Trading scenarios

- Trading as a dealer (TRN)
  - Strategy: post bids and asks, try to make money on the turn. *Maximize profits*

- Trading on information (F1, PD0)
  - Strategy: forecast price trend (possibly by reading the order flow). *Maximize profits*

- Hedging (H1, H3)
  - Goal is risk reduction. *Minimize tracking error*
Hedging: risk reduction

- We have some risk exposure that can’t be directly mitigated (reduced).
- Example: A bank portfolio of loans might be exposed to risk from unexpected interest rate changes.
  - The bank can’t simply sell the loans because
    - The loans are earning returns that the bank can’t get elsewhere.
    - There might be no market for the loans.

- Example: An airline is exposed to risk arising from changes in the price of fuel.
  - It might enter into long-term fixed-price contracts, but if the airline’s projected fuel needs change, it will be difficult to modify the contracts.
- Example: A pension fund with a large portfolio of stocks has a negative market outlook in the short run (weeks or months).
  - Selling the stocks and repurchasing them will lead to substantial trading costs.
We won’t try to eliminate *all* risks.

- Hedging is expensive.
  - Most hedges will incur trading costs.
- The securities that we need may not exist.
- There are some risk exposures that we (or our investors) might want us to keep.
  - A bond fund with expertise in credit scoring might want to hedge interest rate risk, but not credit risk.
  - Investors in gold mining stocks usually want some exposure to the price of gold. They don’t want the firm to eliminate this exposure.
- We want to be thoughtful and selective about the risks we hedge and the risks we keep.

The basic hedging principle

- Reduce risk by establishing a position in a security that is negatively correlated with the risk exposure.
- Negative correlation: the *value of the hedge* moves against or opposite to the risk exposure.
  - The ideal hedging security is cheap to buy, easy to trade, and very highly correlated with the risk exposure.
  - If we can go long or short the hedging security, it doesn’t matter of the correlation is positive or negative.
Static hedging

- When we buy/sell the hedging security, we need to trade quickly.
  - Until the hedging position is established we have risk.
  - But if we trade too quickly we'll incur high trading costs.
- The trade-off is risk vs. cost
- If the hedge just needs to be set up initially, and doesn’t have to be modified, it is a static hedge.
  - The hedging in the first RIT case is static.

Dynamic hedging

- In some situations the hedge position must be adjusted after the initial set-up. This is a dynamic hedge.
- The need for dynamic hedging typically arises in
  - Stock portfolios that have put and call options.
  - Bond portfolios that try to match the duration of some liability.
- The second RIT case involves a dynamic hedge.
Sample situation 1: Removing the market return in CAT

- CAT is the ticker symbol for Caterpillar (a manufacturer of heavy equipment)
- Portfolio manager Beth has $10 Million to invest.
- If she thinks that Caterpillar is undervalued, she simply buys CAT.
- Suppose that Beth thinks that Caterpillar is undervalued relative to the market.
  - She’s analyzed the heavy equipment industry, but has no opinion on interest rates, commodity prices, consumer spending or any of the many other things that drive the market.
  - She wants to invest in the difference between the return on CAT and the return on the market.

Betting on the return difference, $r_{CAT} - r_M$

- If the return on the market is $r_M = 5\%$ and $r_{CAT} = 7\%$, she wants a return of 2%.
  - If $r_M = -11\%$ and $r_{CAT} = -8\%$, she wants a return of 3%
- She wants to be long CAT and short the market.
- She’ll use the Standard and Poors Composite Index to approximate “the market”.
- To mirror the market “M,” there are two candidate hedge securities.
  - She can go long or short the SPDR (ticker symbol “SPY”)
  - She can go long or short the S&P Composite E-mini futures contract.
The S&P composite index is a weighted average of the prices of 500 stocks. It is computed every fifteen seconds.

- Many market data systems use “SPX” to denote the index.
  - But since it is not a traded security “SPX” is not a real ticker symbol.
- As of November, 2014, \( SPX \approx 2,000 \).

Ticker symbol SPY refers to the exchange-traded-fund (ETF) based on the index.

- It actually is traded. SPY is a real ticker symbol.
- It is constructed to have a value of one-tenth the index.
  - As of November, 2014 its price is \( SPY \approx 200 \).
- The SPY tracks the SPX closely, but not perfectly.
  - Discrepancies arise due to dividends, management fees, and so on.

