Class 3
Futures and Forwards (Part II):
Hedging Strategies Using Futures

Overview of This Class

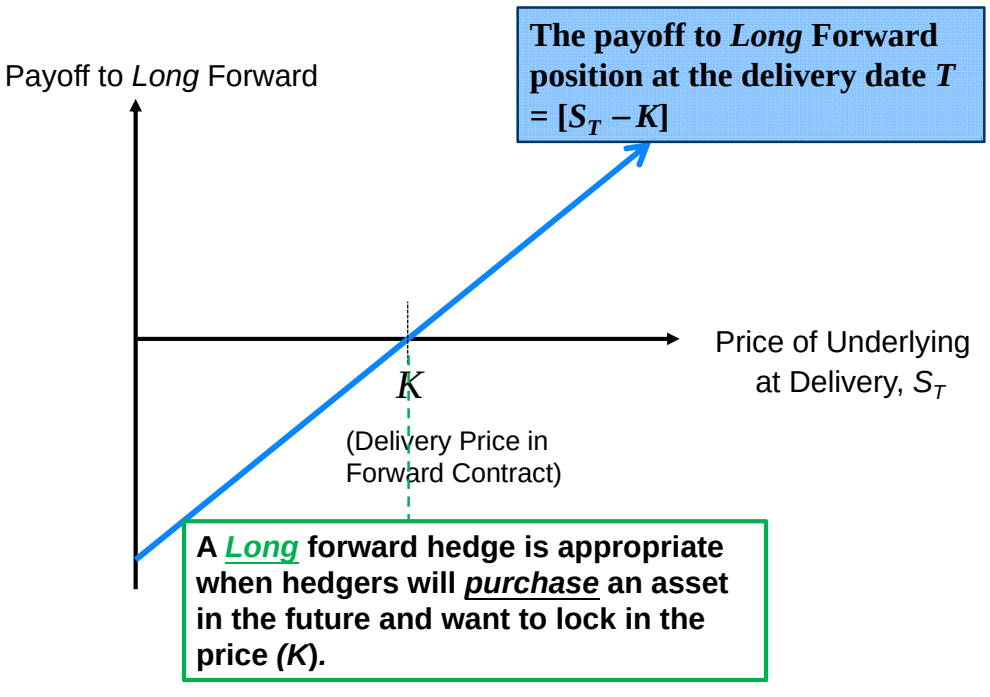
- **Motivations:** Hedging and risk management applications of forward and futures.
  - ❑ **Hedging with Forwards and Futures:** Unlike Speculators, Hedgers use derivatives to reduce risks; e.g., risk drivers related to business risks, financial transactions, investments ,etc.
  - ❑ Hedging is analogous to an insurance policy on the underlying price (remember the case of hedging illustrated in our "Casino Game" in Class #1). In practice, firms often hedge their input or output price risks.
  - ❑ Also, investors can use futures (forwards) as risk management and hedging of asset (commodity) price risks at future dates.
- **Futures and Forwards:**
  - ➢ Part 2. Hedging Strategies Using Futures and Forwards (Focus of This Class):
  - ➢ Important Concepts, Frameworks, and Applications:
    - ❑ Hedging using Futures/Forwards: Long Hedge vs. Short Hedge
    - ❑ Basis Risk; Case Study of Futures Hedging
    - ❑ Optimal Hedge Ratio
    - ❑ Index Futures (Trading Strategies and Rationales)

