

AG313 TREASURY MANAGEMENT & DERIVATIVES  
COURSEWORK SUMMARY

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# 1 Derivatives

## 1.1 Options

### 1.1.1 Option vs. Forward Contracts

- *Option*: Right to buy/sell, in future, at rate (no future exchange rate safety)
- *Future*: Obligation to buy/sell, in future, at rate (future exchange rate safety)

### 1.1.2 Spot vs. Future/Forward Prices

- *Spot Price*: immediate delivery ( $S_0, S_T$ )
- *Future/Forward Price*: future delivery price (locked-in today) ( $F_0, F_T$ )
  - $F_T < S_T$ : Forward = Spot grossed up @  $r$
  - Spot expected to be  $> r$  growth

### 1.1.3 Short vs. Long Positions

- *Short*: Sell shares now ( $S_0 = \text{Spot}$ ), buy later ( $S_T = \text{Delivery}$ )
  - Expect fall in share price, in future
  - Futures price ( $\uparrow$ ), loss
  - Profit =  $S_0 - K$
- *Long*: Buy shares now
  - Expect rise in share price, in future
  - Futures price ( $\uparrow$ ), gain
  - Profit =  $K - S_T$

### 1.1.4 Call vs. Put Options

- “At The Money”:  $S_T = K$
- *Call*: Agreement to buy at specified time and Strike Price
  - Profit (“In The Money”):  $S_T > K$
  - Profit =  $N(S_T - K) - \text{Cost}$ ; Cost =  $N(C_0)$
- *Put*: Agreement to sell at specified time and Strike Price

- Profit (“In The Money”):  $K > S_T$
- Profit = Cost –  $N(K - S_T)$ ; Cost =  $N(P_0)$
- European Option: exercised only on expiration
- American Option: exercised any time up-to expiration and expiration

#### 1.1.5 Exchange vs. Over-the-Counter

- *Exchange*: \$60tn valuation; more standardized and regulated
  - Trades Futures contracts
- *Over-the-Counter*: \$600tn valuation; higher credit risk, higher prices
  - Trades Forward contracts

## 1.2 Futures Markets

- Regulated by Commodities Futures Trading Commission (CFTC)
- *Clearing House*: always used in Futures Market to ensure payment method
- *Central Clearing Parties*: similar job to the above
- *Haircut*: difference between Market Value and Collateral usage of an asset
- *Bilateral Clearing*: group agree terms to trade w/ each-other to minimise risk
- *Limit Order*: trader identifies worst at which trade can take place

### 1.2.1 Forward vs. Future

- Futures based on a shorter period than Forwards
- Futures usually don't have final cash settlements

### 1.2.2 Margin 'Curtain Call' Call

- Broker's demand that investor adds funds to retain minimum value of fund, daily
- Options up-to 9 months must be bought in full; post-9-months margin can be taken
- The seller posts the margin
- Margin accounts adjusted daily for gain/loss
- Reduce systematic risk  $\rightarrow$  ensure funds available  $\rightarrow$  reduce risk of back-out
- Margin Call when:  $\text{Loss} > (\text{Initial Margin} - \text{Maintenance Margin})$

$\alpha$  If Short: ea. \$1 rise in price is a \$1 per-unit loss; find = to above

$\beta$  Add the per-unit rise to the per-unit price

$\gamma$  If Long: ea. \$1 rise in price is a \$1 per-unit gain; find = to above

$\delta$  Add the per-unit rise to the per-unit price

### 1.2.3 Corn Futures Contract

- Initiated by party w/ Short Position; 'Notice of Intention' [to deliver]
- Exchange goes through procedure of choosing party to take Long Position

#### 1.2.4 Hedging vs. Speculating

- *Hedging*: e.g. expect volatility, perhaps price rise to take Futures contract to lock in a better price now
- *Speculating*: e.g. act upon volatility expectation perhaps where there's expected fall in price, take a Short position and buy back for profit
- Hedgers hold Long, Speculators hold Short: ( $F_T > S_T$ )

