality study, we define the associated single decrement model functions as follows:

$$\begin{aligned} {}_tp_x^{\prime(j)} &= \exp\left[-\int_0^t \mu_x^{(j)}(s)ds\right], \\ {}_tq_x^{\prime(j)} &= = 1 -_t p_x^{\prime(j)}. \end{aligned}$$

- **Makeham分布**
  Makeham Distribution: Makeham's law is proposed to improve Gompertz's model, which encounters a systematic underestimation for mortality curve in older ages. Makeham's distribution assumes the hazard rates for different ages have independent parts to ages; therefore, an additional age-independent constant is added to Gompertz's distribution.

$$h(x) = A + Bc^x,$$

  and its survival function is

$$S(x) = \exp\left(\frac{B}{\ln c}(1 - c^x) - Ax\right).$$

- 生存模型
  Survival Model: Models employed in survival analysis to study survival random variables are called survival models.

- 生存分析
  Survival Analysis: Survival analysis is a branch of statistics which deals with death in biological organisms and failure in mechanical system.

- 生存时间随机变量
  Survival Time Random Variable: In survival analysis, we are interested in the time of an individual or a group terminating a status or an event since beginning, and the associated random variable is called survival time random variable, usually denote as T.

- 韦伯分布
  Weibull Distribution: Weibull distribution is a continuous-time distribution with density function in form of

$$f(x) = \frac{k}{\lambda}\left(\frac{x}{\lambda}\right)^{k-1} e^{-(x/\lambda)^k}, x \geq 0$$

  where $\lambda > 0$ is the scale parameter and $k > 0$ is the shape parameter.

- 未来生命随机变量
  Future Lifetime Random Variable: Let T_x be the length of time till death of an Age (x), then we call T_x the future lifetime random variable for an Age (x).

- 危险率函数
  Hazard Rate Function: Let T be a lifetime random variable and $S(T)$ be the corresponding Survival

distribution function, then the hazard rate is defined as

$$h(t) = \frac{-S(t)'}{S(t)} = \frac{f(t)}{S(t)}$$

where $f(t)$ is the density function of T.

- 续存函数
  Remaining Function: In multiple decrement modeling, the probability function of Age (x) survives for t years is called the remaining function and denoted as ${}_tp_x^{(\tau)}$.
- （指数分布的）无记忆性
  Memoryless Property (of Exponential Distribution): If X is an exponential random variable, then it has memoryless property, i.e.,

$$P(X > x + y|X > x) = P(X > y).$$

- 中心死亡率
  Central Death Rate: Central death rate is a measure of death rate within a age interval $(x, x+n]$, which is in form of

$${}_nM_x = \frac{\int_x^{x+n} S(y)h(y)dy}{\int_x^{x+n} S(y)dy},$$

  where $h(.)$ and $S(.)$ are density function and survival function accordingly.
- 主要变量
  Primary Random Variable

§3.3 第三章：生命表 Chapter Three: Life Tables

- Balducci假设
  Balducci's Assumption: Under Balducci's Assumption, survival function in fractional age interval has following property

$$\frac{1}{S(x+t)} = \frac{1-t}{S(x)} + \frac{t}{S(x+1)}, 0 < t < 1$$

  where $S(x)$ is the survival function at age x.
- 死亡力恒定假设
  Constant Force of Mortality Assumption: In mortality modeling and survival analysis, the constant force of mortality (CFM) assumes mortality rates unchange in fractional age, that is,

$$\ln S(x+t) = (1-t)\ln S(t) + t\ln S(x+1), 0 < t < 1$$

  or equivalently

$$S(x+t) = S(x)^{1-t} \cdot S(x+1)^t, 0 < t < 1.$$

- 死亡时间均匀分布假设
  Uniform Distribution at Deaths Assumption: In mortality modeling and survival analysis, uniform distribution at deaths (UDD) assumption assumes the death time in a unit interval $(x, x+1]$ is uniformly distributed. In this case, the survival function is a linear function

$$S(x+t) = (1-t)S(x) + tS(x+1), 0 < t < 1,$$

  leading to

$${}_tp_x = 1 - tq_x$$

  and

$${}_{s|t}q_x = tq_x.$$

- 选择期
  Select Period: In life contingency study, an individual who enters the group at, say, age x, is said to be selected, or just select, at age x. The period d after which the age at selection has no effect on future survival probabilities is called select period for the model. The mortality that applies to lives after the select period is complete is called the ultimate mortality.
- 选择生命表
  Select Life Table: A life table only containing information of insurers in select period is called the select life table.
- 选择－终极生命表
  Select-Ultimate Life Table: A select-ultimate life table contains the death and survival information of insurers in select period as well as thereafter.
- 终极生命表
  Ultimate Life Table: A life table only with survival information after select period is a ultimate life table.

§3.4 第四章：理赔额和理赔次数的分布 Chapter Four: Distributions of Claim Amounts and Frequencies

- (a,b,0)类分布
  (a,b,0) Class of Distributions: In probability theory, the distribution of a discrete random variable N is said to be a member of the (a, b, 0) class of distributions if its probability mass function obeys

$$\frac{p_k}{p_{k-1}} = a + \frac{b}{k}, k = 1, 2, 3, ...$$

  where $p_k = Pr(N = k)$.
- (a,b,1)类分布
  (a,b,1) Class of Distributions: Let p_k be the probability function of a discrete random variable. It is a member of the (a,b,1) class of distributions provided that there exists constants a and b such that

$$\frac{p_k}{p_{k-1}} = a + \frac{b}{k}, k = 2, 3, 4, ...$$

  Note that the only difference from the (a,b,0) class is that the recursion begins at p_1 rather than p_0.

- **(a,b,k)分布**
  (a,b,k) Class of Distribution：Let p_i be the probability function of a discrete random variable. It is a member of the (a,b,k) class of distributions provided that there exists constants a and b such that
  $$\frac{p_i}{p_{i-1}} = a + \frac{b}{i}, i = k+1, k+2, k+3, ...$$
  Note (a,b,k) class of distributions start recursion at p_k.

- **保单限额**
  Policy Limit: The opposite of a deductible is a policy limit. The typical policy limit arises in a contract where for losses below u the insurance pays the full loss, but for losses above u the insurance pays for u.

- **比列赔付**
  Coinsurance: In this case the insurance company pays a proportion, α, of the loss and the policyholder pays the remaining fraction.

- **柏松－逆高斯分布**
  Poisson-Inverse Gaussian Distribution:

- **对数正态分布**
  Log-normal Distribution: In probability theory, a log-normal distribution is a probability distribution of a random variable whose logarithm is normally distributed. If X is a random variable with a normal distribution, then $Y = \exp(X)$ has a log-normal distribution; likewise, if Y is log-normally distributed, then $X = \log(Y)$ is normally distributed. Formally, Y has probability density function
  $$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{(\ln x - \mu)^2}{2\sigma^2}},$$
  where μ and σ are parameters.

- **多项分布**
  Multinomial Distribution: In probability theory, the multinomial distribution is a generalization of the binomial distribution. The binomial distribution is the probability distribution of the number of "successes" in n independent Bernoulli trials, with the same probability of "success" on each trial. The probability mass function of multinomial distribution is
  $$f(x_1, ..., x_k) = Pr(X_1 = x_1, ..., \text{AND } X_k = x_k)$$
  $$= \begin{cases} \frac{n!}{x_1!...x_k!} p_1^{x_1}..p_k^{x_k}, \text{when } \sum_{i=1}^k x_i = n \\ 0, \text{ Otherwise} \end{cases}.$$
  for non-negative integers $x_1, ..., x_k$.

- **负二项分布**
  Negative Binomial: In probability theory and statistics, a discrete random variable N said to have negative binomial distribution, $N \sim NB(r,p)$ if its probability mass function takes the form
  $$p_k = Pr(N = k) = \binom{r+k-1}{k} p^r (1-p)^k$$
  where $0 < p < 1$ and $k \in \mathbb{N}$ are parameters.

- **复合随机变量**
  Compounded Random Variable: In aggregate claim process, let
  $$S = X_1 + X_2 + ... + X_N$$
  where X_is are i.i.d claim amount random variables and N is claim frequency random variable. Then S is the compound random variable.

- **概率母函数**
  Probability Generating Function: Suppose a discrete random variable N has the probability distribution $p_k = Pr(N = k), k = 0, 1, 2, ...$, then its probability generating function is defined as
  $$P_N(t) = E(t^k) = \sum_{k=0}^{\infty} p_k t^k.$$

- **混合柏松分布**
  Mixed Poisson Distribution: In Poisson distribution, if the poisson rate, Λ is a density function $u(\lambda)$ instead of deterministic value, then such a distribution is called mixed Poisson distribution/ Formally,
  $$P(N = k) = \int_0^{\infty} \frac{e^{-\lambda}\lambda^k}{k!} u(\lambda) d\lambda, k = 0, 1, 2, ...$$

- **矩母函数**
  Moment Generating Function: In probability theory and statistics, the moment-generating function of any random variable is an alternative definition of its probability distribution. The definition of moment generating function is as follows
  $$M_X(t) = E(e^{tX}), t \in \mathbb{R}$$
  whenever this expectation exists.

- **零点截断分布**
  Zero-truncated Distribution:In (a,b,1) class of distributions, if $p_0 = 0$, then this distribution is also called zero-truncated distribution. It is can be viewed as a mixture of a truncated distribution and a degenerate distribution with all the probability at zero.

- **零点修正分布**
  Zero-modified Distribution: In (a,b,1) class of distributions, zero-modified distribution has probability at zero $p_0 > 0$.

- **理赔额**
  Claim Amount

- 免赔额

  Deductible: Insurance policies are often sold with a per-loss deductible of d. When the loss x, is at or below d, the insurance pays nothing. When the loss is above d, the insurance pays $x-d$.

- 帕累托分布

  Pareto Distribution: A continuous random variable X is said to have Pareto distribution if its probability density function obeys

  $$f(x)=\frac{\alpha\theta^{\alpha}}{(x+\theta)^{\alpha+1}}, x>0, \alpha>0, \theta>0$$

  and denote as $X \sim Pareto(\alpha,\theta)$.

- 损失额

  Loss Amount

- 右截断

  Right Truncation: An observation is right truncated at u if when it is above u it is not recorded, but when it is below u it is recorded at its observed value.