1. Long vis-à-vis Short Hedges

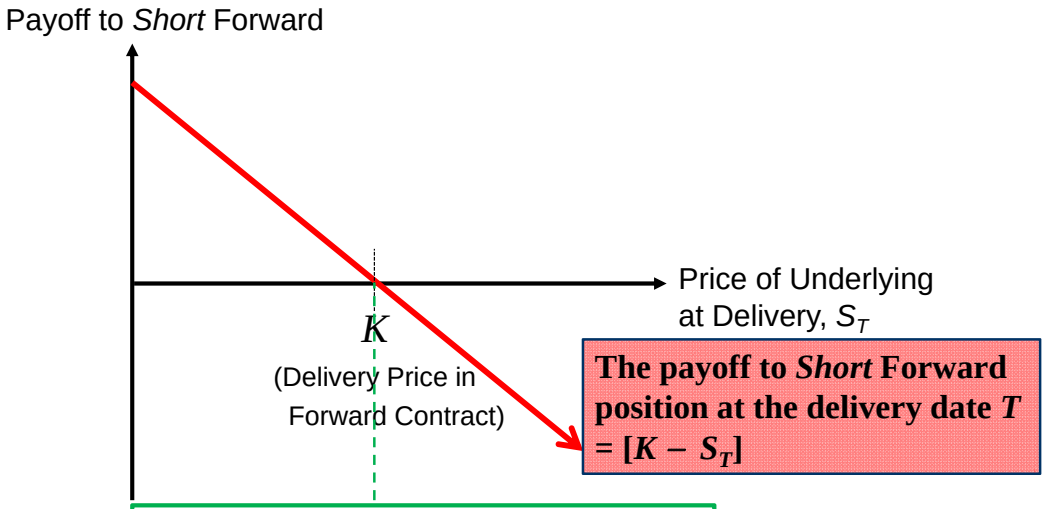
- A ***Long*** futures/forward hedge is appropriate when you know you will ***purchase*** an asset in the future and want to lock in the price.
  - Expectation of price ***increase*** in the future.
  - To reduce input price risk, a firm sets up a ***long hedge*** (or ***buying hedge***) by taking a ***long position in a forward contract***.
  - For example, a company (e.g., Southwest Airlines) that is a **user/purchaser** of jet fuels (derived from crude oil) may ***long*** a forward contract on crude oil, in order to hedge against price increase in the future.

- A ***Short*** futures/forward hedge is appropriate when you know you will ***sell*** an asset in the future and want to lock in the price.
  - Expectation of price ***decrease*** in the future.
  - To reduce output price risk, the company can establish a ***short hedge*** (or ***selling hedge***) by taking a ***short position in a forward contract***.
  - For example, a company (e.g., Chevron) that is a **producer/seller** of crude oil may ***short*** a forward contract on crude oil, in order to hedge against price decrease in the future. The hedging remove or lessen the potential loss (as well as gain) from spot price fluctuations in the future.

1.1. Payoff to *Long* Forward Position (*Long* Hedge)



1.2. Payoff to *Short* Forward Position (*Short* Hedge)



A *Short* futures/forward hedge is appropriate when hedgers will *sell* an asset in the future and want to lock in the price.

2. Convergence of Futures Price to Spot Price: Basis and Hedging

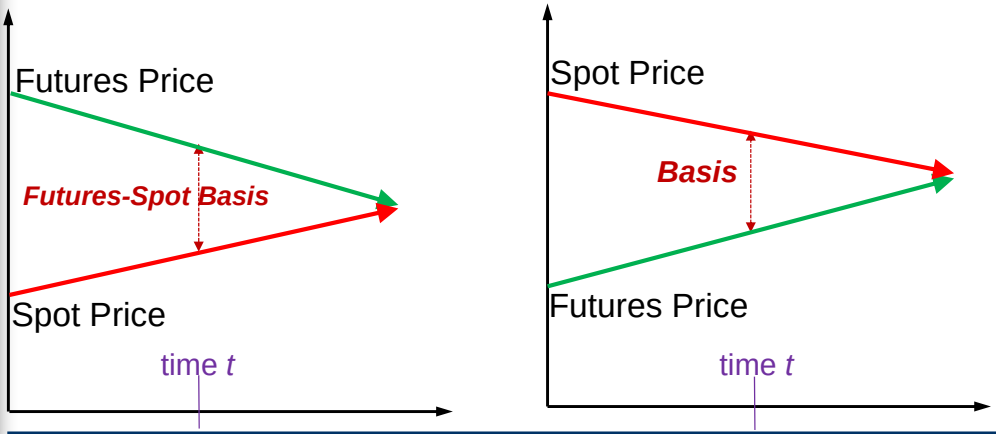
Case (1) *Contango*

Futures Price > Spot Price

Case (2) *Backwardation*

Futures Price < Spot Price

Hedge closed out at time *t* with Non-Zero Basis



***Basis* = (Spot price – Futures price)**
***Futures-Spot Basis* = (Futures price – Spot price)**
Convergence of the Basis: basis should eventually converge to 0 at maturity.

