NRK's Statistics Chart Book

Dear Students,

This chart book is designed to help you revise and reinforce the key concepts you have learned in the main book.

Please use this chart book only after you have thoroughly studied the main book. It is intended to be a tool for quick reference and review, not a replacement for comprehensive study.

As you go through these charts, remember to:

1. **Revisit the Concepts**: Use this as an opportunity to refresh your memory on the key points.
2. **Test Your Understanding**: Try to recall details and explain the concepts in your own words.
3. **Identify Gaps**: Note any areas where you feel less confident and revisit those sections in the main book.

Happy studying, and best of luck in your revision!

Sincerely,

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	$\text{Frequency density} = \frac{\text{Class frequency}}{\text{Class length}}$
	$\text{RF} = \frac{\text{Class frequency}}{\text{Total frequency}}$
	$\text{Percentage frequency} = \text{RF} \times 100$
	Pie Chart $\text{Central angle} = \frac{x}{\sum x} \times 360$
	$\text{Number of Classes} = \frac{\text{Range}}{\text{Class length}}$ $\text{Number of classes} = 1 + 3.322 \log N$
	$\text{Range} = \text{Largest observation} - \text{Smallest observation}$

	Arithmetic Mean (AM) for ungrouped data $= \frac{\sum x}{n}$
	
	• If x_i are the original observations and $\bar{x}$ is their arithmetic mean:
	  ◦ Adding k: New observations are $x_i + k$, and the new mean is $\bar{x} + k$.
	  ◦ Subtracting k: New observations are $x_i - k$, and the new mean is $\bar{x} - k$.
	  ◦ Multiplying by k: New observations are $x_i \times k$, and the new mean is $\bar{x} \times k$.
	  ◦ Dividing by k: New observations are $\frac{x_i}{k}$, and the new mean is $\frac{\bar{x}}{k}$.

	Combined Mean $= \frac{n_1\bar{X}_1 + n_2\bar{X}_2}{n_1 + n_2}$

For grouped data, the arithmetic mean $\bar{X}$ can be calculated using the formula:

$$\bar{X} = \frac{\Sigma f \cdot x}{N}$$

where:

- $\bar{X}$ is the arithmetic mean.
- f represents the frequency of each group.
- x represents the mid-point of each group.
- N is the total number of observations, calculated as $N = \Sigma f$.

Median (M) for Ungrouped Data:

If the number of observations (n) is odd:

$$M = \left(\frac{n+1}{2}\right) \text{th observation}$$

This means the median is the observation at the position $\frac{n+1}{2}$ in the sorted list.

If the number of observations (n) is even:

$$M = \text{Arithmetic Mean of the } \left(\frac{n}{2}\right) \text{th and } \left(\frac{n}{2}+1\right) \text{th observations}$$

Median for discrete grouped data

Step 1.Find the Less Than Cumulative Frequencies (LCF):

Calculate the cumulative frequency for each class by adding the frequency of the current class to the sum of the frequencies of all previous classes.

Step 2.Determine the Median Position:

Identify the median position using

$$Median\ Position = \left(\frac{N+1}{2}\right)^{th} value$$

N is the sum of all frequencies.

Step 3.Identify the Median Value:

Find the first cumulative frequency that is greater than the median position determined in step 2. The corresponding value of x (the variable representing the data) will be the median

	Median for Continuous Grouped Data $$M = l_1 + \left(\frac{\frac{N}{2} - cf}{f}\right) \times c$$ where: • l_1 → LCB of the median class • l_2 → UCB of the median class • c → Length of the median class $= l_2 - l_1$ • f → Median class frequency
Mode for Ungrouped Data	It is the observation that occurs the most number of times.