- 右删失

  Right Censoring: An observation is right censored at u if when it is above u it is recorded as being equal to u, but when it is below u it is recorded at its observed value.

- 有限期望函数

  Limited Expected Function: For a random variable X and a pre-determined real number u, the limited loss variable is defined as

  $$Y=X\bigwedge u=\begin{cases}X, X<u\\ u, X\geq u\end{cases}$$

  Then its expected value,

  $$E(X\bigwedge u)=\int_{\infty}^{u}xf(x)dx+u[1-F(u)]$$

  is called the limited expected function.

- 左截断

  Left Truncation: An observation is left truncated at d if when it is below d it is not recorded, but when it is above d it is recorded at its observed value.

- 左删失

  Left Censoring: An observation is left censored at d if when it is below d it is recorded as being equal to d, but when it is above d it is recorded as its observed value.

§3.5 第五章：短期个体风险模型 Chapter Five: Short-term Individual Risk Model

- 贝努里分布

  Bernoulli Distribution: Refer to 0-1分布（0-1 Distribution).

- 个体风险模型

  Individual Risk Model: The individual risk model represents the aggregate loss as a sum, $S=X_1+...+X_n$, of a fixed number, n, of insurance contracts. The loss amounts for the n contracts are $(X_1,X_2,...,X_n)$, where the X_js are assumed to be independent but are not assumed to be identically distributed. The distribution of the X_js usually has a probability mass at zero, corresponding to the probability of no loss or payment.

- 林德贝格条件

  Lindeberg's Condition: In probability theory, Lindeberg's condition is a sufficient condition for the central limit theorem to hold for a sequence of independent random variables. Suppose $X_1,X_2,...,X_n$ are sequence of independent random variables with $E(X_k)=\mu_k$, $Var(X_k)=\sigma_k^2$, and $F_k(x)$ is the distribution function. Also, let $s_n^2=\sum_{k=1}^{n}\sigma_k^2$. If this sequence satisfies the Lindeberg's condition:

  $$\lim_{n\to\infty}\frac{1}{s_n^2}\sum_{k=1}^{n}\int_{\{|X_k-\mu_k|>\epsilon S_n\}}(X_k-\mu_k)^2dF_k(x),$$

  for all $\epsilon>0$, then the central limit theorem holds.

§3.6 第六章：短期聚合风险模型 Chapter Six: Short-term Aggregate Risk Model

- 比例再保险

  Proportional Reinsurance: Proportional reinsurance involves one or more reinsurers taking a stated percent share of each policy that an insurer produces. This means that the reinsurer will receive that stated percentage of each dollar of premiums and will pay the percentage of each dollar of losses.

- 复合柏松模型

  Compound Poisson Model: Refer to 复合柏松过程(Compound Poisson Process).

- 复合负二项分布

  Compound Negative Binomial Distribution: In aggregate claim process, if the claim frequency employs negative binomial distribution, then the aggregate claim random variable follows the compound negative binomial distribution.

- 聚合理赔量

  Aggregate Claim Random Variable: In insurance risk study, the sum of i.i.d claim amount random variables X_is

  $$S=\sum_{i=1}^{N}X_i$$

  is the aggregate claim random variable, where N is the claim frequency random variable.

- 理赔次数变量
Claim Frequency Random Variable: Let $N \in \mathbb{N}$ which satisfies $P(N = 0) > 0$ represent the number of claims generated by insurance policies, then N is called the claim frequency random variable.

- 理赔额变量
Claim Amount Random Variable: Let $\{N(t)\}_{t\geq 0}$ be the claim number process. For a determined $N(t) = n > 0$, we have a sequence of random variables $X_i, i = 1, 2, ..., n$ representing the i-th claim amount, and we call such random variables claim amount random variables.

- 平移伽玛分布
Horizontally-shifted Gamma Distribution: Let $Gamma(x; \alpha, \beta)$ be the cumulated density function of Gamma random variable X with parameters α and β. Then the horizontally-shifted Gamma distribution is defined as

$$H(x; \alpha, \beta, x_0) = Gamma(x - x_0; \alpha, \beta), x \geq x_0.$$

The new distribution shifts the original distribution horizontally by x_0 units.

- 限额损失再保险
Stop-loss Reinsurance: Stop loss is a nonproportional type of reinsurance and works similarly to excess-of-loss reinsurance. While excess-of-loss is related to single loss amounts, either per risk or per event, stop-loss covers are related to the total amount of claims X in a year.

§3.7 第七章：破产模型 Chapter Seven: Ruin Model

:

- 柏松盈余过程
Poisson Surplus Process: Poisson surplus process is defined as

$$U(t) = u + ct - S(t), t \geq 0$$

where

1. u is the initial surplus, and $u \geq 0$;
2. $\{S(t), t \geq 0\}$ is a compounded Poisson process with Poisson parameter λ, and claim amount random variable $X \sim F(x)$;
3. and c is the premium rate.

- 初始盈余
Initial Surplus: In surplus process, the surplus at time t is denoted as $U(t), t > 0$. The initial surplus then is defined as $U(0)$ and simply written as u.

- 带漂移的布朗运动
Brownian Motion with Drift: The Brownian motion with a drift $\{W(t), t \geq 0\}$ is defined as follows:

1. $W(0) = 0$;
2. $\{W(t), t \geq 0\}$ has independent and stationary increments;
3. For any $t > 0$, $W(t) \sim N(\mu t, \sigma^2 t)$, where $\mu \geq 0$.

- 等待时间变量
Waiting-time Random Variable: In a counting process, the time difference between two events is called the waiting-time random variable.

- 复合柏松过程
Compound Poisson Process: Let the number of claim process $\{N_t : t \geq 0\}$ be a Poisson process with rate λ. let the individual losses $\{X_1, X_2, ...\}$ be independent and identically distributed positive random variables, independent of N_t, each with cumulative distribution function $F(x)$ and mean $\mu < \infty$. Thus X_j is the amount of the jth loss. Let S_t be the total loss in $(0, t]$. It is given by $S_t = 0$ if $N_t = 0$ and $S_t = \sum_{j=1}^{N_t} X_j$ if $N_t > 0$. Then, for fixed t, S_t has a compound Poisson distribution. The process $\{S_t : t \geq 0\}$ is said to be a compound Poisson process. Because $\{N_t : t \geq 0\}$ has stationary and independent increments, so does $\{S_t : t \geq 0\}$. Also,

$$E(S_t) = E(N_t)E(X_j) = (\lambda t)(\mu) = \lambda \mu t.$$

- 负债
Liability

- 计数随机过程
Counting Process: Refer to 计数过程(Counting Process).

- 理赔次数过程
Claim Number Process: Let $N(t) \in \mathbb{N}$ represent the aggregate claim numbers in time interval $[0, t]$, and $N(0) = 0$, then we call $\{N(t)\}_{t\geq 0}$ the claim amount process.

- lundberg系数（调节系数）
Lundberg Coefficient (Adjust Coefficient): For the Poisson surplus process, the non-negative root R satisfying the following equation

$$\lambda + cr = \lambda M_X(r)$$

is the adjust coefficient.

- 破产时刻
Ruin Time: In a surplus process, the ruin time T is the time surplus revealing a negative value. Mathematically,

$$T = \inf\{t, t \geq 0, U(t) < 0\}$$

where $U(t)$ is the surplus at time t.

- 强度函数
  Intensity Function: Let $\{N(t), t \geq 0\}$ be a counting process. Then define
  $$\lambda(t) = \lim_{\Delta t \to 0^+} \frac{1}{\Delta t} P[N(t+\Delta t) - N(t) = 1 | N(s), 0 < s \leq t],$$
  if the limit exists. $\lambda(t)$ is the intensity function of the counting process.
- 无限时间破产概率
  Infinite Time Ruin Probability: Ruin probability is sometimes called infinite time ruin probability.
- 盈余
  Surplus: Surplus is defined as the difference between assets and liabilities, written as:
  $$U(t) = A(t) - L(t), t \geq 0$$
  where $A(t)$ and $L(t)$ are assets and liabilities at time t accordingly.
- 有限时间破产概率
  Finite Time Ruin Probability: Given a surplus process $\{U(t)\}_{t\geq 0}$, the finite time ruin probability is defined as
  $$\psi(u,t) = P(\exists s \in (0,t], U(s) < 0).$$
  This is the probability to ruin within time interval $(0, t]$ given initial surplus u.
- 终极破产概率
  Ruin Probability: For a surplus process $\{U(t)\}_{t\geq 0}$,
  $$\psi(u) = P(\exists t \geq 0, U(t) < 0)$$
  is called the ruin probability given initial surplus u.
- 终极生存概率
  Survival Probability: For a surplus process $\{U(t)\}_{t\geq 0}$, the survival probability given initial surplus u is defined mathematically as
  $$\phi(u) = P(U(t) \geq 0, \forall t \geq 0).$$
- 资产
  Asset
- 总理赔过程
  Aggregate Claim Process: Define the process $\{S(t), t \geq 0\}$ be the aggregate claim process if
  $$S(t) = \sum_{i=1}^{N(t)} X_i$$
  where $\{N(t), t \geq 0\}$ is the claim number process and X_is are claim amount random variables.
- 最大损失随机变量
  Maximal Aggregate Loss Random Variable: In a surplus process $\{U(t), t \geq 0\}$, the maximal aggregate loss random variable of the process is
  $$L = \max[S(t) - ct].$$

