CFA Level 2 Notes

Ethics and Professional standards

Reading 1: Code of Ethics and Standards of Professional Conduct

6 components of the Code of Ethics

1. Act with **integrity**, **competence**, diligence and respect
2. Place integrity of profession and clients **above personal interests**
3. **Reasonable care** and exercise **independent** professional judgment when making investment recommendations
4. Practice and encourage others to **practice in ethical manner**
5. **Promote** integrity and viability of **global capital markets** for ultimate benefit of society
6. Maintain and improve **professional competence**

Disciplinary Review Committee (DRC) responsible for the enforcement of Code and Standards

Professional Conduct inquiries come from number of sources:

- **Self-disclose** on annual Professional Conduct Statement
- **Written complaints** received by Professional Conduct staff about investigation
- **Media, regulatory notices** or public sources
- Monitored by proctors who complete report on candidates who **violated exam day**

Sanctions include:

- **Public censure**
- **Membership suspension and use of CFA designation**
- **Revocation of CFA charter**

7 standards of Professional Conduct

1. **PROFESSIONALISM**
    A. *Knowledge of the law* (including code of ethics and standards of professional conduct) – in the event of a conflict, the stricter law, rule or regulation applies.
    B. *Independence and objectivity* – not offer or accept gift or compensation that would compromise independence/objectivity
    C. *Misrepresentation* – not make any in regards to analysis, recommendations or actions
        - Crediting source not required when using statistics, tables and projections from recognised financial and statistical reporting services
    D. *Misconduct* – not engage in conduct involving dishonesty, fraud, deceit

2. **INTEGRITY OF CAPITAL MARKETS**
    A. *Material nonpublic info* – that could affect value of investment
        - Public once it is announced to the marketplace
        - Mosaic theory = reaching investment conclusion through analysis of public info + non-material nonpublic info
        - Members should make effort to achieve public dissemination by the firm of information they possess. Firms should review employee trades and maintain watch lists.
    B. *Market manipulation* – not distort prices or artificially inflate trading volume → only if there is INTENT to mislead.

3. **DUTIES TO CLIENTS**

A. *Loyalty, Prudence and Care* – act in benefit of client, place clients interest before employer's/own interest
    - Submit at least quarterly statements showing securities in custody and all debits, credit and transactions. Not vote on all proxies.
B. *Fair Dealing* – dealing with clients when making analysis, recommendations, engagement
    - E.g. do not take shares of an oversubscribe IPO
C. *Suitability* – risk and return objectives, suitable investments, consistent with objectives and constraints of portfolio
    - Members gather info at beginning of relationship in the form of an investment policy statement (IPS)
D. *Performance presentation* – fair, accurate and complete
    - Include terminated accounts and state when terminated
E. *Preservation of confidentiality* – keep info about clients (current and past) confidential unless 3 exceptions: illegal activities, disclosure required by law, client permits disclosure

4. DUTIES TO EMPLOYERS

A. *Loyalty* – act for benefit of employer and not divulge confidential info
    - No requirement to put employer interests ahead of family and personal obligations
    - Violations include misappropriation of trade secrets and client lists, misuse of confidential info, soliciting employer's clients, self-dealing.
B. *Additional Compensation Arrangements* – not accept gifts, benefits that might create conflict of interest unless obtain written consent from all parties involved
    - If client offers bonus depending on future performance, this is an compensation arrangement → requires written consent in advance
    - If client offers bonus depending on past performance, this is a gift → requires disclosure to employer to comply with Standard I(B) Independence and Objectivity
C. *Responsibilities of Supervisors* – make sure people comply with laws, regulation and Code and Standards

5. INVESTMENT ANALYSIS, RECOMMENDATIONS AND ACTIONS

A. *Diligence and Reasonable Basis* – reasonable basis supported by research and investigation for analysis, recommendation
    - Application depends on investment philosophy adhered to, members' roles in investment decision making process, and resources and support provided by employer
    - Considerations include economic conditions, firms financial results/operating history, fees and historical results, limitations of quant models, peer group comparisons for valuation are appropriate
    - Members should encourage firm to adopt policy for periodic internal review of quality of 3rd party research
B. *Communication with Clients* – disclose basic principles of investment process and construct portfolios and any changes that might materially affect processes, significant limitations and risks, identifying important factors and communicate them, distinguish between fact and opinion.
    - Expectations based on modeling/analysis are not facts
    - Communicate gains/losses in terms of total returns
    - Explain limitations of model/assumptions used and of the investment itself – e.g. liquidity and capacity
C. *Record Retention* – develop and maintain records to support analysis and recommendation with clients (e.g. documenting details of convo)
    - Member who changes firms must re-create analysis documentation supporting recommendation and must not rely on material created at previous firm
    - If no regulatory standards/firm policies in place, recommends 7-year minimum holding period