Mode for Grouped Data

$$Z = l_1 + \left(\frac{f_1 - f_0}{2f_1 - f_0 - f_2}\right) \times C$$

where,

- l_1 → LCB of the modal class
- C → Modal class length

$$C = l_2 - l_1$$

- l_2 → UCB of the modal class
- f_1 → Frequency of the modal class (highest frequency)
- f_0 → Frequency of the class before the modal class
- f_2 → Frequency of the class after the modal class

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Relationship between mean, Median & mode	a) **For symmetrical distribution** $$\text{Mean} = \text{Median} = \text{Mode}$$ b) **For positively skewed (skewed right) distribution** $$\text{Mean} > \text{Median} > \text{Mode}$$ c) **For negatively skewed (skewed left) distribution** $$\text{Mode} > \text{Median} > \text{Mean}$$ d) **For moderately skewed distribution** $$\text{Mean} - \text{Mode} = 3(\text{Mean} - \text{Median})$$ or $$\text{Mode} = 3(\text{Median}) - 2(\text{Mean})$$

Quartiles (Q) Deciles (D) Percentiles (P)	**For Ungrouped Data** $Q_i = \left[\frac{i}{4}(n+1)\right]^{th}$ value $D_i = \left[\frac{i}{10}(n+1)\right]^{th}$ value $P_i = \left[\frac{i}{100}(n+1)\right]^{th}$ value where n is the number of observations.
	For Discrete Grouped Data $Q_i = \left[\frac{i}{4}(N+1)\right]^{th}$ value $D_i = \left[\frac{i}{10}(N+1)\right]^{th}$ value $P_i = \left[\frac{i}{100}(N+1)\right]^{th}$ value where $N = \Sigma f$ (sum of frequencies).

For Continuous Grouped Data:

$$Q_i = l_1 + \left[\frac{\frac{iN}{4} - cf}{f}\right] \times C$$

$$D_i = l_1 + \left[\frac{\frac{iN}{10} - cf}{f}\right] \times C$$

$$P_i = l_1 + \left[\frac{\frac{iN}{100} - cf}{f}\right] \times C$$

where:

- $\frac{iN}{4} > cf$, $\frac{iN}{10} > cf$, $\frac{iN}{100} > cf$

Partition class is a class next to cf

- f → The frequency of the partition class.
- l_1 → LCB of the partition class.
- l_2 → UCB of the partition class.
- C → Class width $(l_2 - l_1)$

GM For Ungrouped Data

$$\text{GM} = (X_1 \times X_2 \times X_3 \times \ldots \times X_n)^{1/n}$$

Or

$$(\text{GM})^n = (X_1 \times X_2 \times X_3 \times \ldots \times X_n)$$

where n → number of observations.

Harmonic mean (HM)	**For Ungrouped Data** $$\text{HM} = \frac{n}{\sum\left(\frac{1}{x}\right)}$$ where n → number of observations. $$\sum \frac{1}{x} = \frac{1}{x_1} + \frac{1}{x_2} + \ldots + \frac{1}{x_n}$$ **For Grouped Data** $$\text{HM} = \frac{N}{\sum\left(\frac{f}{x}\right)}$$ where $N = \sum f$ (sum of frequencies). $$\sum\left(\frac{f}{x}\right) = \frac{f_1}{x_1} + \frac{f_2}{x_2} + \ldots + \frac{f_n}{x_n}$$

	$\text{Combined HM} = \frac{n_1+n_2}{\frac{n_1}{H_1}+\frac{n_2}{H_2}}$ where n_1 & n_2 → number of observations, H_1 & H_2 → Harmonic means. **HM of any two observations** $\text{HM} = \frac{n}{\sum\left(\frac{1}{x}\right)} = \frac{2}{\frac{1}{a}+\frac{1}{b}} = \frac{2ab}{a+b}$
Relationship between AM, GM, and HM	→ If the observations are positive and equal, then: $\text{AM} = \text{GM} = \text{HM}$ → If the observations are positive and distinct, then: $\text{AM} > \text{GM} > \text{HM}$ → For any two observations a & b, GM is the GM of AM and HM: i.e., $\text{GM} = \sqrt{\text{AM} \times \text{HM}}$

When dealing with two variables x and y that have a linear relationship given by the equation $ax + by + c = 0$, you can determine the central tendency (mean, median, or mode) of y if you know the central tendency of x. The steps to do this are as follows:

1. **Identify the Central Tendency of x:**
   - Determine the central tendency (e.g., mean, median, or mode) of the variable x. Let this be denoted as CT_x.
2. **Use the Linear Relationship:**
   - Substitute CT_x into the linear equation in place of x.
3. **Solve for the Central Tendency of y:**
   - Solve the resulting equation for y to find the central tendency of y. Let this be denoted as CT_y.