§3.8 第八章：经验模型 Chapter Eight: Empirical Models

- 带宽
  Bandwidth: In kernel density estimation, especially uniform kernel and triangular kernel, there is a parameter that relates to the spread of the kernel, which is called the bandwidth.
- 对数转化的置信区间
  Log-transformed Confidence Interval: For Kaplan-Meier product-limit estimator, the log-transformed confidence interval for a confidence level of α is defined by $(S_n(t)^{1/U}, S_n(t)^U)$, where
  $$U = \exp\left[\frac{z_{0.5+\alpha/2}\sqrt{\hat{Var}[S_n(t)]}}{S_n(t)\ln S_n(t)}\right].$$
  For Nelson-Aalen estimator for cumulative hazard rate, the corresponding log-transformed confidence interval is $(\hat{H}(t)\exp(-U), \hat{H}(t)\exp(U))$, where
  $$U = \frac{z_{0.5+\alpha/2}\sqrt{\hat{Var}[\hat{H}(y_j)]}}{\hat{H}(t)}$$
  $z_{0.5+\alpha/2}$ is the $0.5 + \alpha/2$-th quartile of standard normal distribution, and $S_n(t)$ is the empirical survival distribution.
- 多元终止概率
  Multiple Decrement Probability:
- 风险集
  Risk Set: In survival analysis, the risk set at $j$the ordered observation y_j is denoted r_j. When thinking in terms of a mortality study, the risk set comprises the individuals who are under observation at that age. Included are all who die at that age or later and all who are censored at that age or later. However, those who are first observed at that age or later were not under observation at that time.
- 分组数据
  Grouped Data: Grouped data is a statistical term used in data analysis. A raw data set can be organized by constructing a table showing the frequency distribution of the variable. Such a frequency table is often referred to as a grouped data.
- **Greenwood近似公式**
  Greenwood Approximation: In survival analysis, the survival distribution is estimated by Kaplan-Meier product-limit estimator, then the variance of the estimator can be simplified by Greenwood approximation:
  $$\hat{Var}[S_n(y_j)] = S_n(y_j)^2 \sum_{i=1}^{j} \frac{s_i}{r_i(r_i - s_i)},$$
  where y_j, s_j, r_j are defined as follows:

- let $y_1 < y_2 < ... < y_k$ be the k unique values that appear in the sample;
- let s_j be the number of times the uncensored observation y_j appears in the sample;
- r_j is the risk set at time t.

- 核密度估计方法

Kernel Density Estimation: In empirical modeling, Kernel density estimation is a method of obtaining a smooth, empirical-like distribution. Let $p(y_j)$ ne the probability assigned to the value $y_j (j = 1, ..., k)$ by the empirical distribution. Let $K_y(x)$ be a distribution function for a continuous distribution such that its mean is y. Let $k_y(x)$ be the corresponding density function. A kernel density estimator of a distribution function is

$$\hat{F}(x) = \sum_{j=1}^{k} p(y_j) K_{y_j}(x),$$

and the estimator of the density function is

$$\hat{f}(x) = \sum_{j=1}^{k} p(y_j) k_{y_j}(x).$$

The function $k_y(x)$ is called the kernel. Three kernels are commonly used: uniform, triangular and gamma.

- 伽玛核函数

Gamma Kernel Function: In kernel density estimation, a gamma kernel function is a kernel density function employing the gamma distribution with shape parameter α and scale parameter y/α, i.e., its kernel is given by:

$$k_y(x) = \frac{x^{\alpha-1} e^{-x\alpha/y}}{(y/\alpha)^{\alpha} \Gamma(\alpha)}.$$

Note that the gamma distribution has a mean of $\alpha(y/\alpha) = y$ and a variance of $\alpha(y/\alpha)^2 = y^2/\alpha$.

- 截断数据

Truncated Data: Truncated data includes left-truncated data and right-truncated data. For more details and formal definitions of both types of data refer to 左截断(Left Truncation) and 右截断(Right Truncation).

- 经验分布

Empirical Distribution: The empirical distribution is obtained by assigning probability $1/n$ to each data point. Mathematically,

$$F_n(x) = \frac{\text{number of observations} \le x}{n},$$

where n is the total number of observations.

- 经验分布概率函数

Empirical Distribution Probability Function: Let $\{x_1, x_2, ..., x_n\}$ be a set of observation data, and let $y_1 < y_2 < ... < y_k$ be k different observation values. Define s_j be the number of x_i having the value of y_j, i.e. $s_j = \sum_{i=1}^{n} I(x_i)$, where $I(.)$ is the indicator function. The the empirical distribution probability function is given by

$$p_n(x) = \begin{cases} \frac{s_j}{n}, x = y_j \\ 0, \text{otherwise.} \end{cases}$$

- 经验分布光滑曲线（卵形线）

Ogive: For grouped data, the distribution function obtained by connecting the values of the empirical distribution function at the group boundaries with straight lines is called the ogive. The formula is

$$F_n(x) = \frac{c_j - x}{c_j - c_{j-1}} F_n(c_{j-1}) + \frac{x - c_{j-1}}{c_j - c_{j-1}} F_n(c_j),$$

for $c_{j-1} \le x \le c_j$.

- 经验生存函数

Empirical Survival Function: The empirical survival function is given by

$$S_n(x) = \frac{\text{number of observations} > x}{n}$$

where n is the total number of observations.

- 均匀核函数

Uniform Kernel Function: In kernel density estimation, a uniform kernel function is a kernel density function employing the uniform distribution, i.e., its kernel is given by:

$$k_y(x) = \begin{cases} 0, x < y - b, \\ \frac{1}{2b}, y - b \le x \le y + b, \\ 0, x > y + b, \end{cases}$$

$$K_y(x) = \begin{cases} 0, x < y - b, \\ \frac{x-y+b}{2b}, y - b \le x \le y + b, \\ 1, x > y + b. \end{cases}$$

where $k_y(x)$ is the kernel density function and $K_y(x)$ is the corresponding distribution function. There is a parameter that relates to the spread of the kernel, $b > 0$, which is called the bandwidth.

- Kaplan-Meier乘积极限估计

Kaplan-Meier Product-limit Estimator: In survival analysis, the estimate function for survival function can be obtained by Kaplan-Meier product-limit estimator. The general formula is

$$S_n(t) = \begin{cases} 1, 0 \le t < y_1, \\ \prod_{i=1}^{j-1} \frac{r_i - s_1}{r_i}, y_{j-1} \le t < y_j, j = 2, ..., k, \\ \prod_{i=1}^{k} \frac{r_i - s_i}{r_i} \text{or} 0, t \ge y_k, \end{cases}$$

where y_j, s_j, r_j are defined as follows:

– let $y_1 < y_2 < ... < y_k$ be the k unique values that appear in the sample;

– let s_j be the number of times the uncensored observation y_j appears in the sample;

– r_j is the risk set at time t.

- 累积危险率函数

Cumulative Hazard Rate Function: The cumulative hazard rate function is defined as

$$H(x) = -\ln S(x).$$

The name comes from the fact that, if $S(x)$ is differentiable,

$$H'(x) = -\frac{S'(x)}{S(x)} = \frac{f(x)}{S(x)} = h(x),$$

then

$$H(x) = \int_{-\infty}^{x} h(y)dy.$$

Note $S(x)$ is the survival distribution function and $h(x)$ is the hazard rate.

- **Nelson-Aalen估计**

Nelson-Aalen Estimator: Given a data set $\{x_1, x_2, ..., x_n\}$, the Nelson-Aalen estimate of the cumulative hazard rate function is

$$\hat{H}(x) = \begin{cases} 0, x < y_1, \\ \sum_{i=1}^{j-1} \frac{s_i}{r_i}, y_{j-1} \le x \le y_j, j = 2, ..., k, \\ \sum_{i=1}^{k} \frac{s_i}{r_i}, x \ge y_k, \end{cases}$$

where y_j, r_j and s_j are defined as follows:

– let $y_1 < y_2 < ... < y_k$ be the k unique values that appear in the sample;

– let s_j be the number of times the observation y_j appears in the sample;

– let $r_j = \sum_{i=j}^{k} s_i$ be the number of observations greater than or equal to y_j.

- 完整数据

Complete Data: A complete data set is a set of data without any truncation and censoring. It includes individual data and grouped data.

- 三角核函数

Triangular Kernel Function: In kernel density estimation, a triangular kernel function is a kernel density function employing the triangular-shaped density function, i.e., its kernel is given by:

$$k_y(x) = \begin{cases} 0, x < y - b \\ \frac{x-y+b}{b^2}, y - b \le x \le y, \\ \frac{y+b-x}{b^2}, y \le x \le y + b, \\ 0, x > y + b, \end{cases}$$

$$K_y(x) = \begin{cases} 0, x < y - b, \\ \frac{(x-y+b)^2}{2b^2}, y - b \le x \le y, \\ 1 - \frac{(y+b-x)^2}{2b^2}, y \le x \le y + b, \\ 1, x > y + b. \end{cases}$$

where $k_y(x)$ is the kernel density function and $K_y(x)$ is the corresponding distribution function. There is a parameter that relates to the spread of the kernel, $b > 0$, which is called the bandwidth.

- 删失数据

Censored Data: Censored data includes left-censored data and right-censored data. For more details and formal definitions of both types of data refer to 左删失(Left Censoring) and 右删失(Right Censoring).

- 示性函数

Indicator Function: Indicator takes value of 1 if a designed event occurs and value of 0 otherwise. Formally, let S be a set of designed events and A be a certain event, then

$$I(A) = \begin{cases} 1, \text{if } A \subseteq S \\ 0, \text{otherwise} \end{cases}.$$

- 数据依赖型分布

Data-Dependent Distribution: A data-dependent distribution is at least as complex as the data or knowledge that produced or, and the number of "parameters" increases as the number of data points or amount of knowledge increases.

- 完整个体数据

Complete Individual Data: A complete individual data set is a set of non-grouped complete data.

- 线性插值

Linear Interpolation: Linear interpolation is a method of curve fitting using linear polynomials. If the two known points are given by the coordinates (x_0, y_0) and (x_1, y_1), the linear interpolant is the straight line between these points. For a value x in the interval (x_0, x_1), the value y along the straight line is given from the equation

$$\frac{y - y_0}{x - x_0} = \frac{y_1 - y_0}{x_1 - x_0},$$

then

$$y = \frac{x - x_0}{x_1 - x_0} y_1 + \frac{x_1 - x}{x_1 - x_0} y_0.$$

- 右截断数据

Right-Truncated Data: Refer to 右截断(Right Truncation).

- 右删失数据

Right-Censored Data: Refer to 右删失(Right Censoring).

- 直方图
  Histogram
- 左截断数据
  Left-Truncated Data: Refer to 左截断(Left Truncation).
- 左删失数据
  Right-Censored Data: Refer to 左删失(Left Censoring).