6. CONFLICT OF INTEREST

A. *Disclosure of Conflicts* – matters that could impair independence and objectivity or interfere with duty to clients and employer
    - E.g. ownership of stock in company that recommending
B. *Priority of Transactions* – clients/employers priority over own
    - Limitations on employee participation in equity IPO, private placement
    - Blackout period – no personal purchase/sale of security in advance of client/employer
C. *Referral Fees* – compensation received or paid to others for recommendation of products/services

7. RESPONSIBLE AS A CFA INSTITUTE MEMBER/CANDIDATE

1. *Conduct as Participants in CFA Institute Programs* – not compromise reputation or integrity of CFA
    - e.g. exam cheating, improperly using designation, not reveal confidential info regarding CFA, misrepresenting info on Professional Conduct Statement (PCS)
2. *Reference to CFA Institute, Designation and Program* – not misrepresent or exaggerate meaning/implications
    - Members must sign the PCS annually, and pay CFA membership dues annually → if fail to do this, person will no longer be an active member

No requirement to report violations to govt authorities, but is advisable

Reading 3: CFA Institute Research Objectivity Standards

Objectives of Research Objectivity Standards

Objective is to provide **specific measureable standards** for managing and disclosing **conflicts of interest** that may interfere with analyst ability to conduct **independent research** and make **objective recommendations**

- Clients interest before employees and firms
- Minimize possible conflicts which will affect independence and objectivity
- Support self regulation
- Provide work environment conducive to ethical behavior and adherence to Code and Standards

Company policies & practices to research objectivity + changes required vs recommended compliance

Research Objectivity Policy	
Requirements	**Recommended**
• Formal written independence and objectivity of research policy distributed to clients • Supervisory procedures in place • Senior officer attesting annually to clients	• Identify covered employees (conducts research, takes investment action, ability to influence reports) • Factors on which analysts compensation based • How reports may be purchased by clients

Public Appearances	
Requirements	**Recommended**
• Covered employees making public appearances to discuss research or investment recommendations must disclose any personal and firms conflicts of interest	• Audience can make informed judgement • Prepared to disclose all conflicts and all IB and marketing relationships • Research reports should be provided at a reasonable costs
Reasonable and Adequate Basis	
Requirements	**Recommended**
• Single employee or committee charged with reviewing and approving all reports and investment recommendations	• Firms providing guidance on what constitutes reasonable and adequate • Provide supporting data to client

Investment Banking (IB)	
Requirements	**Recommended**
• Separate research analysts from IB dept • Analyst NOT supervised by IB personnel • Prevent IB from reviewing or approving research reports and recommendations	• Not sharing report with IB until publication • IB personnel only review to verify factual info or identify possible conflict of interest • Analyst not allowed to participate in roadshow

Research Analyst Compensation	
Requirements	**Recommended**
• Comp directly related to quality of research and recommendations, and NOT linked to IB or corporate finance activities	• Measurable criteria consistently applied to all analysts • Disclose extent to which compensation is dependent on IB revenue

Relationship with Subject Companies	
Requirements	**Recommended**
• Analyst not allow subject company to see any part of research that might signal recommendation or make promises	• Governing r/ship with companies (e.g. gifts) • Check facts contained before publication • Legal dept receive draft before shared

Personal Investment and Trading	
Requirements	**Recommended**
• Policies addressing personal trading of employees • Ensuring employees do not share info with any one who could trade ahead • Prohibit employees and family from trading contrary to recommendations	• Interests of client ahead of personal & firm • Obtain approval from legal/compliance department in advance of any trading • Restricted periods for employee trading • Contrary investment due to financial hardship • Provide list of personal holdings

Timeliness of Research Reports and Recommendations	
Requirements	**Recommended**
• Regularly issue research reports on subject companies on a timely basis	• Regular updates on research e.g. quarterly • If company coverage discontinued, issue a "final" research report

Compliance and Enforcement	
Requirements	**Recommended**
• Disciplinary action, monitoring effectiveness, maintain records for audit	• Distribute client list of activities which are violations and include disciplinary sanctions