## 1.3 Forward & Futures Prices

- Future Price quoted as no. of US\$ per-unit of foreign currency
- Lenders cannot issue instructions
- *Investment Asset*: traded but not usually physically usable or tangible
- *Consumption Asset*: traded and usable for consumption (e.g. Copper)
- *Convenience Yield*:  $0/(+)$ , measures benefit of owning rather than Forward/Future
  - Having real value vs. locked-in F value
  - Investment: 0
  - Consumption:  $(+)$
  - Increase: F as % of S  $\downarrow$ ; more convenient to own
  - Decrease: F as % of S  $\uparrow$ ; more convenient to F
- *Dividend Yield*: Div.'s as a % of stock price at t of Div. payment
- *Contango*:  $F_T > S_T$  abnormally

### 1.3.1 Shorting With Dividends

1. Sell now ( $S_0$ ), buy later ( $S_T$ ) (Gain-Per-Share =  $S_0 - S_T$ )
2. Pay Dividend (Gain-Per-Share =  $S_0 - S_T - \text{Div.}$ )

### 1.3.2 Spot-to-Forward Price

$$F_T = S_0 e^{rT}$$

$$F_T = (S_0 - \text{Income}) e^{rT}$$

$$\text{Income} = Y_t e^{-rT} + \dots + Y_{t+n} e^{-rT}$$

$$F_T = ER_0 e^{(r_1 - r_2)T}$$



## 1.4 Hedging Strategies With Futures

- Futures delivery month should be as close as possible to purchase of asset
- “Tailing the Hedge”: corrects for daily settlement
- Hedging Futures leads to predictability

$$\text{Basis} = \text{Spot}_{\text{At Close}} - \text{Futures}_{\text{At Close (For Maturity)}}$$

$$\text{Price Recieved} = \text{Basis} + \text{Futures}_{\text{At Purchase (ForMaturity)}}$$

$$\text{Optimal Hedge Ratio} = \rho_{A,B} \left( \frac{\sigma_A}{\sigma_B} \right)$$

“Movement in S price to movement in F price”

$$\text{Optimal Folios} = (\beta_{\text{Current}} - \beta_{\text{Desired}}) \left( \frac{V_{\text{Folio}}}{F_0 F_N} \right)$$

If (+): Short

If (−): Long

$$P_{\text{Total}} = w_{\text{Hedged}} P_{\text{Hedged}} + w_{\text{Not-Hedged}} P_{\text{Not-Hedged}}$$

Where:

Given  $S_0, F_0, S_T, F_T$

$$P_{\text{Hedged}} = S_T - (F_0 F_T)$$

$$P_{\text{Not-Hedged}} = S_T$$

## 1.5 Option Market Mechanics

- *Option Class*: All Calls or Puts on a stock
- *Option Series*: All options on a certain stock type
- *LEAPS*: Long-Term Equity Anticipation Securities w/ long maturities
- *Stock Split*
  - E.g.:  $N = 100$ ,  $K = 20$ , 2-for-1 Split;
  - Ans.:  $N = 2(100) = 200$ ,  $K = \frac{1}{2}(20) = 10$
- *Stock Dividend*
  - E.g.:  $N = 100$ ,  $K = 20$ , Div. = 25%;
  - Ans.:  $N = 1.25(100) = 125$ ,  $K = \frac{4}{5}(20) = 16$
- *Cash Dividend*
  - No effect
- Option Value = Time Value + Intrinsic Value
  - At-the-Money Time Value = 0 so Option Value = Intrinsic Value
  - Call:  $(S_T - K, 0)$
  - Put:  $(K - S_T, 0)$

## 1.6 Option Pricing

### 1.6.1 Binomial Option Tree: European Put

#### Step 1

$$u = e^{\sigma\sqrt{\Delta t}}$$
$$d = e^{-\sigma\sqrt{\Delta t}} = \frac{1}{u}$$

$$p = \frac{e^{r\Delta t} - d}{u - d} = \text{Risk Neutral Probability of Up Movement}$$