§3.9 第九章：参数模型的估计 Chapter Nine: Parametric Model Estimation

- 比例风险假定
  Proportional Hazards Assumption: In Cox model, any pairs of individuals should satisfy the proportional hazards assumption, that is, the proportion of any two hazard rates are unchanged with respect to time.
  $$\frac{h_i(t)}{h_j(t)} = \exp(a'(z_i - z_j)), j = 1, ..., n,$$
  where $h_i(t) = h(t|z_i)$.
- Cox比例风险模型
  Cox Proportional Hazards Model: Given a baseline hazard rate function $h_0(t)$ and values $z_1, ..., z_p$ associated with a particular individual, the Cox proportional hazards model for that person is given by the hazard rate function
  $$h(x|\mathrm{z}) = h_0(x)c(\beta_1 z_1 + ... + \beta_p z_p) = h_0(x)c(\beta^T \mathrm{z}),$$
  where $c(y)$ is any function that takes on only positive values; $\mathrm{z} = (z_1, z_2, ..., z_p)^T$ is a column vector of the z values (called covariates); and $\beta = (\beta_1, ..., \beta_p)^T$ is a column vector of coefficients. Usually, Cox model takes the case of $c(y) = \exp(y)$.
- Delta方法
  Delta Method: In statistics, the delta method is a method for deriving an approximate probability distribution for a function of an asymptotically normal statistical estimator from knowledge of the limiting variance of that estimator. Let $X_1, X_2, ..., X_n$ be a sequence of random variables such that
  $$n^b(X_n - a) \to_D X$$
  for some $b > 0$. Suppose the function $g(x)$ is differentiable at a and $g'(a) \neq 0$. Then
  $$n^b[g(X_n) - g(a)] \to_D g'(a)X,$$
  where $\to D$ means converges in distribution.
- 对数似然函数
  Loglikelihood Function: Let $L(\Theta) = f(x_1, ..., x_n|\Theta)$ be likelihood function, then the loglikelihood function is
  $$l(\Theta) = \ln(L(\Theta)) = \ln(f(x_1, ..., x_n|\Theta)).$$
- 分位数估计
  Percentile Matching Estimation: A percentile matching estimate of θ is any solution of the p equations
  $$\pi_{g_k}(\theta) = \hat{\pi}_{g_k}, k = 1, 2, ..., p,$$
  where $g_1, g_2, ...g_p$ are p arbitrarily chosen percentiles, and $\hat{\pi}_k$ is the sample estimate of k-th moment. From the definition of percentile, the equations can also be written
  $$F(\hat{g_k}|\theta) = g_k, k = 1, 2, ..., p.$$
- Fisher信息量
  Fisher's Information: Let $l(\theta)$ be the loglikelihood function, then the Fisher's information is defined as
  $$I(\theta) = -E\left[\frac{\partial^2}{\partial\theta^2} l(\theta)\right].$$
- Frank耦合分布
  Frank Copula: Frank copula is a commonly used copula, and it takes the form
  $$C(u, v) = \log_\alpha\left[1 + \frac{(\alpha^u - 1)(\alpha^v - 1)}{\alpha - 1}\right].$$
- 个人年金
  Individual Life Annuity
- 广义线性回归模型
  Generalized Linear Regression Model: In a generalized linear regression model, each outcome of the dependent variables, Y, is assumed to be generated from a particular distribution in the exponential family, a large range of probability distributions that includes the normal, binomial and poisson distributions, among others. The mean, μ, of the distribution depends on the independent variables, X, through:
  $$E(\mathrm{Y}) = \mu = g^{-1}(\mathrm{X}\beta)$$
  where $E(\mathrm{Y})$ is the expected value of Y; $\mathrm{X}\beta$ is the linear predictor, a linear combination of unknown parameters, β; g is the link function, and its inverse function g^{-1} is called the mean function.
- 古典线性回归模型
  Ordinary Linear Regression Model: In ordinary linear regression, the random variable, X, has a normal distribution with $mean = \mu$ and $variance = \sigma^2$. Then the model is $\mu = \beta^T\mathrm{z}$, where β is a vector of coefficients and z is a vector of covariates for an individual.

- **均值函数**
  Mean Function: Refer to 广义线性回归模型(Generalized Linear Regression Model).

- **矩估计**
  Method of Moments: In statistics, the method of moments is a method of estimation of population parameters such as mean, variance, media, etc., by equating sample moments with unobservable population moments and then solving those equations for the quantities to be estimated.

- **联合生存年金**
  Joint Life Annuity

- **联结函数**
  Link Function: Refer to 广义线性回归模型(Generalized Linear Regression Model).

- **Logistic模型**
  Logistic Model: Logistic model employs the logistic distribution as its underlying model. The logistic distribution is a continuous distribution whose cumulative distribution is a logistic function. The logistic distribution has density function

$$f(x) = \frac{e^{-(x-\mu)/\beta}}{\beta[1 + e^{-(x-\mu)/\beta}]^2}$$

  where $\beta > 0$ and μ are parameters.

- **耦合分布**
  Copula Distribution: In statistic, a copula is used as a general way of formulating a multivariate distribution in such a way that various general types of dependence can be represented. It is a multivariate joint distribution defined on the n-dimensional unit cube $[0, 1]^n$ such that every marginal distribution is uniform on the interval $[0, 1]$. Some common copulas include Gaussian copulas, Archimedean copulas, and periodic copula. Suppose $F_X(x), F_Y(y)$ be two marginal distributions for random variables X and Y. Let $C(u, v)$ be the copula function. Then following relationship holds

$$F_{X,Y}(x, y) = C[F_X(x), F_Y(y)].$$

- **偏导数**
  Partial Derivative: In mathematics, a partial derivative of a function of several variables is its derivative with respect to one of those variables, with the others held constant. The partial derivative of a function f with respect to the variable x is variously denoted by

$$f'(x), f_x, \partial_x f, \text{or } \frac{\partial f}{\partial x}.$$

- **先验权重**
  Predetermined Weights

- **指数分布族**
  Exponential Family of Distributions: We say a distribution belongs to the exponential family if its density distribution has the form of

$$f(y_i; \theta_i, \phi) = \exp\left\{\frac{y_i\theta_i - b(\theta_i)}{a(\phi)} + c(y_i, \phi)\right\}$$

  where $a(.)$, $b(.)$, $c(.)$ are functions and θ_i and ϕ are parameters.
  The alternative presentation is

$$f(y_j; \Theta) = \frac{p(y_j)e^{r(\Theta)y_j}}{q(\Theta)}$$

  where Θ is a set of parameters.

§3.10 第十章：参数模型的检验和选择 Chapter Ten: Parametric Model Selection

- **Anderson-Darling检验**
  Anderson-Darling Test: In statistics, the Anderson-Darling test is a statistical test of whether there is a evidence that a given sample of data did not arise from a given probability distribution. The test statistic is

$$A^2 = n\int_t^u \frac{[F_n(x) - F^*(x)]^2}{F^*(x)[1 - F^*(x)]} f^*(x)dx.$$

  That is, it is a weighted average of the squared differences between the empirical and model distribution function. This test statistic tends to place more emphasis on good fit in the tails than in the middle of the distribution.

- **Bull分布**
  Bull Distribution:

- **χ^2 拟合优度检验**
  Chi-square Goodness of Fit Test: Refer to 拟合优度检验(Chi-square Goodness of Fit Test).

- **K-S检验**
  K-S Test: In statistics, the Kolmogorov-Smirnov test (K-S test) is a nonparametric test for the equality of continuous, one-dimensional probability distributions that can be used to compare a sample with a reference probability distribution (one-sample K-S test). The test statistic is

$$D = \max_{t \le x \le u} |F_n(x) - F^*(x)|,$$

  where t is the left truncation point ($t = 0$ if there is no truncation) and u is the right censoring point ($u = \infty$ if there is no censoring).

- **p-p图**
  P-P Plot: In statistics, a P-P plot (probability-probability plot or percent-percent plot) is a probability plot for assessing how closely two data sets agree,

which plots the two cumulative distribution functions against each other.

- **q-q图**
  Q-Q Plot: In statistics, a Q-Q plot (quartile-quartile plot) is a probability plot, which is a graphical method for comparing two probability distributions by plotting their quartiles against each other.

- **似然比检验**
  Likelihood Ratio Test: Likelihood ratio test is testing the null hypothesis (H_0) that "the data came from a population with distribution A and alternative hypothesis (H_1) that "the data came from a population with distribution B. Let the likelihood function be written as $L(\theta)$. Let θ_0 and θ_1 be the values of the parameters that maximizes the likelihood function under null hypothesis and alternative hypothesis correspondingly. Then the test statistic is

$$T = 2\ln(L(\theta_1)/L(\theta_0)).$$

§3.11 第十一章：修匀理论 Chapter Eleven: Theory of Smoothing

- **Baysian修匀**
  Baysian Graduation Method: Let T be the vector of unknown true values of interest, and U be the vector of sample data. Then Baysian graduation method uses $V = E(T|U)$ to have the best estimates of T. The underlying concept is very similar to Baysian estimation.

- **Dirichlet修匀**
  Dirichlet Smoothing: Dirichlet smoothing method is a modification of Baysian graduation method.

- **Everett公式**
  Everett's Formula

- **分段函数修匀（样条修匀）**
  Spline Smoothing: The smoothing spline is a method of smoothing using a spline function.

- **Kimeldorf-Jones方法**
  Kimeldorf-Jones Graduation Method: Kimeldorf-Jones graduation method, whose prior distribution is a multi-normal distribution, is a special case of Baysian graduation method

- **Whittaker修匀**
  Whittaker Graduation: Let w_x be the weight on index x, v_x and u_x be the estimated value and realized value for index x correspondingly. Then Whittaker graduating method produces the best estimates via minimizing the form

$$M = \sum_{x=1}^{n} w_x(v_x - u_x)^2 + h\sum_{x=1}^{n-z}[\Delta^Z v_x]^2,$$

where h is the parameter, and Δ^k is the k-th moment different quotient.

- **修匀过程（修匀算子）**
  Smoothing Process

- **修匀误差**
  Smoothing Error

- **移动加权平均修匀（m-w-a）**
  Moving-Weighted-Average Smoothing: Let u_x be the realized data value at index x, then the moving-weighted-average smoothing employs the form

$$v_x = \sum_{r=-n}^{n} a_r u_{x+r},$$

with the condition $a_r = a_{-r}$, where v_x is the estimate after smoothing, and a_r's are the weights.

