

FinQuiz Formula Sheet CFA Program Level I

QUANTITATIVE METHODS

Learning Module 1: Rates and Returns

1. Interest Rate r

r = Real risk-free rate + Inflation premium + Default risk premium + Liquidity premium + Maturity premium

Nominal risk-free rate = Real risk-free rate + Inflation premium

2. Holding Period Return (HPR)

$$R = \frac{(P_1 + P_0) + I_1}{P_0} - 1$$

where

P_0 = price at the beginning of period

P_1 = price at the end of period

I = income

3. Arithmetic mean (AM)

$$\bar{R}_i = \frac{R_{i1} + R_{i2} + \dots + R_{iT-1} + R_{iT}}{T}$$

$$= \frac{1}{T} \sum_{t=1}^T R_{it}$$

4. Geometric Mean Return

$$\bar{R}_{Gi} = \sqrt[T]{(1 + R_{i1}) \dots \times (1 + R_{iT})} - 1$$

where,

R_{it} = return in period t

T = total number of periods

5. Harmonic Mean

$$\bar{X}_H = n / \sum_{i=1}^n \left(\frac{1}{X_i} \right)$$

with $X_i > 0$ for $i = 1, 2, \dots, n$.

6. Money-weighted rate of return (MWR)

$$IRR = \sum_{t=0}^T \frac{CF_t}{(1 + IRR)^t} = 0$$

where,

IRR = internal rate of return

T = number of periods

CF_t = cash flow at time t

7. Time-weighted Returns (TWR)

$$r_{twr} = [(1 + r_{t,1}) \times (1 + r_{t,2}) \times \dots \times (1 + r_{t,n})]^{1/N} - 1$$

8. Non-annual Compounding

PV (for more than one Compounding per year)

$$PV = FV_N \left(1 + \frac{r_s}{m} \right)^{-m \times N}$$

where r_s = stated annual rate

9. Annualized Return

$$r_{\text{annual}} = (1 + r_{\text{period}})^c - 1$$

where,

c = number of periods in a year

$$r_{\text{weekly}} = (1 + r_{\text{daily}})^5 - 1;$$

$$r_{\text{weekly}} = (1 + r_{\text{annual}})^{1/32} - 1$$

10. Continuously Compounded Return CCR

CCR associated with a HPR (t to $t + 1$)

$r_{t, t+1} = \ln(1 + \text{holding period return})$ or

$r_{t, t+1} = \ln(\text{price relative}) = \ln(P_{t+1}/P_t) = \ln(1 + R_{t,t+1})$

CCR associated with a HPR (0 to T)

$R_{0,T} = \ln(P_T/P_0)$ or

$$r_{0,T} = r_{T-1,T} + r_{T-2,T-1} + \dots + r_{0,1}$$

11. Gross Return

Gross return = Return – trading expenses – Other expense directly related to the generation of returns

12. Net Return

Net Return = Gross Return – all managerial and administrative expenses

13. After-Tax Nominal Return

After-tax nominal return = Total return – any allowance for taxes on dividends, interest & realized gains

14. Real Returns

$$(1 + r) = (1 + r_{rF}) \times (1 + \pi) \times (1 + RP)$$

$$(1 + r_{\text{real}}) = (1 + r_{rF}) \times (1 + RP) \text{ or}$$

$$(1 + r_{\text{real}}) = (1 + r) \div (1 + \pi)$$

where,

r = Nominal return

r_{rF} = Real risk-free return

π = Inflation

RP = Risk premium

Learning Module 2:**The Time Value of Money in Finance****1. Present Value (PV) and Future Value (FV) Relation**

$$FV_N = PV(1 + r)^N$$

$$FV_N = PVe^{r_s \times N} \text{ (for continuous compounding)}$$

$$PV = FV_t(1 + r)^{-t} \text{ or } PV = \frac{FV_t}{(1 + r)^t}$$

$$PV = FV e^{-rt} \text{ (for continuous compounding)}$$

*PV for Fixed Income***2. Discount Instrument:**

$$PV = \frac{FV_t}{(1 + r)^t}$$

3. Coupon Instrument:

$$P = \frac{PMT_1}{(1 + r)^1} + \frac{PMT_2}{(1 + r)^2} \cdots \frac{PMT_N + FV_N}{(1 + r)^N}$$

4. Perpetual Bond

$$PV = PMT/r$$

5. Annuity Instruments

$$A = \frac{r(PV)}{1 - (1 + r)^{-t}}$$

A = periodic cash flow.

r = market interest rate per period.