$$(1 - p) = \text{Risk Neautral Probability of Down Movement}$$

#### Step 2

$$S_{u/d} = \text{Value of Stock Upon Increase/Decrease}$$

$$S_u = Pu$$

$$S_d = Pd$$

$$S_{u,u} = Pu^2$$

$$S_{u,d} = Pud$$

$$S_{d,d} = Pd^2$$

#### Step 3

$$P_{u/d} = \text{Value of Option Upon Increase/Decrease}$$

$$P_{u,u} = 0$$

$$P_{u,d} = K - S_{u,d}$$

$$P_{d,d} = K - S_{d,d}$$

$$P_u = ((pP_{u,u}) + ((1 - p)P_{u,d})) e^{-r\Delta t}$$

$$P_d = ((pP_{u,d}) + ((1 - p)P_{d,d})) e^{-r\Delta t}$$

$$P_0 = ((pP_u) + ((1 - p)P_d)) e^{-r\Delta t}$$

### 1.6.2 Binomial Option Tree: Converting to American Put

$$P_d = \max\{K - S_d, P_d\}$$

$$P_{dA} = \text{Larger Outcome}; P_{uA} = \text{Remains Same}$$

$$P_{0A} = ((pP_{uA}) + ((1 - p)P_{dA})) e^{-r\Delta t}$$

## 1.7 Stock Options

- Stock Price ( $\uparrow$ ): Call ( $\uparrow$ ); Put ( $\downarrow$ )
- Strike Price ( $\uparrow$ ): Call ( $\downarrow$ ); Put ( $\uparrow$ )
- Volatility ( $\uparrow$ ): Call Payoff ( $\uparrow$ ); Put Payoff ( $\uparrow$ )
- Dividends ( $\uparrow$ ): Stock Price ( $\downarrow$ ); Call ( $\downarrow$ ); Put ( $\uparrow$ )
- Interest Rate ( $\uparrow$ ): Call ( $\uparrow$ ); Put ( $\downarrow$ )
- Time-Maturity ( $\uparrow$ ): European Options ( $\uparrow / \downarrow$ )

### 1.7.1 Call Lower-Bound

$$S_0 - Ke^{-rT}$$

### 1.7.2 Put Lower-Bound

$$Ke^{-rT} - S_0$$

### 1.7.3 Put-Call Parity w/o Dividend (or 0 Interest)

$$C_0 + Ke^{-rT} = P_0 + S_0$$

$$C_0 + K = P_0 + S_0$$

### 1.7.4 Put-Call Parity w/ Divided

$$C_0 + Ke^{-rT} = P_0 + (S_0 - \text{Div.})$$

### 1.7.5 Black & Scholes Models

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + T\left(r + \frac{\sigma^2}{2}\right)}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

$$C_0 = S(N(d_1)) - Ke^{-rT}(N(d_2))$$

$$C_0 = Se^{-yT}(N(d_1)) - Ke^{-rT}(N(d_2))$$

$$P_0 = K(1 - N(d_1)) - Se^{-rT}(1 - N(d_2))$$

## 2 Treasury Management

### 2.1 Foreign Exchange Market

*Domestic in terms of foreign; foreign in terms of domestic*

$$\text{Spread} = \frac{\text{Ask} - \text{Bid}}{\text{Ask}}$$

$$\text{Direct Quotation} = \mathcal{L}/\$ = \frac{1}{\$/\mathcal{L}}$$

$$\text{Indirect Quotation} = \$/\mathcal{L} = \frac{1}{\mathcal{L}/\$}$$

$$\text{Cross Rate} = \$/\mathcal{L} = \text{EUR}/\mathcal{L} \frac{1}{\text{EUR}/\$}$$

### 2.2 Interest Parity Relationships

#### 2.2.1 Interest Rate Arbitrage

$$A_n = \left( \frac{A_h}{S} \right) (1 + i_f)(S(1 + p))$$
$$S(1 + p) = F$$

$A_{h,n}$  = Home/New Home Currency

$i_{h,f}$  = Home/Foreign Currency

$S$  = Spot Exchange Rate = N of  $\mathcal{L}$  Per Unit of  $\$$

$F$  = Forward (Locked) Exchange Rate = N of  $\mathcal{L}$  Per Unit of  $\$$

$p$  = Forward Premium = Amount By Which  $F$  is  $\uparrow / \downarrow$  Than  $S$

$$\text{Convert To } \$ : \left( \frac{A_h}{S} \right)$$

$$\text{End of Period } \$ \text{ Principal \& Interest : } \left( \frac{A_h}{S} \right) (1 + i_f)$$