§3.12 第十二章：信度理论 Chapter Twelve: Credibility Theory

- **半参数估计**
  Semi-parametric Estimation

- **贝叶斯信度估计值**
  Baysian Credibility Estimation: Given the past claim experience $X_1, X_2, ..., X_n$, the Baysian Credibility Estimation is essentially the conditional expectation given the past data, formally,

$$P = E(X_{n+1}|X_1 = x_1, ..., X_n = x_n).$$

- **部分信度**
  Partial Credibility: In limited fluctuation credibility theory, if one individual does not qualified for the full credibility, he is charged for premium

$$P_c = z\bar{X} + (1-z)M,$$

where $\bar{X}$ is the average experience of this individual, M is the manual premium, and z is the credibility factor. Furthermore, z is taking the form of

$$z = \min\left\{\frac{\xi}{\sigma}\sqrt{\frac{n}{\lambda_0}}\right\}$$

where $\xi = E(X)$, $\sigma = \sqrt{Var(X)}$, and $\lambda_0 = (y_p/r)^2$, and n is the number of past data for the individual.

- **Buhlmann信度**
  Buhlmann Credibility: Let X_i be the i.i.d claim amount random variable for i-th claim, define

$$\mu(\theta) = E(X_i|\Theta = \theta); v(\theta) = Var(X_i|\Theta = \theta).$$

Let we have

$$\mu = E(\mu(\theta)), v = E(v(\theta)), a = Var(\mu(theta)).$$

The Buhlman credibility factor is in form of

$$z = \frac{n}{n + v/a},$$

where n is the number of past claims.

- **Buhlmman信度因子**
  Buhlmann Credibility Factor: Buhlmann credibility factor is the the credibility factor defined in Buhlmann model to calculate the premium. Refer to Buhlmann模型(Buhlmann Model).

- **Buhlmman模型**
  Buhlmann Model:In Buhlmann model, let X_i be the i.i.d claim amount random variable for i-th claim, define

  $$\mu(\theta) = E(X_i|\Theta = \theta); v(\theta) = Var(X_i|\Theta = \theta).$$

  Let we have

  $$\mu = E(\mu(\theta)), v = E(v(\theta)), a = Var(\mu(theta)).$$

  The Buhlmann credibility factor is in form of

  $$z = \frac{n}{n + v/a},$$

  where n is the number of past claims. The Buhlmann premium is

  $$P = z\bar{X} + (1 - z)\mu.$$

- **Buhlmman-straub模型**
  Buhlmann-Straub Model: Buhlmann-Straub model extends Buhlmann model to groups of individuals.

- **Buhlmann线性估计**
  The Credibility Premium: In the way to calculate the credibility premium, a linear approximation is employed. Mathematically,

  $$\tilde{X_{n+1}} = \alpha_0 + \sum_{j=1}^{n} \alpha_j X_j,$$

  where $\alpha_0, \alpha_1, ..., \alpha_n$ should satisfy following equations

  1. $E(X_{n+1}) = \alpha_0 + \sum_{j=1}^{n} \alpha_j E(X_j)$,
  2. $Cov(X_i, X_{n+1}) = \sum_{j=1}^{n} \alpha_j Cov(X_i X_j)$.

- **纯保费**
  Manual Premium

- **古典信度模型**
  Classic Credibility Model: Limited fluctuation credibility model is also called the classic credibility model. Refer to 有限波动信度(Limited Fluctuation Credibility).

- **精确信度**
  Exact Credibility: When Bulhmann credibility estimation matches the Baysian Credibility estimation, then we can the estimation has the exact credibility.

- **经验贝叶斯估计**
  Empirical Baysian Estimation: Empirical Baysian Estimator gives the credibility premium from empirical data.

- **完全信度**
  Full Credibility: In limited fluctuation theory, the full credibility is assigned to the insurer if following conditions are satisfied:

  $$Pr(-r\xi \leq \bar{X} - \xi \leq r\xi) \geq p,$$

  where $\bar{X}$ is the average of past experience of the individual, $\xi = E(X)$, r and p are predetermined quantities (commonly $r = 0.05$, $p = 0.9$).
  Then the insurance company charge the individual premium equating $\bar{X}$.

- **先验分布（结构分布）**
  Prior Distribution: In greatest accuracy credibility theory, let θ be unknown risk factors effecting the insurers' claim experience, we assume the distribution of θ, $\pi(\theta)$, is known or predetermined, and $\pi(\theta)$ is called the prior distribution.

- **信度估计**
  Credibility Estimation: The credibility premium sometimes is called the credibility estimation.

- **信度理论**
  Credibility Theory: Credibility theory is a set of quantitative tools that allows an insurer to perform prospective experience rating (adjust future premiums based on past experience) on a risk or group of risks.

- **信度因子**
  Credibility Factor: In credibility theory, the credibility premium usually takes the form

  $$P_c = z\bar{X} + (1 - z)M,$$

  where $\bar{X}$ is the average claim experience and M is the manual premium. The proportional assigned to average past experience is called the credibility factor.

- **有限波动信度**
  Limited Fluctuation Credibility: In credibility theory, limited fluctuation credibility theory is a branch represents the first attempt to quantify the credibility problem.

- **最大精算信度模型**
  Greatest Accuracy Credibility Model: Buhlmann credibility model is also named the greatest accuracy credibility model.

§3.13 第十三章：随机模拟 Chapter Thirteen: Random Simulation

- **Bootstrap模拟**
  Bootstrap Simulation: In Statistic, bootstrapping is a computer-based, method for assigning measures

of accuarcy to sample estimates. This technique allows estimation of the sample distribution of almost any statistic using only very simple method.

- **Box-Muller方法**
  Box-Muller Method: A Box-Muller transform is a method of generating pairs of independent standard normally distributed random numbers.
- **乘同余法**
  Congruential Method: The one of the most common pseudorandom number generator is linear congruential generator which is employed so-called "congruential method". It uses the recurrence

  $$X_{n+1} = (aX_n + b) \mod m$$

  to generate numbers. The starting value X_0 is called the seed.
- **方差缩减技术**
  Variance Deduction Method: In Monte Carlo simulation method, variance reduction is a procedure used to increase the precision of the estimates that can be obtained for a given number of iteration. The main variance deduction methods are: common random numbers, antithetic variates, control variates, importance sampling, and stratified sampling.
- **反函数法**
  Inversion Method: For a continuous random variable X with cumulative distribution function F_X, then we can simulate X by inversion method described as follows:
  1. draw a uniform random number U
  2. $X_{sim} = F^{-1}(U)$.
- **吉布斯抽样**
  Gibbs Sampling: In statistics, Gibbs sampling is an algorithm to generate a sequence of samples from the joint probability distribution of two or more random variables. In its basic version, Gibbs sampling is a special case of the Metropolis-Hasting algorithm.
- **MCMC方法**
  Markov Chain Monte Carlo Method: Markove chain Monte Carlo methods are a class of algorithm for sampling from probability distributions based on constructing a Markov chain that has the desired distribution as its equilibrium distribution.
- **metropolis-hasting抽样**
  Metropolis-Hasting Algoritm: In statistics, the Metropolis-Hasting algorithm is a Markov chain Monte Carlo method for obtaining a sequence of random samples from a probability distribution for which direct sampling is difficult.
- **伪随机数**
  Pseudorandom Number: A pseudorandom number generator, also known as a deterministic random bit generator, is an algorithm for generating a sequence of numbers that approximates the properties of random number.
- **种子**
  Seed: Refer to 乘同余法(Congruential Method).

§3.14 第十四章：案例分析 Chapter Fourteen: Case Study

This chapter contains reading materials, and most of technique terms can be found out in previous context.

A5 Manual

§4 A5 Manual

§4.1 第一章: 生存分布与生命表 Chapter One: Survival Distributions and Life Tables

- **De Moivre 律**
  De Moivre's Law: De Moivre's Law is a survival model applied in actuarial science, named for Abraham de Moivre. It is a simple law of mortality based on a linear survival function. Under De Moivre's law, the force of mortality takes the form
  $$\mu(x) = \frac{1}{\omega - x}, 0 \leq x < \omega,$$
  where ω is the parameter indicating the limiting age.

- **分数年龄假设**
  Fractional Age Assumption: Fractional age assumptions postulate analytical forms about the distribution between integer ages.

- **Gompertz律**
  Gompertz's Law: Gompertz's Law is a mortality model applied in actuarial science. It is based on the observation that mortality rate over ages reveals exponential type increasing. According to Gompertz's law, the force of mortality is defined as
  $$\mu(x) = Bc^x, x \geq 0$$
  where $B > 0$ and $c > 1$ are model parameters.

- **简略未来生命时间长度随机变量**
  Curtate Future Lifetime Random Variable: In actuarial science, a discrete random variable associated with the future lifetime is the number of future years completed by (x) prior to death. It is called the curtate-future0lifetime of x and is denoted by $K(x)$. Thus, the corresponding random variable is called the curtate future lifetime random variable.

- **均匀分布假设（均予分布）**
  Uniform Distribution of Deaths Assumption: UDD fractional age assumption is also known as linear interpolation assumption. Refer to 线性假设(Linear Interpolation Assumption).

- **Makeham律**
  Makeham's Law: Makeham's Law is a mortality model applied in actuarial science, and it is an improved version of Gompertz's Law. In Makeham's law, the force of mortality has the form of
  $$\mu(x) = A + Bc^x, x \geq 0$$
  where $B > 0, c > 1, A \geq -B$ are parameters.

- **平均余寿**
  Expected Future Lifetime: The expected future lifetime of age (x) is denoted by $\mathring{e}_x$ equating to
  $$\mathring{e}_x = \int_0^\infty {}_tp_x dt.$$

- **人口极限年龄**
  Limiting Age: Limiting age is the maximum age an age (x) can live to, which is denoted by ω. Mathematically,
  $$S(\omega) = 0.$$

- **生存函数**
  Survival Function: Refer to 生存分布(Survival Distribution).

- **生命表**
  Life Table:

- **生存分布**
  Survival Distribution: Let $F_X(x)$ denote the distribution function of X, and set
  $$S(x) = 1 - F_X(x) = Pr(X \geq x).$$
  The function $S(x)$ is called the survival function, and the corresponding distribution is called the survival distribution.