Dispersion	
	$\text{Range} = L - S$ where: • L is the largest observation • S is the smallest observation **Coefficient of Range:** $\text{Coefficient of Range} = \left(\frac{L-S}{L+S}\right) \times 100$

Mean Deviation	**For Ungrouped Data:** • **MD about Mean:** $$\text{MD about mean} = \frac{\sum \lvert x - \bar{x} \rvert}{n}$$ • **MD about Median:** $$\text{MD about Median} = \frac{\sum \lvert x - M \rvert}{n}$$
	For Grouped Data (both Discrete and Continuous): • MD about Mean ($\bar{x}$): $$\text{MD about } \bar{x} = \frac{\sum f \cdot \lvert x - \bar{x} \rvert}{N}$$ • MD about Median (M): $$\text{MD about M} = \frac{\sum f \cdot \lvert x - M \rvert}{N}$$

Coefficient of MD about $\bar{x}$:

$$\text{Coefficient of MD about } \bar{x} = \left(\frac{\text{MD about } \bar{x}}{\bar{x}}\right) \times 100$$

Coefficient of MD about Median (M):

$$\text{Coefficient of MD about M} = \left(\frac{\text{MD about M}}{M}\right) \times 100$$

For Ungrouped Data:

Standard Deviation (SD):

$$\text{SD} = \sqrt{\frac{\sum x^2}{n} - (\bar{x})^2}$$

OR

$$\text{SD} = \sqrt{\frac{\sum (x-\bar{x})^2}{n}}$$

where $\bar{x} = \frac{\sum x}{n}$

	Standard Deviation (SD) for Grouped Data: $\mathrm{SD} = \sqrt{\frac{\sum fx^2}{N} - (\bar{x})^2}$ where $\bar{x} = \frac{\sum fx}{N}$ **OR** $\mathrm{SD} = \sqrt{\frac{\sum f(x-\bar{x})^2}{N}}$
	Coefficient of Variation (CV): $\mathrm{CV} = \left(\frac{\mathrm{SD}}{\mathrm{AM}}\right) \times 100$ where: • **SD** is the standard deviation of the data set. • **AM** is the arithmetic mean of the data set.

Combined Standard Deviation (SD):

$$\text{Combined SD} = \sqrt{\frac{n_1 s_1^2 + n_2 s_2^2 + n_1 d_1^2 + n_2 d_2^2}{n_1 + n_2}}$$

where:

- $d_1^2 = (\bar{x}_1 - \bar{x}_c)^2$
- $d_2^2 = (\bar{x}_2 - \bar{x}_c)^2$
- $\bar{x}_c$ is the combined mean:

$$\bar{x}_c = \frac{n_1 \bar{x}_1 + n_2 \bar{x}_2}{n_1 + n_2}$$

Quartile Deviation (QD) and Coefficient of QD:

$$\text{QD} = \frac{Q_3 - Q_1}{2}$$

- $Q_3 - Q_1$ is called the interquartile range.
- $\frac{Q_3 - Q_1}{2}$ = QD is called the semi-interquartile range.

Coefficient of QD:

$$\text{Coefficient of QD} = \left(\frac{Q_3 - Q_1}{Q_3 + Q_1}\right) \times 100$$

	Relationship between SD, MD, & QD for Normal or Symmetrical Distribution: $2\text{SD} = 2.5\text{MD} = 3\text{QD}$ **Note:** $\text{SD} > \text{MD} > \text{QD}$
	If x and y are two variables related as $ax + by + c = 0$, with the dispersion of x given, then: $\text{Dispersion of } y = \left\lvert \frac{a}{b} \right\rvert \times \text{dispersion of } x$

Chapter 15-Probability	
	If A is an event, then the probability of occurrence of A is given by: $P(A) = \frac{n(A)}{n(S)}$ where: • $n(A)$ is the number of favorable outcomes. • $n(S)$ is the total number of possible outcomes.
	For tossing of a coin: $n(S) = 2^n$ where n is the number of coin tosses.

