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Pairs Trading: A Professional Approach

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What is Pairs Trading?

- Pairs Trading or the more inclusive term of Statistical Arbitrage Trading is loosely defined as trading one financial instrument or basket of financial instruments against a second financial instrument or basket of financial instruments - Long one and Short the other.

- This Presentation will concentrate on trading four of the major E-mini stock Index futures against each other.
  - S&P 500
  - Nasdaq 100
  - Dow Jones Industrials
  - Russell 2000

Trading Time Frame.

- An example of the classic Pairs trade was buying Royal Dutch (RD) stock and selling Shell (SC) stock when their values got out of line and holding the trade for a period of days or even weeks.

- This Pairs trade was driven by a fundamental reason. A Corporate Charter stipulated that 60% of income received went to RD and 40% went to SC.

- Today, utilizing High Frequency trading techniques Pairs trades can be executed hundreds or even thousands of times in a single day and are more statistical in nature.

Brief History of Statistical Arbitrage.

- Nunzio Tartaglia was a ground breaking quantitative trader who led Morgan Stanley's analytical and proprietary trading group in the mid 1980's.

- David Shaw (D.E. Shaw & Co.), moved from Morgan Stanley and started his own "Quant" trading firm in the late 1980's.

Types of Mathematical concepts used in Statistical Arbitrage.

- Time Series Analysis methods like PCA, ICA, Cointegration and Autoregression.
- Neural Networks and Pattern Recognition methods.
- Particle Physics concept of "free energy" and and energy minimization.
- Efficient Frontier Analysis and Covariance Matrices.

Mathematical References:

- "A Computational Methodology for Modeling the Dynamics of Statistical Arbitrage" by Andrew Neil Burgess.

- "Optimal Hedging using Cointegration" by Carol Alexander.

- "Optimal Arbitrage Trading" by Elena Boguslavskaya and Michael Boguslavsky

As Traders our objective is to buy the Index futures we think are cheap and sell the Index futures we think are rich. We want to do these trades in the correct ratios with respect to each other and to minimize our out right market exposure. We want to be "Market Neutral" from all our trades and make money from the spread difference between the 4 Indexes relative to some "Fair Value" Benchmark.

We will use the following Ticker Symbols:

- ES – S&P500 E-mini future
- NQ – Nasdaq 100 E-mini future
- ER2 – Russell 2000 E-mini future
- YM – Dow Jones Industrial E-mini future.
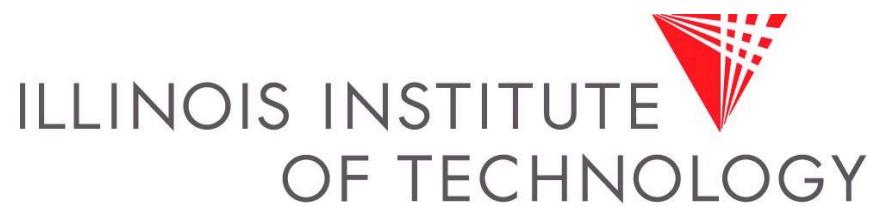
Types of trades available.

- A cointegration approach where we create the following:

- (a) Actual ES versus a synthetic ES created by some combination of NQ, YM, and ER2.

- (b) Actual NQ versus a synthetic NQ created by some combination of ES, YM, and ER2.

- (c) Actual YM versus a synthetic YM created by some combination of ES, NQ, and ER2.

- (d) Actual ER2 versus a synthetic ER2 created by some combination of ES, YM, and NQ.

More types of trades available:

- A Pairs trading approach where we trade each Pair out right based on some mathematical measure of "Fair Value".

Given the 4 major Equity Index futures defined earlier, we can create 6 Pairs of Trades.

