# FinQuiz Formula Sheet CFA Program Level II

## QUANTITATIVE METHODS

### Learning Module 1: Basics of Multiple Regression and Underlying Assumptions

1. **Multiple Regression**
   $Y_i = b_0 + b_1X_{1i} + b_2X_{2i} + \ldots + b_kX_{ki} + \varepsilon_i, i = 1, 2, \ldots n.$

2. **Prediction Equation**
   Prediction equation = $\hat{Y}_i = \hat{b}_0 + \hat{b}_1X_{1i} + \hat{b}_2X_{2i} + \ldots + \hat{b}_kX_{ki} + \varepsilon_i, i$

### Learning Module 2: Evaluating Regression Model Fit and Interpreting Model Results

1. **Coefficient of Determination: $R^2$**

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

2. **Adjusted $R^2$**

$$\bar{R}^2 = 1 - \left(\frac{n-1}{n-k-1}\right)(1 - R^2)$$

3. **F-Statistic or F-Test**

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

*where,*
*df numerator = k = 1*
*df denominator = n – k – 1 = n – 2*

4. **ANOVA**

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

5. **Akaike's information criterion (AIC)**

$$\text{AIC} = n\ln\left(\frac{SSE}{n}\right) + 2(k+1)$$

6. **Schwarz's Bayesian information criterion (BIC or SBC)**

$$\text{BIC} = n\ln\left(\frac{SSE}{n}\right) + \ln(n)(k+1)$$

### Learning Module 3: Model Misspecification

1. **Breusch–Pagan (BP) test**
   Test statistic = $n \times R^2_{residuals}$

   *where,*

   *$R^2_{residuals}$ = $R^2$ from a second regression of the squared residuals from the first regression on the independent variables*
   *n = number of observations*

2. **Variance Inflation Factor $VIF_j$**

$$VIF_j = \frac{1}{1 - R_j^2}$$

**Learning Module 4:**
**Extensions of Multiple Regression**

### 1. Studentized residual $t_{i^*}$

$$t_{i^*} = \frac{e_i^*}{s_{e^*}} = n\sqrt{\frac{n-k-1}{SSE(1-h_{ii})-e_i^2}}$$

### 2. Cook's distance $D_i$

$$D_i = \frac{e_i^2}{k \times MSE}\left[\frac{h_{ii}}{(1-h_{ii})^2}\right]$$

### 3. Linear regression

*with 3 independent Variables*

$$Y_i = b_0 + b_1X_{1i} + b_2X_{2i} + b_3X_{3i} + e_i$$

### 4. Logistic regression (logit)

$= \ln\left(\frac{P}{1-P}\right)$

$= b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \varepsilon$

$P = \frac{1}{1+exp[-(b1X1 + b2X2 + b3X3 + \varepsilon)]}$

**Learning Module 5:**
**Time Series Analysis**

### 1. Linear Trend Models

$y_t = b_0 + b_1t + \varepsilon_t$

Predicted/fitted value of $y_t$ in period (T + 1)

$= \hat{y}_{t+1} = \hat{b}_0 + \hat{b}_1(T+1)$

### 2. Log-Linear Trend Models

$$y_t = e^{b_0+b_1t}$$

### 3. Autoregressive Time-Series Models

First order autoregressive AR (1):

$x_t = b_0 + b_1 x_{t-1} + \varepsilon_t$

pth-order autoregressive AR (p):

$x_t = b_0 + b_1 x_{t-1} + b_2 x_{t-2} + \ldots\ldots + b_p x_{t-p} + \varepsilon_t$

### 4. Mean reverting level

$$x_t = \frac{b_0}{1-b_1}$$

### 5. Chain Rule of Forecasting:

One-period ahead forecast

$\hat{x}_{t+1} = \hat{b}_0 + \hat{b}_1 x_t$

Two-period ahead forecast=

$\hat{x}_{t+2} = \hat{b}_0 + \hat{b}_1 x_{t+1}$

### 6. Random Walks and Unit Roots:

*Random Walk without drift:*

$x_t = x_{t-1} + \varepsilon_t$ where, $b_0 = 0$ and $b_1 = 1$.