PV = initial value/principal of the loan or bond.

t = total no. of payment periods.

*PV for Equity***6. Constant Dividends**

$$PV_t = \frac{D_t}{r}$$

7. Constant Dividend Growth Rate

$$D_{t+1} = D_t(1 + g)$$

$$PV_t = \frac{D_t(1 + g)}{(r - g)}$$

assuming $r - g > 0$

8. Changing Dividend Growth Rate

$$PV_t = \sum_{i=1}^n \frac{D_t(1 + g_s)^i}{(1 + r)^i} + \frac{E(S_{t+n})}{(1 + r)^n}$$

where $E(S_{t+n})$ = stock value in n period

$$E(S_{t+n}) = \frac{D_{t+n+1}}{r - g_l}$$

9. Implied Return for Fixed-Income

$$\text{Implied return: } r = \left(\frac{FV_t}{PV} \right)^{1/t} - 1$$

$$PV (\text{Coupon Bond}) = \sum_{i=1}^N \frac{PMT_i}{(1 + r)^i}$$

10. Implied Return and Implied Growth for Equity

$$\text{Implied Return: } r = \frac{D_t(1 + g)}{PV_t} + g$$

$$\text{Implied Growth: } g = r - \frac{D_{t+1}}{PV_t}$$

where $D_t(1 + g) = D_{t+1}$

11. Price-to-Earnings Ratio (P/E):

$$\frac{PV_t}{E} = \frac{D_t}{E_t} \times \frac{(1 + g)}{r - g}$$

where

$$PV_t = \frac{D_t(1 + g)}{r - g}$$

12. Forward P/E Ratio

$$\frac{PV_t}{E_{t+1}} = \frac{\frac{D_{t+1}}{E_{t+1}}}{r - g}$$

13. Cash Flow Additivity

Two-Year Bond Future Value:

$$FV_{2\text{ yrs}} = 1(1 + r_2)^2$$

14. Forward Exchange Rates

$$F = S_0 \times \frac{(1 + r_d)}{(1 + r_f)}$$

where

 d = domestic currency f = foreign currency**Learning Module 3****Statistical Measures of Asset Returns**Measures of Central Tendency**1. Arithmetic Mean: AM**

$$AM = \frac{\text{Sum of obsv in database}}{\text{No. of obsv in the database}}$$

2. Sample Mean \bar{X}

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

where,

 X_i = i^{th} observation N = no. of observations in the sample**3. Median = Middle Value**

- For Even no of obsv locate median at $\frac{n}{2}$
- For Odd no. of obsv locate median at mean of $\frac{n}{2}$ and $\frac{(n+1)}{2}$

4. Mode

Observation that occurs most frequently in the distribution

5. Weighted Mean: \bar{X}_w

$$\bar{X}_w = \frac{\sum_{i=1}^n w_i X_i}{\sum_{i=1}^n w_i} = \frac{(w_1 X_1 + w_2 X_2 + \dots + w_n X_n)}{\sum_{i=1}^n w_i}$$

where,

 X_1, X_2, \dots, X_n = observed values w_1, w_2, \dots, w_n = Corresponding weights, sum to 1.**6. Geometric Mean: GM**

$$GM = \sqrt[n]{X_1 X_2 \dots X_n} \text{ with } X_i \geq 0 \text{ for } i = 1, 2, \dots, n.$$

or

$$\ln G = \frac{1}{n} \ln(X_1 X_2 X_3 \dots X_n)$$

or

$$\ln G = \frac{\sum_{i=1}^n \ln X_i}{n}$$

$$G = e^{\ln G}$$

7. Harmonic Mean: H.M

$$H.M = \bar{X}_H = \frac{n}{\sum_{i=1}^n \left(\frac{1}{X_i}\right)}$$

with $X_i > 0$ for $i = 1, 2, \dots, n$.Measures of Location**8. Four Measures called Quantiles (collectively)**

- Quartiles = $\frac{\text{Distribution}}{4}$
- Quintiles = $\frac{\text{Distribution}}{5}$

- Deciles = $\frac{\text{Distribution}}{10}$,
- Percentiles = $L_y = (n + 1) \frac{y}{100}$
- Interquartile range (IQR) = $Q3 - Q1$