- ES – NQ
- ES – YM
- ES – ER2
- NQ – YM
- NQ – ER2
- YM – ER2

In a High Frequency trading environment, we want to do as many trades as possible where we can obtain an "Edge". With today's spreading software it is possible to be the Bid and/or Offer for any spread no matter how many legs are involved.
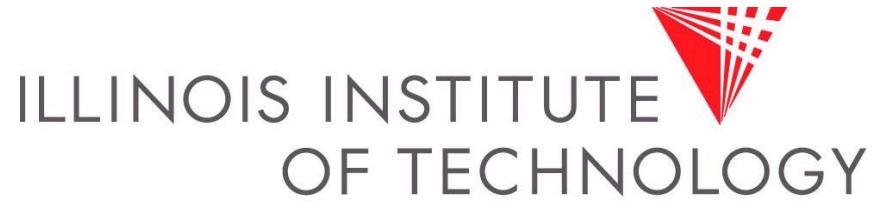
Real Time Issues for Spread Execution:

- Utilize trading Queue algorithms for spread orders so that you can get good order Queue positioning.

- Prepare for worst case scenario's like lost data feeds, late electronic fills, short term Queuing freezes and very wide and erratic Bid/Offer spreads in fast markets (Unemployment and Earnings days).

What are we looking from a Pairs Trading standpoint for?

- (1) How much of Rich Index A do I sell and how much of Cheap Index B do I buy.

- (2) When is the right time to implement the trade quantities of (1).

Two methods to Determine Hedge Ratios.

- (1) Static Hedge

- (2) Dynamic Hedge

We will choose the ES – NQ Pair as an example since it involves two of the most liquid and fast moving Index futures.
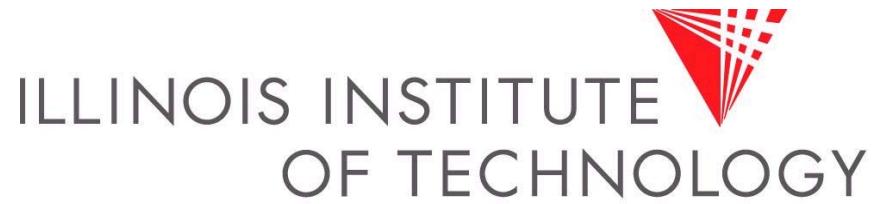
(1) Static Hedge

Example: With ES currently about 1220 and each point worth $50.00, it's Dollar Value is about $61,000.00. With NQ currently about 1634 and each point worth $20.00, it's Dollar value is $32,680.00.

- $61,000.00/$32,680.00 = 1.87, Sell 19 NQ contracts for every 10 ES contracts you Buy.

(2) Dynamic Hedge

- Using a Proprietary Beta forecasting Algorithm, based on Time Dependent Covariance we end up with a Hedge Ratio of Beta(1) = 1.25, Beta(2) = 1.11, ……, each Spread Level and Time change will give us a different Beta.

- This means for each 13 NQ contracts we Sell we will Buy 10 ES contracts to start and adjust when a new trade begins.

We will use a Z-Transform method to determine when to trade each Index Pair and how much of each individual leg to execute. This is a relatively simple way of determining fair value, but recent research has shown that in the very short term time frame, spread oscillations can be quite mean-reverting. More advanced methods can be employed using various Techniques from our previous slides.
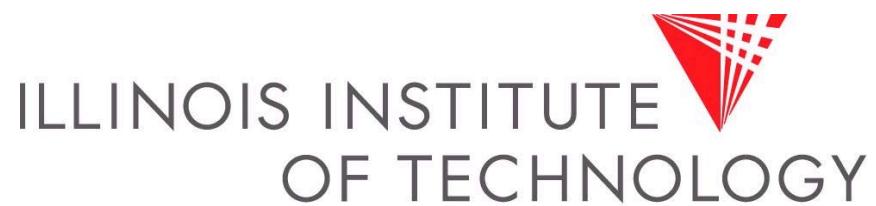
The Z-Transform is defined as:

- X1(norm)=(X1 – B(t)*MA30(X1))/(C(t)*Sigma30(X1))

- Where X1 is an Index Pair.
- MA30(X1) is the 30 period moving average of X1
- Sigma30(X1) is the 30 period standard deviation of X1.
- X1(norm) is a value between about +3 and –3.
- C(t), B(t) are Proprietary functions used for Beta or Hedge forecasting

We want to sell each Index Pair when it's value of X1(norm) is +2 or greater and buy each Index Pair when it's value of X1(norm) is –2 or less.