*Correcting Random Walk:*

$y_t = x_t - x_{t-1}$

*Random walk with a drift:*

$x_t = b_0 + x_{t-1} + \varepsilon_t$ where, $b_0 \neq 0$ and $b_1 = 1$

*By taking first difference*

$y_t = x_t - x_{t-1} = b_0 + \varepsilon_t$

### 7. Using Dickey-Fuller Test

$x_t - x_{t-1} = b_0 + (b_1 - 1) x_{t-1} + \varepsilon_t$

### 8. Smoothing Past Values with n-Period Moving Average

$$\frac{x_t + x_{t-1} + x_{t-2} + \ldots\ldots + x_{t-(n-1)}}{n}$$

### 9. Correcting Seasonality in Time Series Models:

*For quarterly data*

$x_t = b_0 + b_1x_{t-1} + b_2x_{t-4} + \varepsilon_t$

*For monthly data*

$x_t = b_0 + b_1x_{t-1} + b_2x_{t-12} + \varepsilon_t$

### 10. ARCH model =

$$\hat{\varepsilon}^2{}_t = \alpha_0 + \alpha_1\hat{\varepsilon}^2{}_{t-1} + \mu_t$$

where

$\mu_t$ is an error term

Predicting variance of errors in period

t+1 = $\hat{\sigma}_{t+1}^2 = \hat{\alpha}_0 + \alpha_1\hat{\varepsilon}_t^2$

**Learning Module 6:**
**Machine Learning**

### 1. LASSO:

Penalty term (when $\lambda > 0$) = $\lambda\sum_{k=1}^{K}|\bar{b}_k|$

$$\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2 + \lambda\sum_{k=1}^{K}|\hat{b}_K|$$

When $\lambda$ = 0,

LASSO penalized regression = OLS regression

**Learning Module 7:**
**Big Data Projects**

1. **Normalization**

$$X_{i(normalized)} = \frac{X_i - X_{min}}{X_{max} - X_{min}}$$

where $X_i$ = value of observation

*Performance Metrics:*

2. **Accuracy**

$$= \frac{TP+TN}{\text{TP + FP + TN + FN}}$$

F1 score = (2*P*R)/(P + R)

*where*
*T = true, F = false, P = positive,*
*N = negative*

3. **Receiver Operating Characteristic (ROC):**

False positive rate: FPR

FPR = $\frac{FP}{TN+FP}$

True positive rate TPR:

TPR = $\frac{TP}{TN+FP}$

4. **Root Mean Square Error: RMSE:**

RMSE = $\sum_{i=1}^{n}\frac{(Predicted_i - Actual_i)^2}{n}$

## ECONOMICS

**Learning Module 1**
**Currency Exchange Rates**

1. **Bid-offer Spread**

Offer price – Bid price

2. **Forward Rate:**

$$\text{Fwd rate} = \text{Spot Exchange rate} + \frac{\text{Forward points}}{10{,}000}$$

3. **Forward Premium or Discount:**

$$= \frac{\text{spot exchange rate} - (\frac{\text{forward points}}{10{,}000})}{\text{spot exchange rate}} - 1$$

4. **To convert spot rate into forward quote:**

Spot exchange rate × (1 + % premium)
Spot exchange rate × (1 - % discount)

5. **Covered interest rate parity:**

$$(1 + i_d) = S_{f/d}(1 + i_f)\left(\frac{1}{F_{f/d}}\right)$$

$$F_{f/d} = S_{f/d}\left(\frac{1 + i_f}{(1 + i_d)}\right)$$

Using day count convention:

$$\left(1 + i_d\left[\frac{Actual}{360}\right]\right) =$$

$$S_{f/d}\left(1 + i_f\left[\frac{Actual}{360}\right]\right)\left(\frac{1}{F_{f/d}}\right)$$

$$F_{f/d} = S_{f/d}\left(\frac{1 + i_f\left[\frac{Actual}{360}\right]}{1 + i_d\left[\frac{Actual}{360}\right]}\right)$$