\$ Principal & Interest Back to  $\mathcal{L}$  :  $\left(\frac{A_h}{S}\right)(1 + i_f)F$

### 2.2.2 Interest Rate No-Arbitrage

$$A_h(1 + i_h) = A_h(1 + i_f)(1 + p)$$

$A_h(1 + i_h)$  = Investing w/ Home Interest = Investing w/ Foreign Interest w/  $p$

$$\therefore p = \frac{(1 + i_h)}{(1 + i_f)} - 1 \therefore p \approx i_h - i_f$$

### 2.2.3 Absolute PPP

$$S_f^d = \frac{P_s^d}{P_s^f}$$

$$\text{As : } P_s^d = S_f^d P_s^f$$

### 2.2.4 Relative PPP w/ Inflation

$$P_h(1 + \pi_h)$$

$$P_f(1 + \pi_f)$$

If  $\pi_h > \pi_f$ : PP is greater when buying foreign goods  $\rightarrow$  foreign cheaper

If  $\pi_h < \pi_f$ : PP is greater when buying domestic goods  $\rightarrow$  domestic cheaper

Adjust for Change in Currency:

$$P_f(1 + \pi_f)(1 + e_f)$$

$e_f$  = % Change Per Unit of Foreign Currency In Domestic Currency

Hence:

$$P_h(1 + \pi_h) = P_f(1 + \pi_f)(1 + e_f)$$

$$e_f = \frac{P_h(1 + \pi_h)}{P_f(1 + \pi_f)} - 1 = \frac{(1 + \pi_h)}{(1 + \pi_f)}$$

Given  $P_h = P_f$ :

If  $\pi_h > \pi_f$ :  $e_f$  (+): foreign should appreciate; domestic depreciate

If  $\pi_h < \pi_f$ :  $e_f$  (-): foreign should depreciate; domestic appreciate

For Relatively Low Inflation:

$$e_f = \frac{(1 + \pi_h)}{(1 + \pi_f)} - 1 \approx (\pi_h - \pi_f)$$



## 2.3 Exchange Exposure

### 2.3.1 Variance of Two-Asset Folio

$$\sigma_{x,y}^2 = \sigma_x^2 + \sigma_y^2 + 2(\text{cov}_{x,y})$$

Hence:

$$p = \{x, y\}$$

$$\text{cov}_{x,y} = \rho_{x,y}\sigma_x\sigma_y$$

$$\sigma_p^2 = \sigma_x^2 + \sigma_y^2 + 2(\rho_{x,y}\sigma_x\sigma_y)$$

### 2.3.2 Variance of Three-Asset Folio

$$\sigma_p^2 = \sigma_x^2 + \sigma_y^2 + \sigma_z^2 + 2(\rho_{x,y}\sigma_x\sigma_y) + 2(\rho_{x,z}\sigma_x\sigma_z) + 2(\rho_{y,z}\sigma_y\sigma_z)$$

### 2.3.3 Economic Exposure

$$V_{\text{MNC}} = \sum \frac{\sum (E(\text{CF}_{j,t})E(\text{ER}_{j,t}))}{(1+k)^t}$$

Where:

$E(\text{CF}_{j,t})$  = Expected CF in Currency j Recieved At End of Period t

$E(\text{ER})_{j,t}$  = Expeced ER of Currency j At End of Peiod t

k = Weighted Average Cost of Capital (WACC) of MNC

## 2.4 Value of A Multinational Corporation

- Value of Parent Company (p, perhaps in USD)
- Value of Subsidiary 1 (s1, perhaps in EUR)
- Value of Subsidiary 2 (s2, perhaps in GBP)

### 2.4.1 Basic Values

$$V_t = \frac{E(C_{t+1})}{(1+r)^{t+1}} + \frac{E(C_{t+2})}{(1+r)^{t+2}} + \frac{E(C_{t+3})}{(1+r)^{t+3}}$$