	The probability of getting head and tail alternately on tossing a coin n times is: $\text{Probability} = \frac{2}{2^n}$
	For tossing a die: $n(S) = 6^n$ where n is the number of die tosses.
	Total number of cards: 52 • Red Cards: 26 Hearts: 13 Diamonds: 13 • Black Cards: 26 Spades: 13 Clubs: 13

	Each Suit of 13 Cards Consists of: ● Number cards (2 through 10): 9 per suit ● King: 1 per suit ● Queen: 1 per suit ● Jack: 1 per suit ● Ace: 1 per suit **Number of Face Cards:** ● Kings, Queens, and Jacks are considered face cards. ● the number of face cards in the entire deck= **12 face cards in total.**
	$P(A \cup B)$ represents the probability of A or B. $P(A \cap B)$ represents the probability of A and B.
	The probability that either A or B occurs (probability that at least 1 event occurs): $P(A \cup B) = P(A) + P(B) - P(A \cap B)$

	If A & B are mutually exclusive $P(A \cup B) = P(A) + P(B)$
	A & B are said to be exhaustive when $n(A \cup B) = n(S)$ $P(A \cup B) = 1$
	If A & B are mutually exclusive & exhaustive $P(A) + P(B) = 1$
	Conditional Probability $P(A\|B) = \frac{P(A \cap B)}{P(B)} = \frac{n(A \cap B)}{n(B)}$ This represents the probability of A occurring given that B has occurred.

	Similarly, the probability of occurrence of B given that event A has already occurred is: $P(B\|A) = \frac{P(A \cap B)}{P(A)} = \frac{n(A \cap B)}{n(A)}$
	Independent Events $P(A\|B) = P(A)$ $P(B\|A) = P(B)$ $P(A\|B') = P(A)$ $P(B\|A') = P(B)$
	Probability that at least one event occurs For three events A, B, and C, the probability that at least one of these events occurs is given by: $P(A \cup B \cup C) = P(A) + P(B) + P(C) - P(A \cap B) - P(B \cap C) - P(A \cap C) + P(A \cap B \cap C)$

	De Morgan's Theorem 1. $P(A' \cap B') = P(A \cup B)'$ 2. $P(A' \cup B') = P(A \cap B)'$
	Probability Distribution $\sum P(x) = 1$
	Mathematical Expectation of x $E(x) = \sum x \cdot P(x)$ $E(x^2) = \sum x^2 \cdot P(x)$

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	Variance of X $V(x) = E(x^2) - [E(x)]^2$
	Bayes' Theorem $P(E_i\|A) = \frac{P(A\|E_i) \cdot P(E_i)}{\sum P(A\|E_j) \cdot P(E_j)}$
Chapter 16-Theoretical Distribution	
	Binomial Probability Mass Function (PMF): $P(x) = \binom{n}{x} p^x q^{n-x}$ where: • x: Binomial variate (number of successes in n trials) • q: Probability of failure ($q = 1 - p$)

	Mean of a Binomial Distribution $$\text{Mean} = np$$
	Standard Deviation of a Binomial Distribution $$\text{Standard Deviation} = \sqrt{npq}$$
	Variance of a Binomial Distribution $$\text{Variance} = (\sqrt{npq})^2 = npq$$
	Poisson's Probability Mass Function (PMF) $$P(x) = \frac{e^{-m} m^x}{x!}$$

	x is the Poisson variate (the number of occurrences of the event). m (or λ) is the average number of occurrences in the given interval. e is the base of the natural logarithm, approximately equal to 2.72.
	Probability of x being odd: $P(x = \text{odd}) = \frac{1-e^{-2m}}{2}$ **Probability of x being even:** $P(x = \text{even}) = \frac{1+e^{-2m}}{2}$

Normal Probability Density Function (PDF)

$$f(x) = \frac{e^{-\frac{(x-\mu)^2}{2\sigma^2}}}{\sigma\sqrt{2\pi}}$$

μ is the mean of the distribution.

σ is the standard deviation of the distribution.

σ^2 is the variance of the distribution.

e is the base of the natural logarithm, approximately equal to 2.71828.

π is the mathematical constant Pi, approximately equal to 3.14159.

Chapter 17-Correlation and Regression	
	Conditional Distributions: If there are p classifications for x and q classifications for y: • There would be a total of $(p + q)$ conditional distributions.
	Bivariate Frequency Table: For a bivariate frequency table having $(p + q)$ classifications: • The total number of cells is equal to pq.
	Marginal Distributions: For $p \times q$ bivariate distributions: • The number of marginal distributions is 2.

Correlation Coefficient (r):

The value of r lies between -1 and +1 (both inclusive).