- **寿命随机变量**
  Age Random Variable: In actuarial science, the age random variable is always denoted by (x) meaning a life at age x.

- **寿险精算**
  Actuarial Mathematics for Life Contingent Risks:

- **双曲假设（Balducci假设）**
  Harmonic Interpolation Assumption (Balducci Assumption): Under harmonic interpolation assumption, the survival function between ages has the relationship with two ended integer ages as follows:
  $$\frac{1}{S(x+t)} = \frac{1-t}{S(t)} + \frac{t}{S(x+1)},$$
  where $0 < t < 1$. This is what is known as the hyperbolic or Balducci assumption, for under it ${}_tp_x$ is a hyperbolic curve.

- **死亡解析律**
  Mortality Law: The analytical forms for mortality or survival functions are called mortality laws.

- **死亡力**
  Force of Mortality: Let $F(x)$ and $f(x)$ be the cumulative distribution function and the corresponding

probability density function associated with future lifetime random variable for age (x), then the force of mortality of (x) is defined as

$$\mu(x) = \frac{f_X(x)}{1 - F_X(x)}.$$

- **Weibull律**
Weibull's Law: Weibull's Law is a mortality model in actuarial science, which is defined as:

$$\mu(x) = kx^n, x \geq 0$$

where $k > 0, n > 0$ are parameters.

- **未来累计生存人年数**
Year Lived in This and All Subsequent Age Intervals:

- **未来生命时间长度随机变量**
Future Lifetime Random Variable: The future lifetime random variable of (x) is denoted by $T(x)$.

- **线性假设**
Linear Interpolation Assumption: The linear interpolation assumption on fractional ages is often known as the uniform distribution, or, perhaps more properly, a uniform distribution of deaths assumption within each year of age. Under this assumption, ${}_tp_x$ is a linear function.

- **整值平均余寿**
Curtate Expectation of Life: The expected value of curtate future lifetime, $K(x)$, is denoted by e_x and is called the curtate expectation of life. By definition, we have

$$e_x = E[K] = \sum_{k=0}^{\infty} k_k p_x q_{x+k}.$$

- **指数假设（常力假设）**
Exponential Interpolation Assumption (Constant Force of Mortality): Exponential interpolation, or linear interpolation on $\log S(x+t)$ is consistent with the assumption of a constant force of mortality within each year of age. Under this assumption ${}_tp_x$ is exponential.

§4.2 第二章：人寿保险的精算现值 Chapter Two: Actuarial Present Values of Life Insurance

- **保险利益**
Insurance Benefit: Insurance benefit is the contractual payout agreed to by the carrier for the policy holder.

- **保险费**
Insurance Premium: The amount to be charged for a certain amount of insurance coverage is called the premium.

- **保额函数**
Benefit Function: Usually, benefit payout of a insurance contract can be expressed as a function of years that contract is in force and denoted by b_t, which is called the benefit function.

- **保险金**
Sum of Insured: The insurance coverage is also known as the sum of insured.

- **变额保险**
Varying Benefit Insurance: A varying benefit insurance policy agrees to pay non-leveled benefit at the claim.

- **等额保险**
Level Benefit Insurance: In life insurance, level Benefit Insurance provides the same amount of benefits whenever an age (x) is dead.

- **定期死亡保险**
Term Life Insurance: An n-year term life insurance provides for a payment only if the insured dies within the n-year term of an insurance commencing at issue. If a unit is payable at moment of death of (x), then actuarial present value random variable Z is

$$Z = \begin{cases} v^T, T \leq n, \\ 0, T > n. \end{cases}$$

- **趸缴净保费**
Single Net Premium

- **精算贴现因子**
Acturial Discount Factor: The actuarial present value of the unit pure endowment insurance present random variable is also denoted by ${}_nE_x$ and called the actuarial discount factor in annuity context.

- **精算现值**
Actuarial Present Value: In actuarial science, the expectation of the present value random variable, Z, of a certain insurance contract is called the actuarial present value of the insurance.

- **两全保险**
Endowment Insurance: An n-year endowment insurance provides for an amount to be payable either following the death of the insured or upon the survival of the insured to the end of the n-year term, whichever occurs first. If the insurance is for a unit amount and the death benefit is payable at the moment of death, then

$$Z = \begin{cases} v^T, T \leq n \\ v^n, T > n. \end{cases}$$

- 年度递减寿险

  Annually Decreasing Life Insurance: An annually decreasing n-year term life insurance provides n at the moment of death during the first year, $n-1$ at the moment of death during the second year, and so on, with coverage terminating at the end of the n-th year, Such an insurance has the following present value random variable

$$Z = \begin{cases} v^T(n - \lfloor T \rfloor), T \leq n \\ 0, T > n, \end{cases}$$

  where the $\lfloor \rfloor$ denote the greatest integer function.

- 年度递增终身寿险

  Annually Increasing Whole Life Insurance: An annually increasing whole life insurance providing 1 at the moment of death during the first year, 2 at the moment of death in the second year, and so on, is characterized by present value random variable:

$$Z = \lfloor T + 1 \rfloor v^T, T \geq 0,$$

  where the $\lfloor \rfloor$ denote the greatest integer function.

- 人寿保险

  Life Insurance

- 生存保险

  Pure Endowment: An n-year pure endowment provides for a payment at the end of the n years if and only if the insured survives at least n years from the time of policy issue. If the amount payable is unit, then

$$Z = \begin{cases} 0, T \leq n, \\ v^n, T > n. \end{cases}$$

- 贴现函数

  Discount Function: Discount function is the function of time used to discount cash flows, usually denoted by $v(t)$.

- 投保人

  Policyholder

- 延期保险

  Deferred Insurance: An m-year deferred insurance provides for a benefit following the death of the insured only if the insured dies at least m years following policy issue. The benefit payable and the term of the insurance may be any of those discussed above. For example, an m-year deferred whole life insurance with a unit amount payable at the moment of death has

$$Z = \begin{cases} v^T, T > m \\ 0, T \leq m. \end{cases}$$

- 终生寿险

  Whole Life Insurance: Whole life insurance provides for a payment following the death of the insured at any time in the future. If the payment is to be a unit amount at the moment of death of (x), then

$$Z = v^T, T \geq 0.$$

§4.3 第三章：生命年金的精算现值 Chapter Three: Actuarial Present Values of Life Annuity

- 定期生命年金

  Temporary Life Annuity: For the continuous payment case, the present value of a benefits random variable for an n-year temporary life annuity of 1 per year, payable continuously while (x) survives during the next n years, is

$$Y = \begin{cases} \bar{a}_{\overline{T}|}, 0 \leq T < n, \\ \bar{a}_{\overline{n}|}, T \geq n. \end{cases}$$

  For the discrete case, the present value of a benefit random variable can be retrieved in a similar way.

- 精算累计值

  Actuarial Accumulated Value: Actuarial accumulated value for the benefit cash flows represents the accumulated value considering the survival probability of an age. For example,

$$\bar{s}_{x:\overline{n}|} = \frac{\bar{a}_{x:\overline{n}|}}{{}_nE_x} = \int_0^n \frac{1}{{}_{n-t}E_{x+t}} dt,$$

  representing the actuarial accumulated value at the end of the term of an n-year temporary life annuity of 1 per year payable continuously while (x) survives.

- 可分配期初年金

  Apportionable Annuity-Due: This type of annuity due, one with a refund for the period between the time of death and the end of the period represented by the last full regular payment, is called an apportionable annuity-due.

- 年度递减定期生命年金

  Annually decreasing Term Life Annuity: An n-year annually decreasing term life annuity, say, with payable of unit value 1, has a stream of payable of amount $n, n-1, ..., 1$ given the life is survival at the payable date for n-year.

- 年度递增终身生命年金

  Annually Increasing Whole Life Annuity: This type of life annuity, say, with first payable of unit value 1, has a stream of payable of amount $1, 2, 3, 4, ...$ given the life is survival at the payable date.

- 年金

  Annuity: Annuity refers to any terminating stream of fixed payments over a specified period of time.

- 期初付生命年金

  Life Annuity Due: If the payments of a life annuity is due at the beginnings of the payment intervals, this type of annuity is called the life annuity due.

- 期末付生命年金

  Life Annuity Immediate: If the payments of a life annuity is due at the ends of the payment intervals, then this type of annuity is called the life annuity immediate.

- 确定期生命年金

  Guaranteed Life Annuity: A guaranteed life annuity is also called an n-year certain and life annuity. In this case, it is a whole life annuity with a guarantee of payments for the first n years. The present value of annuity payments is

$$Y = \begin{cases} \bar{a}_{\overline{n}|}, T \leq n \\ \bar{a}_{\overline{T}|}, T > n. \end{cases}$$

  Other types of guaranteed life annuities share the similar concepts.

- 生命年金

  Life Annuity: A life annuity is a series of payments made continuously or at equal intervals (such as months, quarters, years) while a given life survives.

- 完全期末年金

  Complete Annuity-Immediate: This type of life annuity immediate, one with a partial payment for the period between the last full payment and the time of death, is called a complete annuity-immediate.

- 延期生命年金

  Deferred Life Annuity: For a deferred life annuity, the payable is delivered by a deferred period. For example, an n-year deferred whole life annuity with continuous payments has the present value random variable Y defined as

$$Y = \begin{cases} 0, 0 \leq T < n, \\ v^n \bar{a}_{\overline{T-n}|}, T \geq n. \end{cases}$$

  Other types of deferred life annuities share the similar concepts.

- 终身生命年金

  Whole Life Annuity: For a continuous whole life annuity, the payable is lasted until (x) is dead. Thus, the present value of benefit random variable can be expressed as

$$Y = \bar{a}_{\overline{T}|}.$$

  A discrete whole life annuity shares the similar concept.

§4.4 第四章：均衡净保费

Chapter Four: Equivalent Net Premiums

- 保额

  Sum of Insured: Refer to 保险金(Sum of Insured).

- 百分位保费原则

  The Portfolio Percentile Premium Principle: The portfolio percentile premium principle requires that the loss random variable be positive with no more than a specified probability.

- 财富效用函数

  Utility Function: In economics, utility is a measure of relative satisfaction. Given this measure, one may speak meaningfully of increasing or decreasing utility, and thereby explain economic behavior in terms of attempts to increase one's utility. Given a wealth amount of ω, then the function associated with ω, $u(\omega)$, is called the utility function.