Measures of Location**9. Range** = Max. value – Min value**10. Mean Absolute Deviation: MAD**

$$MAD = \frac{\sum_{i=1}^n |X_i - \bar{X}|}{n}$$

where,

 \bar{X} = Sample mean n = No. of observations in the sample**11. Sample Var: s^2**

$$s^2 = \frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n-1}$$

12. Sample Standard Deviation: S.D

$$\text{Sample S.D} = s = \sqrt{\frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n-1}}$$

13. Geometric vs. Arithmetic:

$$GM \approx AM - \frac{\text{Variance of } R}{2}$$

14. Semi-deviation (Semi S.D)

$$\text{Semi S.D} = \sqrt{\text{semivariance}} =$$

$$\sqrt{\sum_{\text{For all } X_i \leq \bar{X}} \frac{(X_i - \bar{X})^2}{n-1}}$$

15. Target Semi Var

$$\text{Target Semi-var} = \sum_{\text{For all } X_i \leq B} \frac{(X_i - B)^2}{n-1}$$

where $B = \text{Target Value}$

16. Target Semi-Deviation

$$\text{Target S.D} = \sqrt{\text{target semivariance}}$$

$$= \sqrt{\sum_{\text{For all } X_i \leq B} \frac{(X_i - B)^2}{n-1}}$$

17. Coefficient of Variation CV

$$CV = \left(\frac{s}{\bar{x}} \right)$$

where $s = \text{sample S.D}$ and $\bar{x} = \text{sample mean}$

18. Excess Kurtosis = Kurtosis - 3

Correlation Between Two Variables

19. Sample Covariance

$$s_{XY} = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{n-1}$$

where,

$n = \text{sample size}$

$X_i = \text{ith observation on variable } X$

$\bar{X} = \text{mean of the variable } X \text{ observations}$

$Y_i = \text{ith observation on variable } Y$

$\bar{Y} = \text{mean of the variable } Y \text{ observations}$

20. Correlation coefficient: r

$$r_{XY} = \frac{\text{covariance of } X \text{ and } Y}{\left(\begin{smallmatrix} \text{sample S.D} \\ \text{of } X \end{smallmatrix} \right) \left(\begin{smallmatrix} \text{sample S.D} \\ \text{of } Y \end{smallmatrix} \right)}$$

$$r = \frac{\text{cov}(x, y)}{\sqrt{\text{var}(x)} \sqrt{\text{var}(y)}}$$

Learning Module 4

Probability Trees and Conditional Expectations

1. Expected Value of Random Variable $E(X)$

$E(w_i X_i) = \text{Probability-weighted average of the possible outcomes}$

2. Variance of a random variable $\sigma^2(X)$

$$\sigma^2(X) = E\{[X - E(X)]^2\}$$

3. Standard Deviation S.D

$$S.D = \sqrt{\text{Variance}}$$

4. Conditional Expected Value: $E(X|S)$ of a random variable X given a scenario S .

$$E(X|S) = P(X_1|S)X_1 + P(X_2|S)X_2 + \dots + P(X_n|S)X_n$$

5. Total Probability Rule

$$E(X) = E(X|S)P(S) + E(X|S^c)P(S^c)$$

$$E(X) = E(X|S_1)P(S_1) + E(X|S_2)P(S_2) + \dots + E(X|S_n)P(S_n)$$

$$P(S_1) + \dots + P(S_n) = 1$$

where,

$E(X|S_i) = \text{Expected value of } X \text{ given Scenario } i$

$P(S_i) = \text{Probability of Scenario } i$

S_1, S_2, \dots, S_n are mutually exclusive and exhaustive scenarios.

6. Bayes' formula

$$\frac{P(\text{Event}|\text{New Information})}{P(\text{New Information}|\text{Event})} = \frac{P(\text{New Information})}{P(\text{Prior prob. of Event})}$$