6. **Uncovered Interest Rate Parity :**

- $i_f - \%\Delta S^e_{f/d} = i_d$
- $\%\Delta S^e_{f/d} = i_f - i_d$

Forward premium or discount:

- For one year horizon =

$$F_{f/d} - S_{f/d} =$$

$$S_{f/d}\left(\frac{i_f - i_d}{1 + i_d}\right) \cong S_{f/d}(i_f - i_d)$$

- Using day count convention:

$$F_{f/d} - S_{f/d} = S_{f/d}\left(\frac{\left[\frac{Actual}{360}\right]}{1 + i_d\left[\frac{Actual}{360}\right]}\right)(i_f - i_d)$$

7. **Forward discount or premium as % of spot rate:**

$$\frac{F_{f/d} - S_{f/d}}{S_{f/d}} \cong (i_f - i_d)$$

If uncovered interest rate parity holds

- $$= \frac{F_{f/d} - S_{f/d}}{S_{f/d}} = \%\Delta S^e_{f/d} \cong (i_f - i_d)$$

8. **Purchasing Power parity (PPP)**
   - $P_f = S_{f/d} \times P_d$
   - $S_{f/d} = P_f / P_d$

9. **Relative version of PPP**
   $= \%\Delta S_{f/d} = \pi_f - \pi_d$

10. **Ex ante version of PPP**
    $= \%\Delta S^e_{f/d} = \pi^e_f - \pi^e_d$

11. **Real Exchange Rate**

$$q_{f/d} = \left(\frac{S_{f/d} P_d}{P_f}\right) = S_{f/d}\left(\frac{P_d}{P_f}\right)$$

or

$$q_{f/d} = S_{f/d}\left(\frac{CPI_d}{CPI_f}\right)$$

12. **Fisher effect:**
    $i_d = r_d + \pi^{\varepsilon}_d$
    $i_f = r_f + \pi^{\varepsilon}_f$
    $i_f - i_d = (r_f - r_d) + (\pi^{\varepsilon}_f - \pi^{\varepsilon}_d)$
    $(r_f - r_d) = (i_f - i_d) - (\pi^{\varepsilon}_f - \pi^{\varepsilon}_d)$

## Learning Module 1
## Economic Growth

1. **Economic growth:**
   Annual % Δ in real GDP or in real per capita GDP

2. **Relation between Stock Prices and Economic growth:**

$$P = GDP\left(\frac{E}{GDP}\right)\left(\frac{P}{E}\right)$$

*where,*
*P = Aggregate value (price) of equities*
*E = Aggregate corporate earnings*

3. **Expressing in terms of logarithmic rates:**
   - (1/T) % ΔP = (1/T) % ΔGDP + (1/T) %Δ (E / GDP) + (1/T) % Δ(P / E)
   - % Δ in stock MV = % Δ in GDP + % Δ in share of earnings (profit) in GDP + % Δ in the P/E multiple

4. **A two-factor aggregate production function:**
   Y = AF (K, L)

   Y = Level of aggregate output in the economy
   L = Quantity of labor or number of workers or hours in the economy
   K = Stock of capital used to produce goods and services
   A = Total Factor Productivity (TFP)

5. **Cobb-Douglas Production Function**
   $F(K, L) = K^{\alpha} L^{1-\alpha}$

6. **Under Cobb-Douglas production function:**

   Marginal product of capital = MPK = $\alpha AK^{\alpha-1} L^{1-\alpha} = \alpha Y/K$

   $\alpha Y/K = r \rightarrow \alpha = r(K)/Y$ = Capital income / Output or GDP

7. **Output per worker or Average labor productivity (Y/L or y):**
   GDP/Labor input = TFP × capital-to-labor ratio × share of capital in GDP
   Or
   $y = Y/L = Ak^{\alpha}$

8. **Contribution of Capital Deepening**
   = Labor productivity growth rate – TFP

9. **Contribution of Improvement in technology**
   Labor productivity growth rate – Capital Deepening

10. **Growth Accounting based on Solow Approach**
    $\Delta Y/Y = \Delta A/A + \alpha\, \Delta K/K + (1 - \alpha)\, \Delta L/L$

11. **Labor productivity growth accounting equation**