- 等价原则

  The Equivalence Premium Principle: Using the equivalence premium principle, the premium amount of an insurance product requires the condition

$$E[L] = 0$$

  to be satisfied, where L is the loss random variable. Equivalently, benefit premiums will be such that

$$\begin{aligned} & E[\text{present value of benefits}] \\ = \; & E[\text{present value of benefit premiums}]. \end{aligned}$$

- 趸缴保费

  Single Benefit Premium: When the equivalent principle is used to determine a single premium at policy issue for a life insurance or a life annuity, the premium is equal to the actuarial present value of benefit payments and is called the single benefit premium.

- 附加保费

  Expense-loaded Premium: If the premium calculation allows for the insurance company's expenses, the proportion of gross premium to cover expenses is called the expense-loaded premium, i.e.,

$$\begin{aligned} \text{Gross Premium} \;=\; & \text{Net Premium} \\ & +\text{Expense-loaded Premium}. \end{aligned}$$

- 净保费

  Net Premium: If the premium calculation does not allow for the insurance company's expenses, in this case we refer to a net premium.

- 可分配保费

  Apportionable Premium: The apportionable premium is a type of fractional premium. Here, at death, a refund is made of a portion of the premium related to the length of time between the time of death and the time of the next scheduled premium payment.

- 损失函数
  Loss Function: In calculating the benefit premiums using the equivalent principle, we always first consider the loss function of the insurance product. For example, for a whole life insurance with unit payable immediately on the death of (x), the loss function at time t is defined as
  $$l(t) = v^t - P\bar{a}_{\overline{t}|},$$
  which is the present value of the loss to the insurer if death occurs at time t. The corresponding loss random variable is
  $$L = l(t) = v^T - Pa_{\overline{T}|}.$$
- 损失随机变量
  Loss Random Variable: Loss random variables are random variables corresponding to the loss function of insurance products. Refer to 损失函数(Loss Function).
- 指数保费
  Exponential Premium: Premiums based on the exponential premium principle, using an exponential utility function, are known as exponential premiums.
- 指数保费原则
  Exponential Premium principle: Exponential premium principle is based on the expected utility of the insurer's wealth employing the exponential utility function to calculate premiums.

§4.5 第五章：责任准备金 Chapter Five: Benefit Reserves

- 保费差公式
  Premium-difference Formula: For the continuously n-year term life insurance, the benefit reserve at time t, ${}_t\bar{V}(\bar{A}_{x:\overline{n}|})$, can be obtained by the premium-difference formula
  $${}_t\bar{V}(\bar{A}_{x:\overline{n}|}) = [\bar{P}(\bar{A}_{x+t:\overline{n-t}|}) - \bar{P}(\bar{A}_{x:\overline{n}|})]\bar{a}_{x+t:\overline{n-t}|}.$$
- 风险净额
  Net Amount at Risk: $b_h -_h V$ is called the net amount at risk for policy year h, where b_h is the benefit payable in policy year h and ${}_hV$ is the corresponding reserve.
- 回溯公式
  Retrospective Formula: For the continuously n-year term life insurance, the benefit reserve at time s, ${}_s\bar{V}(\bar{A}_{x:\overline{n}|})$, can be obtained by the retrospective formula
  $$\begin{aligned} {}_s\bar{V}(\bar{A}_{x:\overline{n}|}) &= \bar{A}^1_{x+s:\overline{t}|} + {}_tE_{x+s}\,{}_{s+t}\bar{V}(\bar{A}_{x:\overline{n}|}) \\ &\quad -\bar{P}(\bar{A}_{x:\overline{n}|})\bar{a}_{x+s:\overline{t}|}, \end{aligned}$$
  for $t < n - s$.
- 缴清保险公式
  Paid-up Insurance Formula: For the continuously n-year term life insurance, the benefit reserve at time t, ${}_t\bar{V}(\bar{A}_{x:\overline{n}|})$, can be obtained by the paid-up insurance formula
  $${}_t\bar{V}(\bar{A}_{x:\overline{n}|}) = \left[1 - \frac{\bar{P}(\bar{A}_{x:\overline{n}|})}{\bar{P}(\bar{A}_{x+t:\overline{n-t}|})}\right]\bar{A}_{x+t:\overline{n-t}|}.$$
- 积累成本
  Accumulated Cost of Insurance: For continuous case, the accumulated cost of insurance is defined as
  $${}_t\bar{k}_x = \frac{\bar{A}^1_{x:\overline{t}|}}{{}_tE_x}.$$
  The discrete case shares the similar concept.
- 前瞻损失
  Prospective Loss
- 期初责任准备金
  Initial benefit Reserve: Let π_h be the benefit premium for the policy year h, the sum ${}_hV + \pi_h$ is called the initial benefit reserve for policy year h.
- 期末责任准备金
  Terminal benefit Reserve: ${}_{h+1}V$ stands for the terminal benefit reserve for policy year h.
- 责任准备金（准备金）
  Benefit Reserve: The benefit reserve, also known as the actuarial reserve, is a liability equal to the net present value of the future expected cash flows of a contingent event.
- 指数准备金
  Exponential Reserve: The type of reserves calculated by the exponential principle, which utilizes the utility function of wealth, is called the exponential reserve.

§4.6 第六章：毛保费与修正准备金 Chapter Six: Gross Premiums and Modified Reserves

- 保单费
  Policy Fee: In calculating the gross premium, some parts of expenses do not vary directly with the death benefit b, these type of expenses are included in gross premium and called the policy fee.

- 保单维护费用

  Renewal Expense: Renewal expenses are normally incurred by the insurer each time a premium is payable, and in the case of an annuity, they are normally incurred when an annuity payment is made.

- 等价的续年度均衡保额

  Equivalent Level Renewal Amount

- 理赔费用

  Termination Expense: In calculating the gross premium, the termination expenses occur when a policy expires, typically on the death of a policyholder or on the maturity date of a term insurance or endowment insurance. Generally these expenses are small, and are largely associated with the paperwork required to finalize and pay a claim.

- 利润边际

  Profit Margin: In life insurance, the profit margin is the net present value expressed as a proportion of the expected present value of the premiums, evaluated at the risk discount rate.

- 毛保费

  Gross Premium: The gross premium is calculated incorporating expenses.

- 销售费用

  Commission Expense: Commission if often paid to an agent in the form of a high percentage of the first year's premiums plus a much lower percentage of subsequent premiums, payable as the premiums are paid.

- 修正准备金

  Modified Reserve

- 业务获得费用

  Initial Expense: Initial expenses are incurred by the insurer when a policy is issued. There are two major types of initial expenses - commission to agents for selling a policy and underwriting expenses.

- 盈余

  Surplus

- 一年定期全缴费期修正法（**FPF**法）

  Full Preliminary Term Method

§4.7 第七章：多元生命函数 Chapter Seven: Multiple Life Functions

- **Common Shock**模型

  Common Shock Model: Let $T^*(x)$ and $T^*(y)$ denote two future lifetime random variable that, in the absence of the possibility of a common shock, are independent; that is

$$\begin{aligned} S_{T^*(x)T^*(y)}(s,t) &= Pr[T^*(x) > s \cap T^*(y) > t] \\ &= S_{T^*(x)}(s)S_{T^*(y)}(t). \end{aligned}$$

  In addition, there is a common shock random variable, to be denoted by Z, that can affect the joint distribution of time-until-death of lives (x) and (y). This common shock random variable is independent of $[T^*(x), T^*(y)]$ and has an exponential distribution; that is

$$s_Z(z) = e^{-\lambda z}, z > 0, \lambda \geq 0.$$

  The model described above is called the common shock model.

- 多元生命函数

  Multiple Life Functions

- **Frank Copula**模型

  Frank Copula Model: Frank copula model has following settings. Given marginal distribution functions for time-until-death of lives (x) and (y), $F_{T(x)}(s) = {}_sq_x$ and $F_{T(y)}(t) = {}_tq_y$, and a parameter $\alpha \neq 0$, $T(x)$ and $T(y)$ have joint distribution function

$$F_{T(x),T(y)}(s,t) = \frac{1}{\alpha}\ln[1 + \frac{(e^{\alpha_s q_x} - 1)(e^{\alpha_t q_y} - 1)}{e^{\alpha} - 1}].$$

- 联合生存状态

  Joint Life Status: A status that survives as long as all members of a set of lives survive and fails upon the first death is called a joint life status.

- 边际分布函数

  Marginal Distribution Function: Refer to 边缘分布(Marginal Distribution).

- 最后生存状态

  Last Survivor Status: A survival status that exists as long as at least one member of a set of lives is alive and fails upon the last death is called the last survivor status.

§4.8 第八章：多元风险模型 Chapter Eight: Multiple Decrement Models

- 伴随单风险模型

  Associated Single Decrement Model: For each of the causes of decrement recognized in a multiple decrement model, it is possible to define a single decrement model that depends only on the particular cause of decrement. We define the associated single decrement model functions as follows:

$$\begin{aligned} {}_tp_x{}'^{(j)} &= \exp\left[-\int_0^t \mu_x^{(j)}(s)ds\right], \\ {}_tq_x{}'^{(j)} &= 1 - {}_tp_x{}'^{(j)}. \end{aligned}$$

- 多元风险表

  Multiple Decrement Table: In a random survivorship group, let us consider a group of $l_a^{(\tau)}$ lives age a years. Each life is assumed to have a distribution of time-until-decrement and cause of decrement specified by the p.d.f

$$f_{T,J}(t,j) = {}_tp_a{}^{(\tau)}\mu_a^{(j)}(t), t \geq 0, j = 1, 2..., m.$$

Let ${}_nd_x^{(j)}$ denote the expected number of lives who leave the group between ages x and $x+n$, $x \geq a$. Then we can derive following relationships

$$\begin{aligned} l_x^{(\tau)} &= l_a^{(\tau)}{}_{x-a}p_a^{(\tau)}, \\ d_x^{(j)} &= l_x^{(\tau)}q_x^{(j)}. \end{aligned}$$

This result allow us to display a table of $p_x^{(\tau)}$ and $q_x^{(j)}$ values in a corresponding table of $l_x^{(\tau)}$ and $d_x^{(j)}$. Either table is called a multiple decrement table.