The E-mini S&P futures contract

- Ticker symbols for futures contracts have a two-character product code (“SP”) followed by a month/year code that denotes the maturity of the contract.
  - We’ll use “SP” to denote the nearest maturity.
- The SP price quotes are reported in index points.
- The size of the contract is \( 50 \times SPX \).
- The contract is cash settled.
  - Suppose I go long the contract today (time 0) at a price of \( SP_0 = 2,000 \).
  - Suppose at maturity (time \( T \)) the index is at \( SPX_T = 2,100 \).
  - I receive (from the short side) \( (SPX_T - SP_0) \times 50 = (2,100 - 2,000) \times 50 = 5,000 \).
  - Note: this discussion is somewhat simplified. It ignores margin and daily resettlement.
Method I: Buying CAT and shorting the SPY

- Suppose that CAT is about $100 per share, and that the \( SPX \approx 2,000 \)
- Buy $10,000,000/$100 = 100,000 sh of CAT
- The SPY represents one-tenth of the S&P index. \( SPY \approx \$200 \)
  - Beth goes short $10,000,000/$200=50,000 sh of SPY.
  - She borrows 50,000 sh of SPY and sells them.
- She’s long 100,000 sh of CAT and short 50,000 sh of SPY

Suppose that \( r_{CAT} = 7\% \) and \( r_M = 5\% \)

- CAT stock goes from $100 to $107.
  - Beth’s 100,000 shares are now worth $10,700,000.
- The SPY is initially at $200.
  - A 5% return corresponds to a price of $210.
  - The value of Beth’s short position is 50,000 \( \times \$210 = \$10,500,000 \).
- The net value of Beth’s overall position (CAT + SPY) has gone up by $200,000
- This is a 2% return on the $10 Million initial investment.
Suppose that $r_{CAT} = -8\%$ and $r_M = -11\%$

- CAT stock goes from $100$ to $92$.
  - Beth’s 100,000 shares are now worth $9,200,000$.
- The SPY is initially at $200$.
  - $r_{SPY} = -11\%$ return corresponds to a price of $178$.
  - The value of Beth’s short position is $50,000 \times 178 = 8,900,000$.
- The net value of the overall position (CAT + SPY) has gone up by $300,000$.
- This is a 3\% return on the $10$ Million initial investment.

Problem: suppose that $r_{CAT} = -10\%$ and $r_M = -6\%$. Work out the return on Beth’s $10$ Million investment.

- Answer in online copy of handout.
- The price of CAT goes from $100$ to $90$.
  - Beth’s shares are worth $9,000,000$.
- The SPY goes from $200$ to $188$.
- The value of Beth’s short position is $50,000 \times 188 = 9,400,000$.
- The net change is $-400,000$, a $-4\%$ return.
Method II: Buying CAT and shorting the futures contract

- As in method I, Beth buys 100,000 sh of CAT
- As of November, 2014 (time “0”), the level of the S&P index is about $SPX_0 = 2,000$.
- An E-Mini S&P index futures contract has a notional value of $50 \times SPX = 50 \times 2,000 = 100,000/\text{contract}$.
- She goes short $\frac{10,000,000}{100,000} = 100 \text{ contracts}$ at 2,000

Suppose that $r_{CAT} = 7\%$ and $r_M = 5\%$

- CAT stock goes from $100$ to $107$.
  - Beth’s 100,000 shares are now worth $10,700,000$.
- “$r_M = 5\%$”: The SPX goes from 2,000 to 2,100
  - To settle her 100 short contracts, Beth pays $(2,100 - 2,000) \times 50 \times 100 = 500,000$
- The net gain is $200,000$ (a 2% return on the $10 \text{ Million initial investment}$).
Suppose that $r_{CAT} = -8\%$ and $r_M = -11\%$

- CAT stock goes from $100$ to $92$.
  - Beth’s 100,000 shares are now worth $9,200,000.
- “$r_M = -11\%$”: The SPX goes from 2,000 to 1,780
  - To settle her 100 short contracts, Beth pays
    \[(1,780 - 2,000) \times 50 \times 100 = -1,100,000\]
  - Beth receives $1,100,000
- Her positions are now worth $10,300,000: (a 3\% return on the $10$ Million initial investment).

Problem: suppose that $r_{CAT} = -10\%$ and $r_M = -6\%$. Work through the numbers for method II. (How much to settle the futures contracts? What is the net percentage return?)