Learning Module 5

Portfolio Mathematics

1. Expected Value of Weighted Sum of random Variables

$$E(w_i R_i) = w_i E(R_i)$$

where,

$w_i = \text{weight of variable } i$

$R_i = \text{random variable } i$

2. Expected Return on the Portfolio

$$E(R_p) = E(w_1 R_1 + w_2 R_2 + \dots + w_n R_n)$$

$$= w_1 E(R_1) + w_2 E(R_2) + \dots + w_n E(R_n)$$

3. Covariance between R_i and R_j

$$\text{Cov}(R_i, R_j) = \sum_{i=1}^n [p(R_i - E(R_i))(R_j - E(R_j))]$$

4. Portfolio variance

$$\sigma^2(R_p) = \sum_{i=1}^n \sum_{j=1}^n w_i w_j \text{Cov}(R_i, R_j)$$

For three assets

$$\sigma^2(R_p) = w_1^2 \sigma^2(R_1) + w_2^2 \sigma^2(R_2) + w_3^2 \sigma^2(R_3) + 2w_1 w_2 \text{Cov}(R_1, R_2) + 2w_1 w_3 \text{Cov}(R_1, R_3) + 2w_2 w_3 \text{Cov}(R_2, R_3)$$

where,

σ^2 = Corresponding variance of each asset in the portfolio

5. **Correlation:** $\rho(R_i, R_j)$
(b/w two random variables R_i, R_j)
$$\rho(R_i, R_j) = \frac{\text{Cov}(R_i, R_j)}{\sigma_{R_i} \times \sigma_{R_j}}$$

6. **Safety-first Ratio: SFRatio**
$$\text{SFRatio} = [E(R_p) - R_L] / \sigma_p$$

7. **Sharpe Ratio:**
$$= [E(R_p) - R_f] / \sigma_p$$

Learning Module 6 Common Probability Distributions

For lognormal random variable

- Mean: μ_L**
$$\mu_L = \exp(\mu + 0.50\sigma^2)$$
- Variance: σ_L^2**
$$\sigma_L^2 = \exp(2\mu + \sigma^2) \times [\exp(\sigma^2) - 1]$$
- Log Normal Price**
$$S_T = S_0 \exp(r_{0,T})$$

where,
 $\exp = e$ and $r_{0,t}$ = Continuously compounded return from 0 to T
- Price Relative**
= End price/Beg price
$$= S_{t+1} / S_t = 1 + R_{t,t+1}$$

where,
 $R_{t,t+1}$ = holding period return on the stock from t to $t + 1$.

5. **Continuously compounded return**
(associated with a holding period from t to $t + 1$)

$$r_{t,t+1} = \ln(1 + \text{holding period return})$$

or

$$r_{t,t+1} = \ln(\text{price relative}) = \ln(S_{t+1} / S_t) = \ln(1 + R_{t,t+1})$$

6. **Continuously compounded return**
(associated with a holding period from 0 to T)

$$R_{0,T} = \ln(S_T / S_0) \text{ or } r_{0,T} = r_{T-1,T} + r_{T-2,T-1} + \dots + r_{0,1}$$

where,
 $r_{T-1,T}$ = One-period continuously compounded returns

7. **When one-period continuously compounded returns are random variables.**
$$E(r_{0,T}) = E(r_{T-1,T}) + E(r_{T-2,T-1}) + \dots + E(r_{0,1}) = \mu T$$

$$\text{Variance} = \sigma^2(r_{0,T}) = \sigma^2 T$$

$$\text{S.D.} = \sigma(r_{0,T}) = \sigma\sqrt{T}$$

8. **Annualized volatility**
= sample S.D. of one period continuously compounded returns $\times \sqrt{T}$

Learning Module 7 Estimation and Inference

For Sample Mean

- Var of the distribution** = $\frac{\sigma^2}{n}$
- S.D of the distribution** = $\sqrt{\frac{\sigma^2}{n}}$
- Standard Error of the sample mean:**
 - When the population S.D (σ) is known = $\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}$
 - When the population S.D (σ) is unknown = $s_{\bar{X}} = \frac{s}{\sqrt{n}}$

where s = sample S.D
estimate of $s = \sqrt{\text{sample variance}} = \sqrt{s^2}$
$$s^2 = \frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n-1}$$

Learning Module 8 Hypothesis Testing

1. **Standard Error of Sample Mean $\sigma_{\bar{X}}$**
When Population S.D/variance is known
$$\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}$$

- Test statistic is **Z-distributed**

$$z = \frac{\bar{X} - \mu_0}{\frac{\sigma}{\sqrt{n}}}$$

2. Power of Test

= 1 - Prob of Type II Error

3. Test Statistic for a Test of Difference between Two Population Means

Normally Distributed Populations, Variances Unknown but Assumed Equal based on Independent samples

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\left(\frac{S_p^2}{n_1} + \frac{S_p^2}{n_2}\right)}}$$

where,

S_p^2 = Pooled estimator of the common variance.

$$S_p^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$$

where $df = n_1 + n_2 - 2$.