Disclosure	
Requirements	**Recommended**
• Disclose conflict of interest related to covered employees or firm as a whole	• Disclosures complete & easy to understand • Disclose valuation methods for price tgts

Rating System	
Requirements	**Recommended**
• Must have rating system that investors find useful for investment decision that determines suitability of investment	• Avoid 1-dimensional ratings → Need more info + description of system

	• Absolute (buy/hold/sell) or relative (outperform/underperform) categories recommended

Reading 7: Trade Allocation: Fair Dealing and Disclosure

Evaluate trade allocation practices and determine if comply with Standards

- Allocation of client trades on ad-hoc basis lends itself to fairness problems:
  - Allocation may be based on *compensation arrangements*
    - E.g. allocating disproportionately trades to performance-based fee accounts → breaches III(A) as this increases fees at expense of asset-based fee accounts
  - Allocation may be based *client relationships with firm*
    - E.g. allocating disproportionate share of profitable trades to favored clients

Describe appropriate actions to take in response to trade allocation practices that don't respect client interests

- **Advanced indication** of client interest regarding new issues
- Distribute new issues by **client**, not by PM
- Fair and objective method for trade allocation such as **pro rata system**
- **Execution** of trades and price fairly + in a timely and efficient manner
- **Keeping records** and **periodically review** to ensure clients treated equitably

Reading 8: Changing Investment Objectives

Evaluate disclosure of investment objective and policies

- Investment actions consistent with **stated objectives and constraints** of the fund
- Material deviation from process in absence of client approval violates *III(C) Duties to Clients*
- Investment must fit within mandate or within realm of investment that's allowed according to fund's disclosure (e.g. prospectus or PDS)

Actions needed to ensure adequate disclosure of investment process

- Determine clients financial situation, investment objectives and level of investing expertise
- Adequacy **disclose security selection** and **portfolio construction process**
- Conduct **regular internal checks** for compliance with these processes
- Stick to stated **investment strategy** if managing specific mandate or strategy
- **Notify investors of potential change** in process and secure documentation of authorization for proposed changes

Quantitative Methods for Valuations

Reading 9: Correlation and Regression

Sample covariance and sample correlation coefficient

Covariance measures the degree of how 2 variables move together.

- +ve = move together. –ve = opposite directions. 0 = no relationship
- $\text{cov}_{XY} = \frac{\sum_{i=1}^{n}(X_i-\overline{X})(Y_i-\overline{Y})}{n-1}$
- *Limitations:*
  - Sensitive to scale of two variables
  - Range from negative to positive infinity
- Therefore need to calculate correlation coefficient

Correlation coefficient (r) is a measure of strength of the linear relationship between 2 variables

$\rho_{1,2} = \frac{Cov_{1,2}}{\sigma_1\sigma_2} = \frac{Covariance}{SD1 \times SD2}$

- +1 = perfectly positively correlated. -1 = perfectly negatively correlated

Scatter plot is collection of points on a graph where each point represents values of 2 variables (X/Y pair)

3 Limitations to correlation analysis

1. Impact of **outliers** → i.e. extreme values
2. Potential for **spurious correlation** → appearance of r/ship when there is none (i.e. chance)
3. Correlation only measures linear, does not capture **nonlinear** relationship

Test of hypothesis that population correlation coefficient = 0

Need to know strength of relationship indicated by correlation coefficient by using statistical test of significance

2 Tailed test

- Null → H_0: $\mu = \mu_0$
- Alternate → H_a: $\mu \neq \mu_0$

if normally distributed → use t-test to determine whether null should be rejected

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

r = sample correlation coefficient

Decision: compare t stat with critical t-value for appropriate degrees of freedom and significance level

- REJECT H_0 if:
  - t stat > upper CV
  - t stat < lower CV
- if rejected → ***significantly different from 0***

Dependent vs independent variables in linear regression

Simple linear regression explains variation in dependent variable (predicted) in terms of variation in independent variable (explanatory)

6 Assumptions of linear regression

1. **Linear relationship** exists b/w dependents and independent variable
2. Independent variable **uncorrelated** with residuals
3. Expected value of residual term is zero [**E(Ɛ)=0**]
4. Variance of residual term is **constant** for all observations

5. Residual term **independently distributed** → residual not correlated with any other observations
6. Residual term **normally distributed**

