Simple Derivatives Trading

Creating a Complex Derivatives Trading Strategy that Maximizes Risk-Adjusted Economic Value

Complex Derivative

- Can trade a derivative of two publicly-traded Biotech stocks, “Bio Huge” and “Bio Small”.
- Derivative gives owner an option that may be executed at any time over the next 3 months.
- Owner may exercise option by paying a strike price of $1500.
- By exercising, owner receives a number of dollars equal to the stock price of Bio Huge times the stock price of Bio Small.
- This derivative is somewhat similar to a 3-month American-style put option, except for the unusual payout.

Risk-Free Rate

- The Treasury Yield Curve Rates:
  - 1-month: 2.02%
  - 3-month: 1.91%
  - 6-month: 1.93%
  - 1-year: 2.17%
- The risk-free rates are modeled as certain but changing. The models calculate the forward discount rates that match the yield curve.

Bio Huge

- Shares are currently trading at 130.
- Call options with a strike price of 130 and varying lengths have the following averages between their ask and bid prices:
  - 1-month: $4.20
  - 4-month: $7.90
  - 7-month: $10.65

Calculating Bio Huge Volatility

- The implied volatility of the Bio Huge stock was calculated for each time period covered by the call options.
  - A model was created for each call option.
  - Beginning with the nearest exercise date, we find the expected volatility over that time period that matches the value of the option.
  - This volatility is used to solve for the expected volatility over the next time period which matches the value of the next longest option.
- Implied Volatilities:
  - 0-1 month: 28.280%
  - 1-4 month: 23.193%
  - 4-7 month: 25.812%

Bio Small

- Shares are currently trading at 13.
- Expected Volatility of 30%
  - Based on data and trader's experience and knowledge
- Strong Relationship between Small and Bio Huge stock prices (future expected correlation of 40%)
  - Trader knows that Bio Small and Bio Huge are planning to launch a joint product for the first time ever

Theoretical Price of the Derivatives

- Trader believes that the derivatives could be mispriced by the market and represent an arbitrage opportunity
  - Implied Volatility of Bio Small and Implied Correlation of Bio Small and Bio Huge are not as accurate as trader's beliefs
  - If transaction costs are sufficiently small, there may be a positive NPV from trading the derivative.
- A model was created for the derivative
  - Theoretical price is calculated as $64.66
  - Optimal strategy is to only exercise at the expiration date

Trading Realities

- The trader has experience with this market and illiquid complex derivatives markets in general
- Mispricing
  - The actual traded price in percentage terms of the theoretical price (i.e., 100% represents no mispricing) is a mean-reverting process
  - Volatility of 15%
  - Reversion rate of 450%
- Block Trading -- This derivative is traded in blocks of 1000 units
- Trading Cost is $10 per trade
- Illiquid Market

Illiquid Market

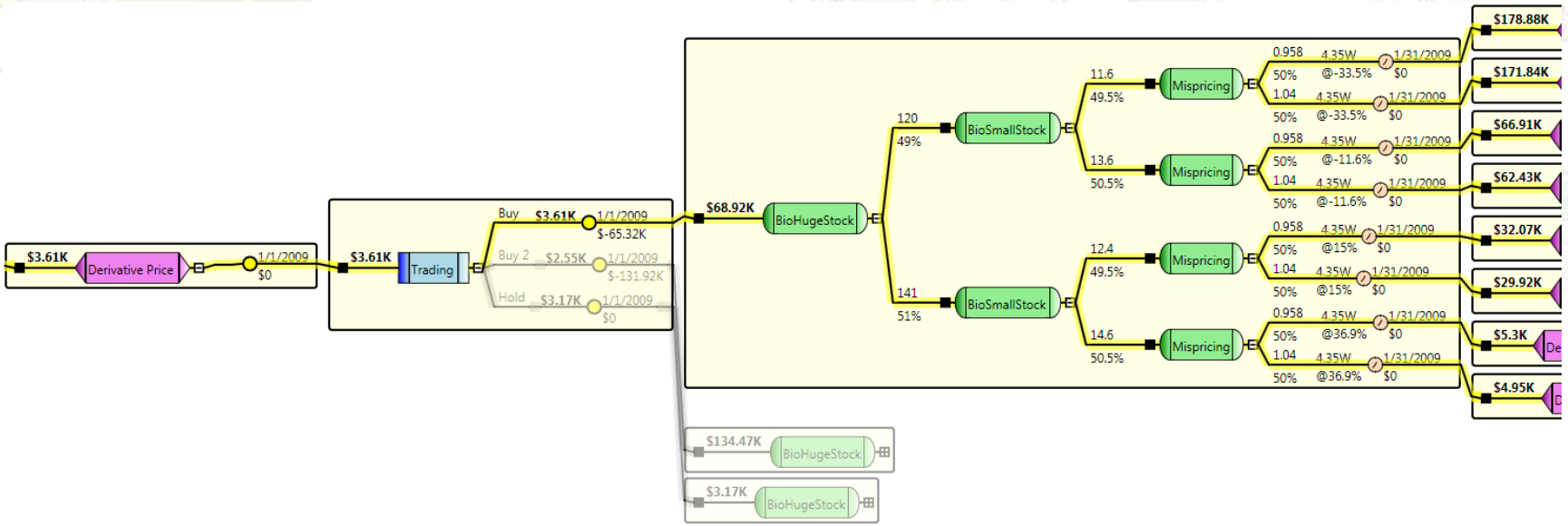
- Bid/Ask Spread is 2%
- Only one block can be traded at the bid or ask price
- After a trade, the bid/ask spread temporarily increases by an additional 2%
  - That is, a second block can be traded but only after a 2% temporary increase/decrease in price
- No reasonable price can be had by buying or selling more than 2 blocks per month