3. Basis Risk

- **Basis is often defined as the difference (Spot Price – Futures Price):**
- **Basis = Spot Price of Asset to be Hedged – Futures Price of Contract Used**
- **Alternatively:** *Futures-Spot Basis* = Future Price – Spot Price > 0 if market becomes "contango". This definition is sometimes used for futures contracts on financial assets. See previous Slide.

- ***Basis Risk*** arises because of the uncertainty about the basis when the hedge is closed out. As time passes, the spot price and the future price do not necessarily change by the same amount. As the result. The basis changes.

3.1. Basis Risk: *Short* vs. *Long* Hedges

- **Basis = $S_2 - F_2$** at time 2; **Basis = $S_1 - F_1$** at time 1.
- The hedging risk ("*Basis Risk*") is the uncertainty associated with **Basis = $S_2 - F_2$**.
- **Decrease (*Increase*) in basis benefits *Long* (*Short*) Hedge.**

Case (1) *Short* Hedge (*Short* Futures)

- Hedgers want to ***sell*** the asset at time 2 and hedge by ***short*** futures at time 1:
  - **F_1: Initial Futures Price**
  - **F_2: Final Futures Price**
  - **S_2: Final Asset Price (the price realized at time 2)**

Price Realized= $S_2 + (F_1 - F_2) = F_1 +$ Basis

Case (2) *Long* Hedge (*Long* Futures)

- Hedgers want to ***buy*** the asset at time 2 and hedge by ***long*** futures at time 1:
  - **F_1: Initial Futures Price**
  - **F_2: Final Futures Price**
  - **S_2: Final Asset Price (the price paid for asset at time 2)**

Cost of Asset = $S_2 - (F_2 - F_1) = F_1 +$ Basis

- **In Case (2), if the basis *decreases*, the *long* hedge *improves* as the cost of asset becomes less. Reverse holds for short hedge (in Case (1) above).**

3.2. Basis Risk and Hedging: Case Study of Metallgesellschaft AG (MG)

- **Rolling the Hedge Forward (known as "*Stack and Roll*"):**
  - Investors use a series of futures contracts to increase the life of a hedge. However, each time switching from 1 futures contract to another will incur ***basis risk.***

- **Case Study: Metallgesellschaft AG (MG)**
  - **Design of MG's hedging strategy:** long positions in short-dated futures that were rolled forward (to hedge against 5- to 10-year supply of oil/gas).
  - **Trading outcomes:** incurred losses in futures trading totaling about $1.33 billion (in 1994). MG closed out all hedge positions.
  - **Problems:** Oil price fell and margin calls on futures. Losses were mainly due to wrong hedge ratio and "rollover" costs due to basis risk.
  - **Verdict:** Short-term cash outflows (due to futures margins) may ultimately be offset by realized gains in the long run. Mismatch between timing of cash flows and liquidity problem (due to margin calls and basis risk).

4. Optimal Hedge Ratio

Optimal Hedge Ratio: the proportion of the exposure that should optimally be hedged is

$$h = \rho \frac{\sigma_S}{\sigma_F}$$

where

σ_S is the standard deviation of ΔS, the change in the spot price during the hedging period;

σ_F is the standard deviation of ΔF, the change in the futures price during the hedging period;

ρ is the coefficient of correlation between ΔS and ΔF.

What if there is no futures on the underlying asset? When there is no futures contract on the asset being hedged, hedgers may choose the futures contract (e.g., on comparable assets) whose futures price is most highly correlated with the asset price.