Value of Cash Flows in USD *Functional Currency*:

$$V_{t,p} = \frac{E(C_{t+1,\$})}{(1+r_{\$})^{t+1}} + \frac{E(C_{t+2,\$})}{(1+r_{\$})^{t+2}} + \dots + \frac{E(C_{t+n,\$})}{(1+r_{\$})^{t+n}}$$

Value of Cash Flows in EUR:

$$V_{t,s1} = \frac{E(C_{t+1,EUR})}{(1+r_{EUR})^{t+1}} + \frac{E(C_{t+2,EUR})}{(1+r_{EUR})^{t+2}} + \dots + \frac{E(C_{t+n,EUR})}{(1+r_{EUR})^{t+n}}$$

Value of Cash Flows in GBP:

$$V_{t,s2} = \frac{E(C_{t+1,\pounds})}{(1+r_{\pounds})^{t+1}} + \frac{E(C_{t+2,\pounds})}{(1+r_{\pounds})^{t+2}} + \dots + \frac{E(C_{t+n,\pounds})}{(1+r_{\pounds})^{t+n}}$$

### 2.4.2 Value Exchange Conversion

Value of Cash Flows in USD *Functional Currency*:

$$V_{t,p} = \frac{E\left(C_{t+1,\$}\left(\frac{\$}{\$}\right)_{t+1}\right)}{(1+r_{\$})^{t+1}} + \frac{E\left(C_{t+2,\$}\left(\frac{\$}{\$}\right)_{t+2}\right)}{(1+r_{\$})^{t+2}} + \dots + \frac{E\left(C_{t+n,\$}\left(\frac{\$}{\$}\right)_{t+3}\right)}{(1+r_{\$})^{t+n}}$$

Value of Cash Flows in USD *Converted from EUR*:

$$V_{t,p} = \frac{E\left(C_{t+1,EUR}\left(\frac{\$}{EUR}\right)_{t+1}\right)}{(1+r_{\$})^{t+1}} + \frac{E\left(C_{t+2,EUR}\left(\frac{\$}{EUR}\right)_{t+2}\right)}{(1+r_{\$})^{t+2}} + \dots$$

$$+ \frac{E\left(C_{t+n,EUR}\left(\frac{\$}{EUR}\right)_{t+3}\right)}{(1+r_{\$})^{t+n}}$$

Value of Cash Flows in USD *Converted from GBP*:

$$V_{t,p} = \frac{E\left(C_{t+1,\mathcal{L}}\left(\frac{\$}{\mathcal{L}}\right)_{t+1}\right)}{(1+r_{\$})^{t+1}} + \frac{E\left(C_{t+2,\mathcal{L}}\left(\frac{\$}{\mathcal{L}}\right)_{t+2}\right)}{(1+r_{\$})^{t+2}} + \dots + \frac{E\left(C_{t+n,\mathcal{L}}\left(\frac{\$}{\mathcal{L}}\right)_{t+n}\right)}{(1+r_{\$})^{t+n}}$$

### 2.4.3 Value of Each Domestic/Foreign Operation

Hence *Total Value of Parent Corporation (p)*:

$$V_{t,p} = \sum_{i=1}^n \frac{E(C_{t+i,\$})}{(1+r_{\$})^{t+i}}$$

Hence *Total Value of European Subsidiary (s1)*:

$$V_{t,s1} = \sum_{i=1}^n \frac{E\left(C_{t+i,EUR}\left(\frac{\$}{EUR}\right)_{t+i}\right)}{(1+r_{\$})^{t+i}}$$

Hence *Total Value of British Subsidiary (s2)*:

$$V_{t,s2} = \sum_{i=1}^n \frac{E\left(C_{t+i,\mathcal{L}}\left(\frac{\$}{\mathcal{L}}\right)_{t+i}\right)}{(1+r_{\$})^{t+i}}$$

### 2.4.4 Total Value of Multinational Corporation

Hence *Total Value of Multinational Corporation*:

$$V_p = V_{s1} + V_{s2}$$

Hence *For 3 Currency Example Over n Periods (i)*:

$$V_{t,MNC} = \sum_{i=1}^n \frac{E(C_{t+i,\$})}{(1+r_{\$})^{t+i}} + \sum_{i=1}^n \frac{E\left(C_{t+i,EUR}\left(\frac{\$}{EUR}\right)_{t+i}\right)}{(1+r_{\$})^{t+i}} + \sum_{i=1}^n \frac{E\left(C_{t+i,\mathcal{L}}\left(\frac{\$}{\mathcal{L}}\right)_{t+i}\right)}{(1+r_{\$})^{t+i}}$$