4. Test Statistic for a test of mean differences

Normally distributed populations, unknown population variances

- $t = \frac{\bar{d} - \mu_{d0}}{s_{\bar{d}}}$
- sample mean difference = $\bar{d} = \frac{1}{n} \sum_{i=1}^n d_i$

- sample variance = $S_d^2 = \frac{\sum_{i=1}^n (d_i - \bar{d})^2}{n-1}$
- sample S.D = $\sqrt{S_d^2}$
- sample error of the sample mean difference = $s_{\bar{d}} = \frac{S_d}{\sqrt{n}}$

5. Chi Square Test Statistic

For test concerning the value of a normal population variance

$$X^2 = \frac{(n-1)S^2}{\sigma_0^2}$$

where $(n-1) = df$ and $S^2 =$

$$\text{sample variance} = \frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n-1}$$

6. Chi Square Confidence Interval for variance

$$\text{Lower limit} = L = \frac{(n-1)S^2}{X_{\alpha/2}^2}$$

$$\text{Upper limit} = U = \frac{(n-1)S^2}{X_{1-\alpha/2}^2}$$

7. Test Statistic for a Test of Mean Differences

Normally Distributed Populations, Unknown Population Variances

$$t = \frac{\bar{d} - \mu_{d0}}{S_{\bar{d}}}$$

where,

- Sample mean difference = $\bar{d} = \frac{1}{n} \sum_{i=1}^n d_i$
- Sample variance = $S_d^2 = \frac{\sum_{i=1}^n (d_i - \bar{d})^2}{n-1}$
- Sample S.D. = $\sqrt{S_d^2}$

- n = number of pairs of observations
- Standard error of sample

$$\text{mean difference} = s_{\bar{d}} = \frac{S_d}{\sqrt{n}}$$

8. F-test

Test concerning differences between variances of two normally distributed populations.

$$F = \frac{S_1^2}{S_2^2}$$

where

S_1^2 = 1st sample var with n_1 obs $S_1^2 =$

2nd sample var with n_2 obs

$df_1 = n_1 - 1$ numerator df

$df_2 = n_2 - 1$ denominator df

9. Relation between Chi Square and F-distribution

$$F = \frac{X_1^2/m}{X_2^2/n}$$

where

- X_1^2 is one chi square random variable with one m df .
- X_2^2 is another chi square random variable with one n df .

Learning Module 9

Hypothesis Testing

Parametric Test of a Correlation

1. Consider two variables X & Y

$$r_{XY} = \frac{s_{XY}}{s_X s_Y}$$

s_{XY} = sample covariance between X & Y.

s_X & s_Y = S.D of X and Y respectively

2. Sample Correlation: r

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

3. Spearman Rank Correlation: r_s

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

- For small samples use table to find rejection points.
- For large sample size ($n > 30$) use t-test as below:

$$t = \frac{(n-2)^{1/2} r_s}{(1-r_s^2)^{1/2}}$$

4. Chi-Square Statistic: χ^2_s

Test of Independence

$$\chi^2 = \sum_{i=1}^m \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

where

- Σ sum of all cells,
- O_{ij} is observed frequency
- E_{ij} is expected frequency

- E_{ij} = The expected frequencies
- $E_{ij} = \frac{(\text{Total row } i) \times (\text{Total row } j)}{\text{Overall Total}}$
- m = no. of cells, calculated by multiplying the no. of groups in the rows by the no. of groups in the columns.

Learning Module 10

Simple Linear Regression

1. Simple Linear Regression Y_i

$$Y_i = b_0 + b_1 X_i + \varepsilon_i,$$

where,

Y = dependent variable

X = independent variable

b_0 = intercept

b_1 = slope coefficient

ε = error term = $Y_i - \hat{Y}_i$

b_0 and b_1 are called regression coefficients

2. Sum of Squares Error SSE

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

as $\hat{Y}_i = \hat{b}_0 + \hat{b}_1 X_i$ therefore

$$SSE = \sum_{i=1}^n (Y_i - (\hat{b}_0 + \hat{b}_1 X_i))^2$$

3. Slope Coefficient

$$\widehat{b_1} = \frac{\text{cov}(x,y)}{\text{var}(x)} = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sum (X_i - \bar{X})^2}$$

4. Intercept b_0

$$\widehat{b_0} = \bar{Y} - \widehat{b_1} \bar{X}$$

where

\bar{Y} and \bar{X} are mean values

5. Sample correlation: r

$$r = \frac{\text{Cov of } Y \text{ and } X}{(S.D \text{ of } Y)(S.D \text{ of } X)}$$