Perfect Positive Correlation:

- If $r = 1$, then the correlation is perfect positive.

Perfect Negative Correlation:

- If $r = -1$, then the correlation is perfect negative.

Low Degree Positive Correlation:

- If $0 < r < 0.25$, then the correlation is low degree positive.

Moderate Degree Positive Correlation:

- If $0.25 < r < 0.75$, then the correlation is moderate degree positive.

High Degree Positive Correlation:

- If $0.75 < r < 1$, then the correlation is high degree positive.

High Degree Negative Correlation:

- If $-1 < r < -0.75$, then the correlation is high degree negative.

Moderate Degree Negative Correlation:

- If $-0.75 < r < -0.25$, then the correlation is moderate degree negative.

	Low Degree Negative Correlation: • If $-0.25 < r < 0$, then the correlation is low degree negative. **No Correlation:** • If $r = 0$, then it is said to be no correlation or zero correlation.
	Karl Pearson's Correlation Coefficient (Product Moment Correlation Coefficient): $$r_{xy} = \frac{\text{Cov}(x,y)}{S_x S_y}$$ $$r_{xy} = \frac{n\sum xy - \sum x \sum y}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

	Karl Pearson's Correlation Coefficient (When Deviation is Taken from AM): $$r_{uv} = \frac{\sum dx \cdot dy}{\sqrt{\sum dx^2 \cdot \sum dy^2}}$$ $$r_{uv} = \frac{\sum dx \cdot dy}{nS_x S_y}$$
	To Determine the Nature of r When x and y are Related by the Equation $ax + by + c = 0$: Perfect Positive Correlation: • If, on increasing x, y also increases, then the correlation is perfect positive. Perfect Negative Correlation: • If, on increasing x, y decreases, then the correlation is perfect negative.

Spearman's Rank Correlation Coefficient (With Tie):

$$r_r = 1 - \left[\frac{6\left(\sum d^2 + \frac{\sum(t^3 - t)}{12}\right)}{n^3 - n} \right]$$

$\sum d^2$ is the sum of the squares of rank differences.

$d^2 = (x_R - y_R)^2$

t is the tie length.

n is the number of observations.

Spearman's Rank Correlation Coefficient (Without Tie):

$$r_r = 1 - \left(\frac{6\sum d^2}{n^3 - n} \right)$$

	Important Notes on Spearman's Rank Correlation Coefficient: • $r_r = -1$ when the ranks are in reverse order. • The association between the two variables need not be linear. • The sum of the rank differences will always be zero.
	Coefficient of Concurrent Deviation: $r_{cd} = \pm\sqrt{\frac{\pm(2c-m)}{m}}$

	c is the number of concurrent deviations. m is the number of pairs of deviation. $m = n - 1$ n is the number of pairs of observations.
	Probable Error (PE): $\mathrm{PE} = 0.6745\dfrac{(1-r^2)}{\sqrt{n}}$ PE is never negative. If r is less than the probable error, then there is no evidence of correlation.
	Standard Error (SE): $\mathrm{SE} = 1.5 \times \mathrm{PE}$

The value of r is said to be significant if $r > 6 \times \text{PE}$.

Coefficient of Determination:

- Definition:
  - It describes the amount of explained variation.
  - It is the square of the correlation coefficient (r^2).

Coefficient of Non-Determination:

- Definition:
  - It describes the amount of unexplained variation.
  - It is given by $(1 - r^2)$.

	b_{yx} is the regression coefficient of y on x and it is given by: $$b_{yx} = r \cdot \frac{S_y}{S_x}$$ $$b_{yx} = \frac{n\sum xy - \sum x \sum y}{n\sum x^2 - (\sum x)^2}$$
	b_{xy} is the regression coefficient of x on y and it is given by: $$b_{xy} = r \cdot \frac{S_x}{S_y}$$ $$b_{xy} = \frac{n\sum xy - \sum x \sum y}{n\sum y^2 - (\sum y)^2}$$

Relationship Between Regression Coefficients and Correlation Coefficient:

Definition:

- The correlation coefficient is the geometric mean (GM) of the regression coefficients.

Formula:

$$r = \pm\sqrt{b_{xy} \cdot b_{yx}}$$

r is positive when both b_{xy} and b_{yx} are positive.

r is negative when both b_{xy} and b_{yx} are negative.