Hence *Generalised for 3 Unknown Currencies Over n Periods (i)*:

$$V_{t,MNC} = \sum_{i=1}^n \frac{E(C_{t+i,1}(ER_1)_{t+i})}{(1+r_{\$})^{t+i}} + \sum_{i=1}^n \frac{E(C_{t+i,2}(ER_2)_{t+i})}{(1+r_{\$})^{t+i}} + \sum_{i=1}^n \frac{E(C_{t+i,3}(ER_3)_{t+i})}{(1+r_{\$})^{t+i}}$$

Hence *Generalised for n Unknown Currencies (j) Over n Periods (i)*:

$$V_{t,MNC} = \sum_{j=1}^n \left( \sum_{i=1}^n \frac{E(C_{t+i,j}(ER_j)_{t+i})}{(1 + r_{\$})^{t+i}} \right)$$

#### 2.4.5 How Can The Value Change?

If  $C_{t+i,j} < E(C_{t+i,j})$ :  $V_{t,MNC}$  lower than expected *country business risk*

If  $r_{\$} > E r_{\$}$ :  $V_{t,MNC}$  lower than expected *country policy risk*

If  $(ER_{\$})_{t+i} < (ER_{\mathcal{L}})_{t+i}$ :  $V_{t,MNC}$  lower than expected *foreign exchange risk (where \$ is domestic)*

## 2.5 Interest Rate Risk

- $\frac{1}{100}$  of a %pt. is a ‘Basis Point’
- Must convert period to days

R = Simple Interest Rate

$$r = \frac{R}{m} = \text{Periodic Interest Rate}$$

“m periods per n”

$$(1 + r)^{mn} - 1 = \text{Compound Interest Rate}$$

$$\text{EAR} = (1 + r)^{\frac{\text{year}}{\text{days}}} - 1$$

### 2.5.1 Duration

$$\Delta B = -DB\Delta y$$

$$B = \sum \frac{CF_t}{(1 + y)^t}$$

$$D = \sum t \left( \frac{\frac{CF_t}{(1+y)^t}}{P} \right) = \sum tw_t$$

y = Yield on Bond

P = Bond Price

$$D_{\text{Zero-Coupon}} = \text{Maturity} = T$$

Constant Maturity :  $D(\uparrow)$ ,  $CF(\downarrow)$

Constant Coupon :  $D(\uparrow)$ ,  $T(\uparrow)$

Constant All Other :  $D(\uparrow)$ ,  $y(\downarrow)$

### 2.5.2 Forward Rate Agreements

$$\text{Payoff} = (\text{Notional Amount}) (\text{LIBOR} - \text{Agreed Upon Rate}) \left( \frac{m}{360} \right)$$

$$\text{Payoff} = (\text{Notional Amount}) \left( ((\text{LIBOR}) - \text{Agreed Upon Rate}) \frac{\left(\frac{m}{360}\right)}{(1 + \text{LIBOR}) \left(\frac{m}{360}\right)} \right)$$

### 2.5.3 Interest Rate Option

$$\text{Payoff}_{\text{Call}} = (\text{Notional Amount}) \left( \text{Max} (0, \text{LIBOR} - X) \left( \frac{m}{360} \right) \right)$$

If  $\text{LIBOR} > X$  : Exercise

$$\text{Payoff}(\uparrow), \text{LIBOR}(\uparrow)$$

Protection Against Rising  $i$  (e.g. future borrowing)

$$\text{Payoff}_{\text{Put}} = (\text{Notional Amount}) \left( \text{Max} (0, X - \text{LIBOR}) \left( \frac{m}{360} \right) \right)$$

If  $\text{LIBOR} < X$  : Exercise

$$\text{Payoff}(\uparrow), \text{LIBOR}(\downarrow)$$

Protection Against Falling  $i$  (e.g. future investing)