Trading Model Details

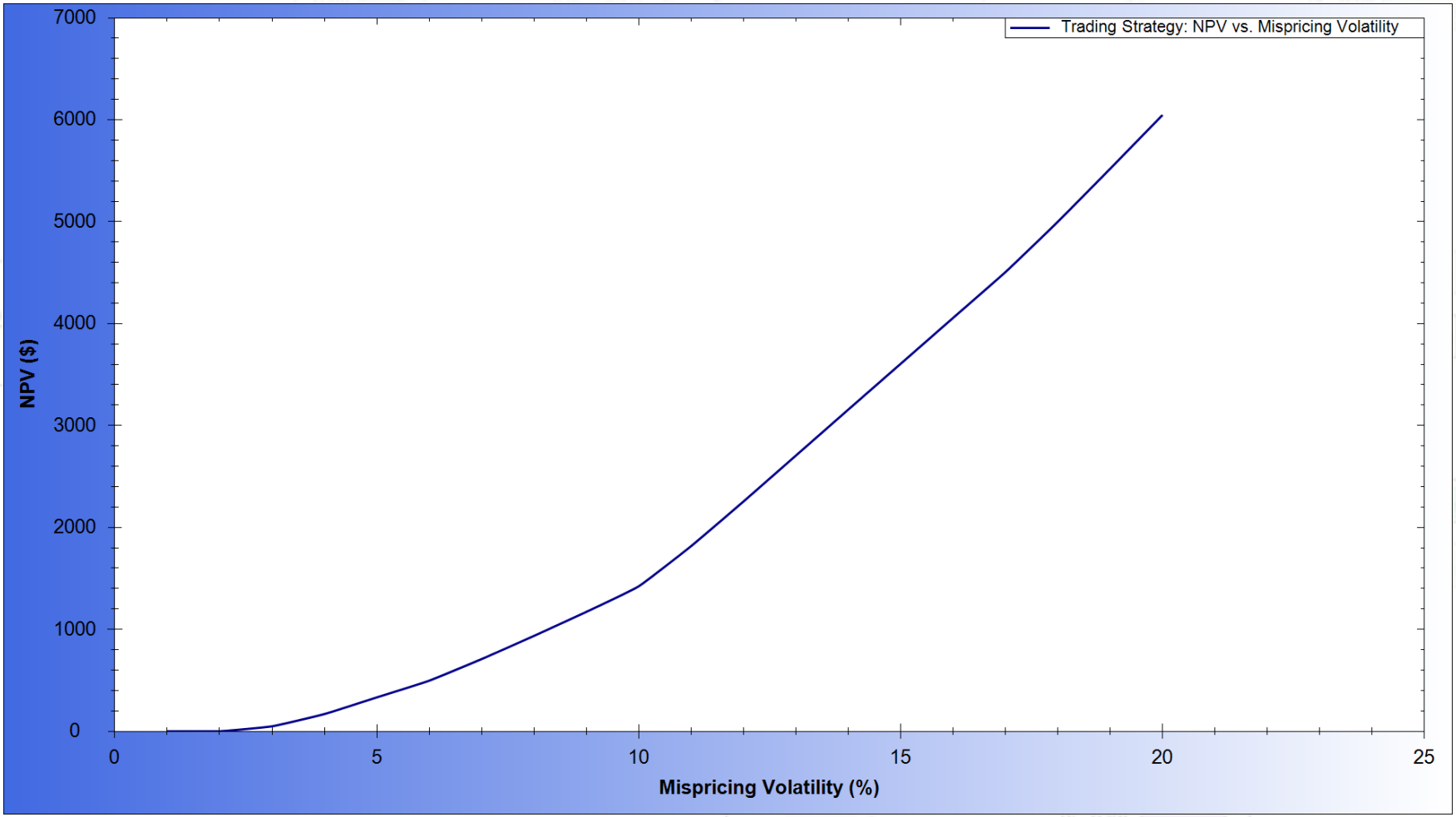
- The current mid-trading price of the derivative is $64.66.
- Monthly option to buy or sell 1 or 2 blocks or do nothing (no short sell option)
- Bio Huge stock, Bio Small stock, and the derivative mispricing are modeled as uncertainties
- Desire trading strategy that maximizes risk-adjusted economic value