To Find r When Regression Lines Are Given

1. Assumption:

Assume one of the regression lines as y on x and the other line as x on y.

2. Finding Regression Coefficients:

Proceed to find b_{xy} and b_{yx} by comparing with the equations $y = a + b_{yx} \cdot x$ and $x = a + b_{xy} \cdot y$.

3. Calculating r:

$$r = \pm\sqrt{b_{xy} \cdot b_{yx}}$$

4. Validation:

If the value of r is within the range, then the assumptions are correct, and the obtained value for r is correct.

Otherwise, reverse the assumptions. In that case:

$$b_{yx} = \frac{1}{b_{xy}} \quad \text{and} \quad b_{xy} = \frac{1}{b_{yx}}$$

Chapter 18-Index numbers	
	$$\text{Simple Aggregative Price Index} = \frac{\sum P_1}{\sum P_0} \times 100$$ P_1 → Current year price. P_0 → Base year price.
	$$\text{Simple Relative Price Index} = \frac{\sum \left(\frac{P_1}{P_0}\right)}{N} \times 100$$ N → Number of commodities.

	Laspeyres Index (L): $$L = \frac{\sum(P_1 q_0)}{\sum(P_0 q_0)} \times 100$$ P_1 → Current year price. P_0 → Base year price. q_0 → Base year quantity.
	Paasche Index (P): $$P = \frac{\sum(P_1 q_1)}{\sum(P_0 q_1)} \times 100$$ P_1 → Current year price. P_0 → Base year price. q_1 → Current year quantity.
	Bowley's Index (B): $$B = \frac{L + P}{2}$$

	Fisher's Index (F): $F = \sqrt{L \times P}$ $$F = \sqrt{\left(\frac{\sum(P_1 q_0)}{\sum(P_0 q_0)}\right) \times \left(\frac{\sum(P_1 q_1)}{\sum(P_0 q_1)}\right)} \times 100$$
	Marshall's Index (M): $$M = \frac{\sum P_1(q_0 + q_1)}{\sum P_0(q_0 + q_1)} \times 100$$ P_1 → Current year price. P_0 → Base year price. q_0 → Base year quantity. q_1 → Current year quantity.

	Consumer Price Index (CPI): $$\text{CPI} = \frac{\sum Iw}{\sum w}$$ $I \rightarrow$ Group index. $w \rightarrow$ Weight.
	$$\text{Deflated value} = \frac{\text{current value}}{\text{current year CPI}}$$
	$$\text{Shifted Price Index} = \left(\frac{\text{original Price Index}}{\text{Price Index of the year to which it has to be shifted}}\right) \times 100$$
	Chain Index Number (CIN): $$\text{CIN} = \frac{\text{Link Relative of current year} \times \text{CIN of Previous year}}{100}$$

	$$\text{Purchasing Power of Money} = \frac{1}{\text{Price Index Number}}$$
	$$\text{Real Wages} = \frac{\text{Current year wages}}{\text{Current year CPI}} \times \text{Base year CPI}$$
	$$\text{Percentage Increase in Real Wages} = \left[1 - \left(\frac{1 + \%\text{Increase in Price}}{1 + \%\text{Increase in Wages}}\right)\right] \times 100$$ % Increase in price is the rate of inflation.
	Time Reversal Test (TRT): **Condition for Satisfying TRT:** • The index should satisfy the condition: $$P_{01} \times P_{10} = 1$$

	• P_{01} represents the index from period 0 to 1. • P_{10} represents the index from period 1 to 0.
	Factor Reversal Test (FRT): Condition for Satisfying FRT: $$P_{01} \times q_{01} = V_{01} = \frac{\sum P_1 q_1}{\sum P_0 q_0}$$ Only Fisher's Index satisfies the Factor Reversal Test.
	Circular Test: **Condition for Satisfying Circular Test:** $$P_{01} \times P_{12} \times P_{20} = 1$$

	Fisher's Index fails to satisfy the Circular Test. The circular test is satisfied by the Simple Geometric Mean (GM) of price relatives and weighted aggregative index with fixed weights.
	$$\text{Current Year Salary} = \frac{\text{Base Year Salary} \times \text{Current Year CPI}}{\text{Base Year CPI}}$$