SIMPLE LINEAR REGRESSION MODEL: $Y_i = b_0 + b_1X_i + \varepsilon_i$,

b_1 is the **slope coefficient** → $\hat{b}_1 = \frac{cov_{XY}}{\sigma_X^2}$

- Predicted change in dependent for 1 unit change in independent
- i.e. beta → measures systematic risk

b_0 is **intercept term** → $\hat{b}_0 = \overline{Y} - \hat{b}_1\overline{X}$

- i.e. ex-post alpha → measures excess risk-adjusted return

Error term (ε_i) represents portion of dependent variable that cannot be explained by independent variable

Regression is a line of best fit. It is the line for which estimates of b_0 and b_1 are such that sum of squared differences between estimated Y-values and actual Y-values is minimized → **Sum of squared errors (SSE)**

- Simple linear regression = ordinary least squares (OLS) regression

Note: Hypothesis test or confidence interval needed to assess importance of variable

Standard error of estimate, coefficient of determination, and confidence interval for regression coefficient

Standard error of estimate (SEE) measures the degree of variability of the actual Y-values relative to the estimated Y-values

- Measures how well regression model "fits" the data → the smaller the SE the better the fit
- SEE is the SD of error terms in regression → also referred to as "standard error of regression/residual"
- SEE will be LOW if r/ship b/w dependent and independent is STRONG (e.g. r/ship b/w treasury yield bond and mortgage rates)
- SEE $= \left(\frac{\text{Unexplained variation}}{n-2}\right)^{1/2}$

Coefficient of Determination (R^2) is the % of total variation in dependent explained by independent

- R^2 of 0.63 means variation of independent explains 63% of variation in dependent variable
- R^2 may be computed by squaring correlation coefficient (r) for a regression with 1 variable
  - $R^2=r^2$
- Note: correlated b/between predicted and actual values is square root of R^2
- If more than 1 variable → multiple regression techniques needed (e.g. ANOVA)
  - E.g. $R^2 = \frac{explained\ variation}{total\ variation} = 1 - \frac{unexplained\ variation}{total\ variation}$

Confidence interval for regression coefficient

- $\hat{b}_1 \pm \left(t_c \times s_{\hat{b}_1}\right)$ → i.e. Coefficient Estimate ±t * SE
  - t_c = critical two tailed t-value → note: n-2
  - s_{b1} = standard error of regression coefficient
- ↑SEE = s_{b1}↑ = wider confidence interval

Null and alternative hypothesis about pop regression coefficient and appropriate test statistic

t-test for true slope coefficient (b_1) is equal to hypothesized value: $t_{b_1} = \frac{\hat{b}_1 - b_1}{s_{\hat{b}_1}}$

- *Reject H_0 if t > CV or if t < -CV*
  - If reject → slope coefficient different from hypothesis

t-stat = Coefficient estimate/SE

Predicted value for dependent variable

Predicted values – values predicted by regression equation, given an estimate of independent variable

- Predicted value of Y: $\hat{Y} = \hat{b}_0 + \hat{b}_1X_p$

- Y = predicted value of dependent
- X_p = forecasted value of independent

Confidence Interval for predicted value of dependent variable

- Confidence interval: $\hat{Y} \pm (t_c \times s_f)$
  - S_f = SE of forecast
    - $s_f^2 = SEE^2 \left[1 + \frac{1}{n} + \frac{(X - \bar{X})^2}{(n-1)s_x^2}\right]$ → note: will most likely be given S_f in exam

Analysis of variance (ANOVA) in regression analysis, and calculate F-statistics

Analysis of variance (ANOVA) – statistical procedure for dividing total variability of variable into components that can be attributed to different sources. Analysing total variables of dependent variable

Total sum of squares (SST) measures total variation in dependent variable → sum of squared differences between actual and mean value of Y

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

ANOVA Table for Simple Linear Regression (k = 1)

Source of Variation	*Degrees of Freedom*	*Sum of Squares*	*Mean Sum of Squares*
Regression (explained)	1	RSS	$MSR = \frac{RSS}{k} = \frac{RSS}{1} = RSS$
Error (unexplained)	n − 2	SSE	$MSE = \frac{SSE}{n-2}$
Total	n − 1	SST	

Regression sum of squares (RSS) measures variation in dependent variable explained by independent → sum of squared distances between predicted Y and mean of Y

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

Sum of squared errors (SSE) measures unexplained variation in dependent variable → (aka sum of squared residuals) → sum of squared vertical distances between actual Y and predicted Y on regression line