4.1. Hedging Using Index Futures

To hedge the risk in a portfolio the number of contracts that should be shorted is

$$\beta \frac{P}{A}$$

where ***P*** is the value of the portfolio, β is its Beta, and ***A*** is the value of the assets underlying one futures contract (i.e., futures price times the contract size). Note that this expression will provide the number of futures contracts (in short position), which will reduce the beta to zero (a complete hedge).

Reasons for Hedging Equity Portfolio Using Index Futures:

- ✓ **(1) Hedging systematic risk:** holding long-term portfolio and creating short-term protection in uncertain markets – i.e., desire to be out of the market for a short period of time (e.g., '*market neutral*' strategy). Hedging may be cheaper than selling the portfolio and buying it back later on.
- ✓ **(2) Locking in benefits of superior stock picking:** e.g., use Index Futures to lock in the benefits of superior stock portfolio (which can outperform the market portfolio).
- ✓ **(3) Reduction of trading/transaction costs:** remember stock market liquidity vis-à-vis futures market liquidity during down markets or financial crisis (see Class 1).
- ✓ **(4) Implications for advanced portfolio management and financial engineering:** e.g., '*market neutral*' strategy, '*market timing*' strategy, etc. See also next page.

4.2. Adjusting Portfolio Risk using Index Futures (Example of Financial Engineering)

Recall the previous equation of short index futures implies a complete hedge (i.e., reduce portfolio Beta to zero):

$$\beta \frac{P}{A}$$

P is the value of the portfolio

β is its Beta of the portfolio

A is the value of the assets (index) underlying one futures contract (= futures price * contract size)

In practice (as examples of **financial engineering**), we can use futures contract to change the risk (Beta) of the portfolio to some other values. In general, of we want to ***reduce*** portfolio risk (Beta) from β ***to*** β^* ***when*** $\beta > \beta^*$**,** we will ***short*** the following number of futures contracts:

$$(\beta - \beta^*) \frac{P}{A}$$

In contrast, we will take ***long*** position of the following number of contacts when we want to increase portfolio risk (Beta) from β ***to*** β^* ***when*** $\beta < \beta^*$:

$$(\beta - \beta^*) \frac{P}{A}$$

4.3. Review Questions (Numerical Examples): Hedging using Futures

Assume the followings:

(i) Value of the assets (S&P 500 index) underlying one futures contract is 1,000

(ii) Value of Portfolio is $1 million

(iii) Beta of portfolio is 1.5

Q1. What position in futures contracts on the S&P 500 is necessary to hedge the portfolio? Hint: review slide 4.2 and compute the number of contacts for short position in index futures. The number of contact with ***short*** position that can reduce the portfolio Beta to zero (complete) hedge should be equal to **1.5*(1 million/1000).**

Q2. What position is necessary to reduce the beta of the portfolio to 0.75? Hint: review slide 4.2. To reduce beta from 1.5 to 0.75 (change in Beta = –0.75), the number of contacts with ***short*** position should be **0.75*(1 million/1000).**

Q3. What position is necessary to increase the beta of the portfolio to 2.0? Hint: review slide 4.2. To increase beta from 1.5 to 2.0 (change in Beta = +0.5), the number of contacts with ***long*** position should be **0.5*(1 million/1000).**

Summary and Useful Readings for This Class

- **Important Concepts for Class #3 "Hedging using Futures/Forwards":**
  - Long vs. Short Hedge; Basis Risk
  - Optimal Hedge Ratio
  - Hedging using Index Futures

- **Important Readings: Jarrow and Chatterjea (2013):**
- Ch. 4 (focus on section 4.6).
- Ch. 9 (focus on section 9.6).
- Ch. 13 (focus on sections 13.1, 13.2, 13.3, 13.4, 13.5).

- **Useful (Additiona/Optional) References: Hull (7th or 8th edition):**
- Ch. 3 (focus on: "Basis Risk"; "Stock Index Futures"; "Stack and Roll").
- Note: references above are equivalent to Hull (6th edition): Ch. 3.