Model Feedback Sample: Screen Shot – Start of Decision Tree

- Useful for investigating model in detail
- Highlights optimal-choice paths
- In the tree below, the left-most blue rectangle represents the first trading decision
- Today's optimal choice is to buy one block, resulting in an NPV of $3.61K



Model Feedback Sample: Queries
NPV vs. Mispricing Volatility



Model Feedback Sample: Gradient Analysis

- A sensitivity analysis that calculates a change in risk-adjusted economic value with a change in a model property value
- Generally calculated with the optimal strategy and all the model properties at their original values
- Similar to a Tornado diagram but arguably more relevant
- The table below contains the gradient analysis of the three model properties that were given in terms of money.

Model Property	d(NPV) / d($)
Bio Small – Initial Price	(-$50.30K)
Bio Huge – Initial Price	(-$5.03K)
Derivative – Initial Price	(-$1.39K)
Derivative – Strike Price	$0.50K
Fixed Trading Cost	(-$2.43)

Model Feedback Sample: Gradient Analyses of Percentages

- The table below contains the gradient analysis of the model properties that were given in terms of percentages.
- Note that the expected growth rate of the Bio Huge and Bio Small stock prices have no effect on the NPV. This is often true of traded assets.

Model Property	d(NPV) / d(%)
Bio Small – Volatility	$3778
Bid/Ask Spread	(-$1094)
Bid/Ask Spread Increase with Trade	(-$468)
Mispricing – Volatility	$450
Correlation – Bio Small / Bio Huge	$391
Mispricing – Global Markets Correlation	$3
Mispricing – Reversion Rate	$0.07
Bio Huge – Expected Growth Rate	$0
Bio Small – Expected Growth Rate	$0

Strategy that Maximizes Risk-Adjusted Economic Value

- Today's optimal choice is to buy one block.
- To continue to get most accurate optimal strategy over time, automatically or manually update new information into software.
- Full three-month strategy is dynamic and complex, strategy at one month is roughly:
  - if the derivative is mispriced on the low side:
    - buy an additional two blocks
  - If the derivative is mispriced on the high side:
    - if both the Bio Small and Bio Huge stock prices rise, hold
    - Otherwise, sell the one owned block

Model Feedback Sample: Queries

- The NPV and optimal trading strategy are sensitive to the current situation. For example, the initial trading choice (wait, buy 1 block, buy 2 blocks) changes depending on the current derivative price. A break-even analysis tells the trader at what derivative prices to make various trades.

Derivative Price Range	Optimal Initial Trading Choice
< $63.11	Buy Two Blocks
$63.11 - $65.40	Buy One Block
> $65.40	Wait

Strategy Comparisons

- Useful for calculating risk-adjusted economic value added by analysis.
- Table below compares optimal strategy to a "Rule-of-thumb" strategy of buying one block when mispricing is low, selling one block when mispricing is high, and exercising at 3 months when profitable.
- The comparisons are in terms of risk-adjusted economic value, in both absolute and percentage terms.

Strategy	NPV	$ increase to optimal	% increase to optimal
Optimal Strategy	$3.61K	$0	0%
Rule-of-thumb Strategy	$1.75K	$1.86K	106.3%

Other Modeling Details

- Modeled time points for months: 1,2,3.
- All uncertainties approximated periodically with 2 possible outcomes.
- For Global Markets proxy, used historical data averages of S&P from 1926-2006 to get stable 'Price of Risk' and Volatility. Then set Risk Free Rate to solve for Average Growth Rate.
  - Risk Free Rate: 3.63%
  - Average Growth Rate: 9.89%
  - Volatility: 17.86%
- The model should be updated frequently with the current prices of stock options and the treasury yield curve rates.

Discussion of Price-Matching Traded Assets

- For models that rely heavily on the accuracy of the risk-free rates, an interest rate (IR) model can be used to capture the uncertainty in the future risk-free rates. Using one these IR models, the parameters of the IR model can be matched against traded IR derivatives. IR models add a level of complexity to the decision model.
- Similarly, a single or set of expected future volatilities of an asset price (e.g., stock) can be determined from the traded derivatives (e.g., options) on that asset. Again, a more complex model of the expected growth rates and volatilities can be used to more closely match the currently traded derivatives prices.