6. Covariance of X and Y: Cov_{XY}

$$Cov_{XY} = \frac{\sum_{i=1}^n (Y_i - \bar{Y})(X_i - \bar{X})}{n-1}$$

7. Standard deviation of Y: S_Y

$$S_Y = \sqrt{\frac{\sum_{i=1}^n (Y_i - \bar{Y})^2}{n-1}}$$

8. Squared residuals $E(\varepsilon_i^2)$

$$E(\varepsilon_i^2) = \sigma_i^2, i = 1, \dots, n$$

9. Sum of Squared Regression: SSR

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

10. Coefficient of Determination: R^2

$$R^2 = \frac{\text{Sum of square regression}}{\text{Sum of square total}} = \frac{\sum_{i=1}^n (\hat{Y} - \bar{Y})^2}{\sum_{i=1}^n (Y_i - \bar{Y})^2}$$

(for single independent variable $R^2 = r^2$)

11. Mean square regression: MSR

$$\text{MSR} = \frac{\text{Sum of square regression}}{k}$$

$$= \frac{\sum_{i=1}^n (\hat{Y} - \bar{Y})^2}{1}$$

12. Mean Square Error: MSE

$$\text{MSR} = \frac{\text{sum of squares error}}{n-k-1}$$

13. F-Statistic or F-Test

$$F = \frac{\text{MSR}}{\text{MSE}} = \frac{\left(\frac{\text{Sum of square regression}}{k} \right)}{\left(\frac{\text{Sum of squares error}}{n-k-1} \right)}$$

(df numerator = k = 1)

(df denominator = n - k - 1 = n - 2)

14. ANOVA

| ANOVA | SS | MSS | F |
|----------------------|---|----------------------------|---|
| Regression df = 1 | SSR = $\sum_{i=1}^n (\hat{y}_i - \bar{y})^2$ | $\frac{\text{SSR}}{k}$ | $\frac{\text{SSR}/k}{\text{SSE}/(n-k-1)}$ |
| Error df = n-2 | SSE = $\sum_{i=1}^n (y_i - \hat{y})^2$ | $\frac{\text{SSE}}{n-k-1}$ | |
| Total df = n-1 | SST = $\sum_{i=1}^n (y_i - \bar{y})^2$ | | |

15. Test statistic

$$t = \frac{\hat{b}_1 - B_1}{s_{\hat{b}_1}}$$

16. Standard error of slope coefficient: $s_{\hat{b}_1}$

$$s_{\hat{b}_1} = \frac{s_e}{\sqrt{\sum_{i=1}^n (X_i - \bar{X})^2}}$$

17. Standard error of the intercept: $s_{\hat{b}_1}$

$$s_{\hat{b}_1} = \sqrt{\frac{1}{n} + \frac{\bar{X}^2}{\sum_{i=1}^n (X_i - \bar{X})^2}}$$

18. Forecasted value of dependent variable: \hat{Y}_f

$$\hat{Y}_f = \hat{b}_0 + \hat{b}_1 X_f$$

19. Standard error of the intercept: s_f

$$s_f = s_e \sqrt{1 + \frac{1}{n} + \frac{(X_f - \bar{X})^2}{\sum_{i=1}^n (X_i - \bar{X})^2}}$$

20. Log-lin Model: $\ln Y_i$

$$\ln Y_i = b_0 + b_1 X_i$$

21. Lin-log Model Y_i

$$Y_i = b_0 + \ln X_i$$

22. Log-log Model $\ln Y_i$

$$\ln Y_i = b_0 + b_1 \ln X_i$$

ECONOMICS**Learning Module 1****Firms and Market Structures****1. Break-Even Price**

P = ATC

P = AR = MR = ATC

where TR = TC.

P = price, ATC = Avg, Total Cost, MR = Marginal Revenue, AR = Avg. Revenue, TR = Total revenue

2. Concentration Ratio: CR

CR = Sum of sales values of the largest 10 firms / Total market sales

3. Herfindahl-Hirschman index: HHI

$$\text{HHI} = \sum X_i^2$$

where,

X_i^2 is squared market share of the i^{th} firm.

*HHI = 1 for monopoly.**HHI \approx 0 for a perfectly competitive industry.***Learning Module 2****Understanding Business Cycles**