- We assume that when the ES – NQ Pair is cheap we will be buying ES and selling NQ and when the ES - NQ Pair is rich we will be selling ES and buying NQ.

The following results were obtained using a proprietary version of the Z-Transform method on 1 minute data for the ES and NQ.

Z-Transform	Sell NQ Buy ES	Cumulative P&L
1.14	0.00	
-0.09	0.00	0.00
-1.21	0.00	0.00
-1.18	0.00	0.00
-2.73	2.00	0.00
-2.11	2.00	0.00
-0.36	2.00	0.00
-1.57	2.00	0.00
-0.68	2.00	0.00
-1.05	2.00	0.00
-0.59	2.00	0.00
-0.56	2.00	0.00
-0.13	2.00	0.00
0.71	2.00	0.00
0.71	2.00	0.00
1.17	2.00	0.00
2.20	-2.00	110.00
1.97	-2.00	0.00
0.86	-2.00	0.00
1.14	-2.00	0.00

- Total Net Profit $61,800.00   Open position P/L   ($310.00)
- Gross Profit $141,580.00   Gross Loss   ($79,780.00)
- Total # of trades   350   Percent profitable   57.43%
- Number winning trades 201   Number losing trades   149
- Largest winning trade $4,980.00 Largest losing trade   ($3,220.00)
- Average winning trade $704.38 Average losing trade   ($535.44)
- Ratio avg win/avg loss 1.32   Avg trade (win & loss) $176.57
- Max drawdown   ($8,400.00)   Profit Factor   1.77
- Account size required $108,400.00
- Return on account   57.01%

Other types of Pair Trades:

- Dax – EuroStoxx
- CAC – FTSE
- 5 Year US Treasury Future – 10 Year US Treasury Future
- 2 Year US Treasury Future – 5 Year US Treasury Future as a Package against the 10Year US Treasury Future – 30 Year US Treasury Future Package.

Other Types of Pairs Trades (Continued):

- Various Currency Pairs against each other.

- Yen/Dollar – Euro/Dollar

- The Triangle Arbitrage Relationship of Yen/Dollar – Euro/Dollar – Yen/Euro

Pairs Trades Gone Bad!!

- ES up 5.0 points, YM down 50 on CAT earnings worries.

- GE – HON   Take over Arbitrage Spread was trading at 0.60 and blew out to over 12.00 when the Deal fell through.

- LTCM Yield Convergence trade blew up when Russia Defaulted.

- 2 Year TED Spread went from 35 bps to 75 bps when plane hit WTC.

Further Research:

- Forecasting Beta's or finding the best hedge ratio to use between Index A and Index B when a trade is signaled. Since the market has many possible distributions during the trading period, determining how much of Index A to buy(sell) relative to how much of Index B to sell(buy) is very important to the success of a Pairs Trading strategy. The standard approach of assuming a GARCH or mean-reverting model where your beta converges to some long term value is not as efficient with drastically changing market conditions.

Further Research continued:

- Position-sizing and Risk management algorithms are the most important part of any trading program whether you trade once a week or three thousand times an hour. Controlling Losses is the key to a good trading system.

Conclusion:

- A Pairs trading approach gives us a good frame work for utilizing today's High Frequency trading software with a relative small downside potential.

- This approach is very sensitive to commission and fee levels and can only efficiently be executed by Individuals or Firms with CME, CBOT or other Exchange memberships and good economies of scale.