- 多元风险理论
  Multiple Decrement Theory: The theory associated with multiple decrement model is called the multiple decrement theory.

- 多元风险模型
  Multiple Decrement Model: The model used to construct the multiple decrement table is called the multiple decrement model.

- 确定存续群体
  Deterministic Survivorship Group

- 随机存续群体
  Random Survivorship Group

- 中心终止率
  Central Rate of Decrement: The central rate of decrement from all causes is defined by

$$m_x^{(\tau)} = \frac{\int_0^1 {}_tp_x{}^{(\tau)}(t)dt}{\int_0^1 {}_tp_x{}^{(\tau)}dt}.$$

- 终止力
  Force of Decrement: In multiple decrement model, the force of decrement due to cause j is defined as

$$\mu_x^{(j)}(t) = \frac{f_{T,J}(t,j)}{1-F_T(t)} = \frac{f_{T,J}(t,j)}{{}_tP_x^{(\tau)}},$$

  where $f_{T,J}(t,j)$ is the joint distribution of future lifetime random variable and the cause of decrement random variable.

§4.9 第九章：养老金计划的精算方法 Chapter Nine: The Actuarial Calculation for Pension Plans

- 解约
  Withdraw

- 捐纳金
  Contribution: Pension contribution shares the similar concept of premiums in life insurance contract.

- 确定给付计划
  Defined Benefit Plan: The defined benefit plan specifies a level of benefit, usually in relation to salary near retirement, or to salary throughout employment. The contributions, from the employer and, possibly, employee are accumulated to meet the benefit. If the investment or demographic experience is adverse, the contributions can be increased; if experience is favorable, the contributions may be reduced.

- 确定缴费计划
  Defined Contribution Plan: The defined contribution plan specifies how much the employer will contribute, as a percentage of salary, into a plan. The employee may also contribute, and the employer's contribution may be related to the employee's contribution. The contributions are accumulated in a notional account, which is available to the employee when he or she leaves the company. The contributions may be set to meet a target benefit level, but the actual retirement income may be well below or above the target, depending on the investment experience.

- 养老金筹资理论
  Theory of Pension Funding

- 养老金计划
  Pension Plan: The pension plan is usually sponsored by an employer. Pension plans typically offer employees either lump sums or annuity benefits or both on retirement, or deferred lump sum or annuity benefits (or both) on either withdrawal.

§4.10 第十章：多种状态转换模型 Chapter Ten: Multiple States Transition Models

- 不可约的
  Irreducible: A Markov chain is said to be irreducible if its state space is a single communicating class; in other words, if it is possible to get to any state from any state.

- 常返状态
  Recurrent State: Refer to 常返态(Recurrent State).

- 非常返状态
  Transient State: Refer to 瞬态(Transient State).

- 基本矩阵
  Fundamental Matrix: The fundamental matrix of the Markov chain is defined as

$$Q = (I - S)^{-1}$$

  where I is the identity matrix and S is the transition probability matrix.

- 吸收状态

  Absorbing State: A state i is called absorbing if it is impossible to leave this state. Therefore, the state i is absorbing if and only if

$$Pr(X_{n+1} = i|X_n = i) = 1,$$

  and

$$Pr(X_{n+1} = j|X_n = i) = 0, \text{for } i \neq j.$$

- 极限概率

  Limiting Probability: If the limiting probabilities of a Markov chain exist, then it can be expressed as

$$\pi_j = \lim_{n\to\infty} P_{ij}^{(n)},$$

  where $P_{ij}^{(n)}$ is the n-step transition probability matrix from state i to j. Moreover, $(\pi_0, ..., \pi_n)$ satisfy the condition

$$(\pi_0, ..., \pi_n) = (\pi_0, ..., \pi_n) \cdot P.$$

- 离散时间马尔可夫链

  Discrete-time Markov Chain:

- 示性变量

  Indicator Random Variable: In statistics, an indicator random variable only takes value 0 and 1 with probability p and $1 - p$.

- 相通的状态

  Communicating State: In a Markov chain, a state i is said to communicate with state j if state j is accessible from state i and state i is also accessible from state j. A state i accessible from state j means

$$Pr(X_n = i|X_0 = j) > 0.$$

- 转移概率矩阵

  Transition Probability Matrix: n-step transition probabilities can be collected in a matrix form, which is namely the transition probability matrix and denoted by $P^{(n)}$.

§4.11 第十一章：人寿保险的主要类型 Chapter Eleven: Main Types of Life Insurance

- 保单红利

  Reversionary Bonuses: In participating insurance, Reversionary bonuses are awarded during the term of the contract; once a reversionary bonus is awarded it is guaranteed.

- 分红保险

  Participating Insurance: Participating insurance is also known as with-profit insurance. Under with-profit arrangements, the profits earned on the invested premiums are shared with the policyholders. In North America, the with-profit arrangement often takes the form of cash dividends or reduced premiums. In the UK and in Australia the traditional approach is to use the profits to increase the sum insured, through bonuses called "reversionary bonuses" and "terminal bonuses".

- 投资连结保险

  Equity-linked Insurance: Equity-linked insurance has a benefit linked to the performance of an investment fund. There are two different forms. The first is where the policyholder's premiums are invested in an open-ended investment company style account; at maturity, the benefit is the accumulated value of the premiums. The is a guaranteed minimum death benefit payable if the policyholder dies before the contract matures. In some cases, there is also a guaranteed maturity benefit. The second form of equity-linked insurance is the equity-indexed annuity(EIA) in USA. Under an EIA the policyholder is guaranteed a minimum return on their premium. At maturity, the policyholder receives a proportion of the return on a specified stock index, if that is greater than the guaranteed minimum return.

- 万能保险

  Universal Life Insurance: Universal life insurance combines investment and life insurance. The policyholder determines a premium and a level of life insurance over. Some of premium is used to fund the life insurance; the remainder is paid into an investment fund. Premiums are flexible, as long as they are sufficient to pay for the designated sum insured under the term insurance part of the contract. Under variable universal life, there is a range of funds available for the policyholder to select from.

§4.12 第十二章：特殊年金与保险 Chapter Twelve: Special Life Annuities and Insurance

- 分期退还年金

  Installment Refund Annuity: For the installment refund annuity contract, a sufficient number of payments is guaranteed so that the annuitant receives at least as much as the contract premium that was paid. Thus, for such a continuous annuity with contract premium, G, the actuarial present value of benefits is

$$\bar{a}_{\overline{G}|} + {}_G E_x \bar{a}_{x+G}.$$

- 假设投资收益率

  Assumed Investment Return

- 家庭收入保险
  Family Income Insurance: An n-year family income insurance provides an income from the data of death of the insured, continuing until n years have elapsed from the date of issue of the policy. It is typically paid for by premiums over the n-year period, or some period shorter than n years, to keep benefit reserves positive. For a continuous annuity, if T is the time of death of the insured, the present value of benefits is

$$Z = \begin{cases} v^T \bar{a}_{\overline{n-T|}}, T \leq n \\ 0, T > n. \end{cases}$$

- 退休收入保险
  Retirement Income Insurance
- 现金退还年金
  Partial Cash Refund Annuity: In a cash refund annuity contract, the death benefit is defined as the excess, if any, of the contract premium paid over the annuity payments received. If G is the single contract premium and T is the time of death, the present value of benefits on a continuous basis is

$$Z = \begin{cases} \bar{a}_{\overline{T|}} + (G-T)v^T, T \leq G \\ \bar{a}_{\overline{T|}}, T > G \end{cases}.$$

- 最低保证年金
  Guaranteed Minimum Annuity:

§4.13 第十三章：寿险定价概述 Chapter Thirteen: Introduction on Pricing

This chapter contains reading materials, and most of technique terms can be found in previous context.

§4.14 第十四章：资产份额定价法 Chapter Fourteen: Calculation on Assets Share

- 风险贴现利率
  Risk Adjusted Discount Rate: Opposite to the risk free rate, risk adjusted discount rate is used to discount the risky cash flow which has possibilities to occur default.
- 积累盈余
  Emerging Surplus
- 利润边际
  Profit Margin: In life insurance, the profit margin is the net present value expressed as a proportion of the expected present value of the premiums, evaluated at the risk discount rate.
- 投资回报率
  Internal Rate of Return: The internal rate of return (IRR) is the interest rate such that the present value of the expected cash flows in zero.
- 盈余平衡年
  Payback Period: Payback period in capital budgeting refers to the period of time required for the return on an investment to "repay" the sum of the original investment.
- 资产份额
  Assets Share: In practice, the invested premiums may have earned a greater or smaller rate of return than that used in the premium basis, the expenses and mortality experience will differ from the premium basis. Each policy contributes to the total assets of the insurer through the actual investment, expense and mortality experience. It is of practical importance to calculate the share of the insurer's assets attributable to each policy in force at any given time. This amount is known as the asset share of the policy at that time and it is calculated by assuming the policy being considered is one of a large group of identical policies issued simultaneously.

§4.15 第十五章：资产份额法的进一步应用 Chapter Fifteen: Further Applications of Asset Share

- 通货膨胀
  Inflation: In economics, inflation is a rise in the general level of prices of goods and services in an economy over a period of time.
- 退保
  Withdraw

§4.16 第十六章：保单现金价值及退保选择权 Chapter Sixteen: Cash Values and Withdraws

- 现金价值
  Cash Value: A policy which is canceled at the the request of the policyholder before the end of its originally agreed term, is said to lapse or to be surrendered, and any lump sum payable by the insurance company for such a policy is called a surrender value or a cash value.
- 展期保险
  Extended Insurance

§4.17 第十七章：准备金评估I Chapter Seventeen: Valuation on Reserves I

- 敏感性测试
  Sensitivity Test: Sensitivity test is the study of how the variation in the output of a mathematical model can be apportioned, qualitatively or qualitatively, to different sources of variation in the input of the model.

§4.18 第十八章:准备金评估II Chapter Eighteen: Valuation on Reserves II

- 偿付能力
  Solvency: The solvency of a company indicates its ability to meet its long-term fixed expenses and to accomplish long-term expansion and growth.

§4.19 第十九章：偿付能力监管制度介绍 Chapter Nineteen: Introduction on Supervisory System of Insurance Solvency

This chapter contains reading materials, and most of technique terms can be found in previous context.

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