- Answer in online copy of handout
- Beth’s shares are worth $9,000,000
- “$r_M = -6\%$”: The SPX goes from 2,000 to 1,880
  - To settle her 100 short contracts, Beth pays
    \[(1,880 - 2,000) \times 50 \times 100 = -600,000\]
  - Beth receives $600,000
- Her net position is now worth $9,600,000.
- This is a loss of $400,000, a $-4\%$ return.
Situation 2: Removing the market risk from CAT

- Beth owns $10 Million worth of CAT
- She likes CAT, but would like to eliminate the market risk in CAT.
  - Market risk: randomness in CAT’s return that is driven by the market.
- We need a model of the joint randomness in CAT and the market.
  - We’ll use a simple linear regression.
  - Regress the returns on CAT vs the returns on M.

\[
\begin{align*}
\hat{r}_{CAT,t} &= \alpha_{CAT} + \beta_{CAT} \times \hat{r}_{SPY,t} + \epsilon_{CAT,t} \\
\end{align*}
\]

- Simple linear regression in Excel
  - Use in-cell formulas, SLOPE and INTERCEPT
  - Use array formula, LINEST. Can also be used for multiple regression.
  - Using Excel’s charting menus: plot data on an XY scatterplot; add an estimated trend line; display the equation of the trend line.
  - Use Excel’s data analysis menu to run the regression and display the output. Can also be used for multiple regression.
    - This method computes more diagnostic statistics.
    - But the results do not automatically update if the data change. You need to rerun the regression.
### Approach

- Download prices for CAT stock and the SPY (or the S&P index)
- We’ll use month-end prices from 2009-2013.
- Construct monthly returns for CAT and the SPY.
- Plot them and find the best fit linear regression line.
  - A linear regression takes two variables “x and y” and relates them as a straight line plus an error:
    - For data point $i$, $y_i = \alpha + \beta \times x_i + e_i$
- The data and details are in workbook H1.xlsx, worksheet CATSPY, posted to the web.
- You’ll be doing similar calculations for the stocks in the RIT hedging case.

### Going from prices to returns

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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</table>

The formula used to calculate returns is $\frac{C4}{C3} - 1$. 

---

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Method 1: Use the SLOPE and INTERCEPT functions

\[ \beta_{CAT} \]

Beta and intercept from SLOPE and INTERCEPT functions:

\[ 1.8589 = \text{SLOPE}(F4:F62, G4:G62) \]

\[ -0.0037 = \text{INTERCEPT}(F4:F62, G4:G62) \]

Beta with zero intercept

\[ 1.8336 = \frac{\text{SUMPRODUCT}(F4:F62, G4:G62)}{\text{SUMPRODUCT}(G4:G62, G4:G62)} \]

Method 2: Make a scatterplot with a trendline

\[ y = 1.8589x - 0.0037 \]

\[ R^2 = 0.6147 \]
Method 3: Use the LINEST array function

\[
\beta_{\text{cat}} \quad \beta_{\text{cat}}
\]

\[
\begin{array}{c|cc}
 & \text{F4:F62} & \text{G4:G62} \\hline
1.8589 & -0.0037 & =\text{LINEST(F4:F62,G4:G62,TRUE,TRUE)} \\
0.1949 & 0.0090 & \\
0.6147 & 0.0654 & \leftarrow \text{Std. Errors.}
\end{array}
\]

\[
\begin{array}{c|c}
\text{R}^2 & 0.1949 \\
\text{Mean Sq. Error} & 0.6147 \\
\text{Observations} & 90.9345 \\
\text{Residual} & 0.3886 \\
\text{Total} & 0.2436
\end{array}
\]

Method 4: Use the DATA > Analysis > Regression menu

**SUMMARY OUTPUT**

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<th>Regression Statistics</th>
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<tr>
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<table>
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<th>t Stat</th>
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<th>Lower 95%</th>
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</table>

If you don’t see “Data Analysis” on the DATA menu, you may need to enable the Analysis-ToolPak add-in. You can reach this menu from FILE ➔ Options ➔ Add-Ins.
Interpretation of one observation

- \( r_{\text{CAT},t} = \alpha_{\text{CAT}} + \beta_{\text{CAT}} \times r_{\text{SPY},t} + e_{\text{SPY},t} \)
- In June, 2009, \( r_{\text{CAT},t} = 0.334 \) (33.4%) and \( r_{\text{SPY},t} = 0.075 \) (7.5%)
- Statistical interpretation:
  - \( 0.334 = -0.004 + 1.859 \times 0.075 + 0.199 \)
  - Predicted value of \( r_{\text{CAT},t} \)
  - Regression error

- Economic interpretation:
  - “In June, 2009, factors in the broader market caused CAT to go up by 13.5%. An additional return of 19.9% came from factors unrelated to the market.”
  - These unrelated factors would be due to industry- and company-specific effects.