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

Note: memorizing formula not important. Need to know what they measure to construct ANOVA

Total Variation = explained variation + unexplained variation → SST = RSS + SSE

$$R^2 = \frac{Total\ variation\ (SST) - unexplained variation\ (SSE)}{Total\ variation\ (SST)} = \frac{Explained\ variation\ (RSS)}{Total\ variation\ (SST)}$$

- R^2 is the correlation squared

$$SEE = \sqrt{MSE} = \sqrt{\frac{SSE}{n-2}}$$

- MSE = mean squared error
- SSE is sum of squared residuals. SEE is the SD of the residual

F-test assesses how well set of independent variables, as a group, explains variation in dependent variable

- Tests whether all slope coefficients are equal to 0
- Used to test whether at least one independent variable explains significant portion of variation
- F-statistic: $F = \frac{MSR}{MSE} = \frac{RSS/k}{SSE/n-k-1}$

  MSR = mean regression sum of squares
  ALWAYS **1 TAILED TEST**
  k is number of slope parameters estimated (i.e. df = k)
  $k_{(numerator)} = 1$
  $k_{(denominator)} = n-2$

Multiple regression → F-stat tests all independent variables
Simple linear regression → only 1 independent variable

Reject null if F(test-statistic) > F_c (critical value) → independent variable sign diff from 0 → makes sign contribution to explanation of dependent variable

Limitations of regression analysis

- Linear relationships can change over time → **parameter instability:** estimation from specific time period may not be relevant for forecasts in another period (e.g. economic and financial variables)
- Usefulness limited if **other market participants are aware and act** on this evidence
- If **assumptions not hold**, the interpretation and tests of hypotheses may not be valid
    - E.g. if data is **heteroskedastic** (non-constant variance of error) or exhibits **autocorrelation** (error terms not independent) → then regression results may be invalid

Reading 10: Multiple Regression and Issues in Regression Analysis

Multiple regression is regression analysis with more than1 independent variable

- Used to quantity influence of two or more independent variables on a dependent variable
- E.g. variation in stock returns in terms of beta, firm size, equity, industry classification etc…

$Y_i = b_0 + b_1X_{1i} + b_2X_{2i} + \ldots + b_kX_{ki} + \varepsilon_i$

- Estimates intercept and slope coefficients such that SSE is minimized
- Residual (ε_i) is the difference between observed value and predicated value from regression:
    - $\varepsilon_i = y_i - \hat{y}_i$

Interpret estimated regression coefficients and their p-values

Interpretation of estimated regression coefficients for multiple regression is same as simple linear regression for intercept term BUT significantly different for slope coefficient:

- **Intercept term** is value of dependent variable when independent variables are equal to 0
- Each slope coefficient is estimated change in dependent variable for 1 unit change in independent variable, *holding other independent variables constant* → **partial slope coefficient**

P-value is the smallest level of significant for which null hypothesis can be rejected

- Alternative to hypothesis testing of coefficients is to ***compare p-values to the significance level***
    - p-value < significance level → REJECT NULL → SIGNIFICANT DIFFERENT to 0
    - p-value > significance level → DO NOT REJECT NULL

Interpret results of hypothesis tests of regression coefficients

Need to determine if independent variable makes significant contribution to explaining variation in dependent

T-statistic → $$t = \frac{\hat{b}_j - b_j}{s_{\hat{b}_j}} = \frac{\text{estimated regression coefficient} - \text{hypothesized value}}{\text{coefficient standard error of } b_j}$$

Degrees of freedom is ***n – k – 1***

- K is the number of regression coefficients in the regression. 1 is for the intercept term

Confidence interval for population value of regression coefficient

Same as simple linear regression: $\hat{Y} \pm (t_c \times s_f)$ → coefficient ± (critical t-value) * (coefficient SE)

- Two tailed value with n – k – 1

Assumptions of multiple regression model

- Same as simple linear regression assumptions (just with more than 1 variable)

ANOVA	df	SS	MSS
Regression	3	0.1720	0.0573
Residual	152	0.8947	0.0059
Total	155	1.0667	
Residual standard error	0.0767		
R-squared	0.1610		
Observations	156		

$$F = \frac{RSS/k}{SSE/(n-k-1)} = \frac{0.17230/3}{0.8947/(156-3-1)}$$

F-statistic and how it used in regression analysis

- F-test assesses how well set of independent variables explains variation in dependent
- i.e. whether *at-least one* independent variable explains significant portion of variation in dependent
- Same formula as simple linear regression: $F = \frac{MSR}{MSE} = \frac{RSS/k}{SSE/n-k-1}$
- Reject hypothesis if F(test-stat) > F(critical value)
    - *Rejection → at least one coefficient significantly different → at least 1 independent variables makes significant contribution to explanation of dependent variable*

An analyst runs a regression of monthly value-stock returns on five independent variables over 60 months. The total sum of squares is 460, and the sum of squared errors is 170. Test the null hypothesis at the 5% significance level that all five of the independent variables are equal to zero.