Decomposition of CAT’s risk

- \( r_{\text{CAT},t} = \alpha_{\text{CAT}} + \beta_{\text{CAT}} \times r_{\text{SPY},t} + e_{\text{CAT},t} \)
- \( \text{Var}(r_{\text{CAT},t}) = \sigma_{\text{CAT}}^2 = \beta_{\text{CAT}}^2 \times \sigma_{\text{SPY}}^2 + \sigma_{e,\text{CAT}}^2 \)
- Note: \( \alpha_{\text{CAT}} \) is constant and doesn’t contribute any risk.
- Interpretation:
  - \( \sigma_{\text{CAT}}^2 = \frac{\beta_{\text{CAT}}^2 \times \sigma_{\text{SPY}}^2}{\text{Total risk of CAT}} + \frac{\sigma_{e,\text{CAT}}^2}{\text{CAT’s firm-specific risk}} \)}

Total risk of CAT
CAT’s market risk
CAT’s firm-specific risk
Implications for hedging

- \( r_{\text{CAT},t} = \alpha_{\text{CAT}} + \beta_{\text{CAT}} \times r_{\text{SPY},t} + e_{\text{CAT},t} \)
- \( \beta_{\text{CAT}} \approx 1.86 \) is a multiplier
  - If the market is up 1%, then all else equal, we expect CAT to be up 1.86%
- If we are long $1 in CAT, we should be short \( \beta_{\text{CAT}} \times $1 \approx $1.86 \) of the SPY.
- To eliminate the market risk in $10 Million worth of CAT we can
  - Short $18.6 Million worth of SPY
    - \( \frac{$18.6 \text{Million}}{\$200} \approx 93,000 \) shares of SPY
  - Or, short $18.6 Million notional of the index futures contract
    - \( \frac{$18.6 \text{Million}}{2,000 \times \$50} \approx 186 \) Contracts

Example

- If \( r_{\text{SPY}} = 0.01(= 1\%) \), then we expect (all else equal, ignoring \( \alpha_{\text{CAT}} \)) that \( r_{\text{CAT}} = 0.0186 \).
- Our $10 Million position in CAT goes up by $186,000.
- A 1% gain on SPY corresponds to the S&P going from 2,000 to 2,020.
  - We settle our 186 futures contracts by paying
    \( 186 \times (2,020 - 2,000) \times \$50 = $186,000 \)
  - This is a total offset.
The RIT H1 hedging case

- We have a $100 Million portfolio and we need to hedge the market risk with a stock index futures contract for one month.
  - We need to design and implement the hedge.
  - Figure out how many contracts to short, and trade to reach that position.
- The market index is the RTX. The current value of the RTX is 1,050.
- The RTX futures contract has a notional value of $RTX \times $250. At present, this is $1,050 \times $250 = $262,500.
- The contract is cash settled. At maturity the long side receives $(RTX_{maturity} - 1,050) \times $250$.
  - Example. If the RTX in one month is 1,045, then the long side receives $(1,045 - 1,050) \times $250 = -$1,250
  - Since the RTX has declined, the long side pays the short side $1,250.