Answer:

The null and alternative hypotheses are:

$H_0: b_1 = b_2 = b_3 = b_4 = b_5 = 0$ versus H_a: at least one $b_j \neq 0$

$$\text{RSS} = \text{SST} - \text{SSE} = 460 - 170 = 290$$

$$\text{MSR} = \frac{290}{5} = 58.0$$

$$\text{MSE} = \frac{170}{60-5-1} = 3.15$$

$$\text{F} = \frac{58.0}{3.15} = 18.41$$

The critical *F*-value for 5 and 54 degrees of freedom at a 5% significance level is approximately 2.40. Remember, it's a **one-tailed** test, so we use the 5% *F*-table! Therefore, we can reject the null hypothesis and conclude that at least one of the five independent variables is significantly different than zero.

R^2 vs adjusted R^2 in multiple regression

Coefficient of determination (R^2) used to test overall effectiveness of entire set of independent variables in explaining the dependent variable

Same calc as simple linear regression: $R^2 = \frac{Total\ variation\ (SST) - unexplained variation\ (SSE)}{Total\ variation\ (SST)} = \frac{Explained\ variation\ (RSS)}{Total\ variation\ (SST)}$

Unfortunately R^2 may not be reliable measure of explanatory power of multiple regression model → because R^2 almost always **increases as variables added to the model** → high R^2 may reflect impact of large set of independent variables rather than how well set explains dependent variable → **overestimating regression**

- ***R^2 of at least 30% is considered reasonable fit***

To overcome problem, recommend used **adjusted R^2** → $R_a^2 = 1 - \left[\left(\frac{n-1}{n-k-1}\right) \times (1 - R^2)\right]$

n is # observations. K is # independent variables

- $R_a^2 \leq R^2$ → adding new independent variables will increase R^2 but may either *increase or decrease* R_a^2
    - if new variable has small effect on R^2, value of R_a^2 may decrease
- R_a^2 may be less than 0

Example: Calculating R^2 and adjusted R^2

An analyst runs a regression of monthly value-stock returns on five independent variables over 60 months. The total sum of squares for the regression is 460, and the sum of squared errors is 170. Calculate the R^2 and adjusted R^2.

Answer:

$$R^2 = \frac{460-170}{460} = 0.630 = 63.0\%$$

$$R_a^2 = 1 - \left[\left(\frac{60-1}{60-5-1}\right) \times (1 - 0.63)\right] = 0.596 = 59.6\%$$

The R^2 of 63% suggests that the five independent variables together explain 63% of the variation in monthly value-stock returns.

Multiple regression equation using dummy variables

When independent variable is binary (on or off), they are called **dummy variables** → used to quantity impact of qualitative events

- assigned value of 0 or 1
- if want to distinguish *n* classes → use n-1 dummy variables

Types of heteroskedasticity and how serial correlation affects statistical inference

Heteroskedasticity occurs when variance of residuals is not the same across all observations in the sample. This happens when there are subsamples that are more spread out than the rest of the sample → i.e. variance of errors increases magnitude (i.e. as x increases, variances increase)

- **Unconditional heteroskedasticity**: *not related* to level of independent variables (function of x) → doesn't systematically increase/decrease with changes in value of independent variables
    - Violation of equal variance assumption. Usually causes *no major problems* with regression
- **Conditional heteroskedasticity:** related to level of independent variable (depends on x)
    - E.g. variance of residual term increases as value of independent variable increases
    - Creates *significant problems* for statistical inference
    - Chi-square used as test → if t > cv reject null

Note: *homoscedasticity* is if variance of residuals stays the same.

Effects of Heteroskedasticity on regression analysis:

- F-test for overall significant of regression is **unreliable**
- Coefficient estimates are **not affected**
- **Standard Errors (SE) are unreliable estimates**
    - If SE is understated → T-stat overstated → problem that will **incorrectly reject null hypothesis**