Materials (workbook H1.xlsx, posted to web)

- Worksheet CATSPY (already used earlier)
- Worksheet Portfolio contains the composition of the portfolio.
- Worksheet Securities has the price history for the portfolio’s ten securities.
### Worksheet Portfolio

<table>
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<tr>
<th>A</th>
<th>B</th>
<th>C</th>
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### Worksheet Securities

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|-----|---------|-------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
|     | Rotman In | Rotman In | GD Stock | POP Stock | RMS Stock | BBL Stock | TC Stock | GEB Stock | PKR Stock | TTW Stock | NWL Stock | GGS Stock |
| 2   | Tick    | RTX   | RTF     | GD      | POP     | RMS     | BBL     | TC      | GEB     | PKR     | TTW     | NWL     | GGS     |
| 3   | 1,050.00| 1,050.00| $ 50.00 | $ 80.00 | $ 25.00 | $ 16.00 | $ 84.00 | $ 52.00 | $ 154.00| $ 62.00  | $ 8.00  | $ 21.00 |
| 4   | 1,051.13| 1,051.13| $ 49.99 | $ 79.86 | $ 24.95 | $ 16.01 | $ 84.12 | $ 51.54 | $ 153.15| $ 61.92  | $ 8.07  | $ 21.03 |
| 5   | 1,051.78| 1,051.78| $ 50.07 | $ 79.57 | $ 25.09 | $ 15.98 | $ 83.65 | $ 51.60 | $ 153.70| $ 61.97  | $ 8.06  | $ 20.93 |
| 6   | 1,049.51| 1,049.51| $ 50.12 | $ 79.73 | $ 24.97 | $ 15.80 | $ 83.62 | $ 51.47 | $ 153.54| $ 61.81  | $ 8.00  | $ 20.81 |
| 7   | 1,053.16| 1,053.16| $ 50.23 | $ 80.20 | $ 25.02 | $ 15.89 | $ 83.47 | $ 51.56 | $ 153.99| $ 62.07  | $ 8.06  | $ 20.92 |
| 8   | 1,052.72| 1,052.72| $ 50.27 | $ 79.91 | $ 24.98 | $ 15.82 | $ 83.45 | $ 51.50 | $ 154.98| $ 62.01  | $ 8.10  | $ 20.86 |
| 9   | 1,052.55| 1,052.55| $ 50.14 | $ 79.84 | $ 24.96 | $ 15.82 | $ 83.47 | $ 52.04 | $ 154.99| $ 62.15  | $ 8.07  | $ 20.81 |
| 10  | 1,047.85| 1,047.85| $ 49.72 | $ 79.38 | $ 24.85 | $ 15.70 | $ 83.48 | $ 51.82 | $ 153.15| $ 61.44  | $ 8.04  | $ 20.76 |
| 11  | 1,050.04| 1,050.04| $ 49.72 | $ 79.45 | $ 24.92 | $ 15.75 | $ 83.65 | $ 51.81 | $ 153.57| $ 61.81  | $ 8.03  | $ 20.75 |
| 12  | 1,044.84| 1,044.84| $ 49.44 | $ 78.62 | $ 24.99 | $ 15.70 | $ 83.31 | $ 51.39 | $ 151.82| $ 61.27  | $ 7.96  | $ 20.72 |
| 13  | 1,044.12| 1,044.12| $ 49.49 | $ 78.65 | $ 24.98 | $ 15.67 | $ 82.82 | $ 51.43 | $ 151.55| $ 61.14  | $ 7.93  | $ 20.68 |
Notes

- RTX is the index; RTF is the futures price.
  - In this case, they are the same; you can use either to represent “the market”

Two ways to estimate the portfolio beta, $\beta_P$

- Compute the portfolio weights $w_1, w_2, ..., w_{10}$.
- Using the returns on the individual stocks, estimate the individual beta’s: $\beta_1, \beta_2, ..., \beta_{10}$.
- Compute the portfolio beta as the weighted average of the individual betas:
  $$\beta_P = w_1 \beta_1 + w_2 \beta_2 + \cdots + w_{10} \beta_{10}$$

- Compute the portfolio weights $w_1, w_2, ..., w_{10}$.
- For each month $t$, compute the portfolio return as the wtd avg
  $$r_{Pt} = w_1 r_{1t} + w_2 r_{2t} + \cdots + w_{10} r_{10t}$$
- Using the portfolio returns, estimate $\beta_P$
Assignment

- Design the hedge.
  - Estimate the portfolio beta.
  - Figure out how many contracts to short.
- Implement the hedge
  - H1 is running on the server. In any given round, you need to actually establish the short position.
  - Play two rounds of H1.
  - Hints: Try to establish the hedge quickly. (This reduces your risk exposure.)
  - The important thing here is not overall profits: it is selling the correct number of futures contracts.
- Answer questions 1-3. (This submission will be online via NYU classes; you'll receive an email when the submission page is available.)
- Due date: Monday, April 20, 11:59 PM