

**An overview of Asia-Pacific financial markets
and common applications of financial mathematics**

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Introduction and Background

Went to the University of Sydney. Focused mainly on problems in financial mathematics.

- Bachelor of Science Honours Applied Mathematics
 - Monte Carlo Methods in Option Pricing
- PhD Applied Mathematics
 - Modelling asset dynamics via an empirical investigation of Australian Stock Exchange Data

Financial mathematics is a new and developing field.

While this type of research differs from the more traditional financial mathematics topics such as option pricing it has seen an increase in demand from investment banks and hedge funds.

Asia-Pacific Financial Markets

The financial industry can be roughly divided into two types of participant.

1. Sell-Side

2. Buy-Side

1. Sell-Side

The sell-side participants are entities that provide services. They do not engage buying and selling securities for profit. However, they often run *risk-positions* but as a means of providing *liquidity*.

Most investment banks have a securities arm

- CLSA Asia
- Goldman Sachs Securities
- Macquarie Securities
- J.P. Morgan Securities
- Morgan Stanley Securities
- Cazanove Securities Asia
- Nikko Citigroup Securities Japan
- UBS Securities
- Credit Suisse Asia Securites

What do sell-side firms offer their clients?

- Brokerage
 - Efficient execution of orders
 - Providers of liquidity
 - Tools for electronic order management
- Research
 - Qualitative
 - Quantitative
- Deals
 - Initial public offerings (IPOs)
 - Placements and new issues
- Prime Brokerage
 - Settling trades
 - Stock borrow
 - Swaps and *over-the-counter* (OTC) products
 - Basic risk and position monitoring tools

2. Buy-Side

Buy and sell securities in an attempt to make a profit. The main participants can be categorised as:

- Mutual funds
- Hedge funds
- Proprietary desks

Different strategies:

- Long only funds
 - Majority of funds are long only
 - Performance is benchmarked to the major stock index of the country
 - Mathematically unsophisticated
- Long/short funds
 - Operate much like a long only fund except allowed to short stock usually 120/20
 - Still benchmarked to the major stock index of the country
- Market neutral funds
 - For every dollar invested in a long position, they have a dollar invested in a short position
 - Idea is to produce steady returns regardless of what the market in general is doing
 - Profit through inefficiencies in the market
 - use relative value models to exploit mispricing
- Arbitrage funds
 - Event arbitrage
 - Statistical arbitrage
 - Convertible arbitrage
 - Volatility arbitrage

Australian Market

The Australian market is quite unique in its behaviour which has arisen as a result of both government and industry behaviour.

- Australia is a relatively small market. Only a few hundred stocks with liquidity.
- Market driven by superannuation policy of the government
- Long only fund managers benchmarked to ASX200
- Land of duopolies. Australian companies typically do not have many competitors (if any). This is partially a result of a small population.

Asia-Pacific

In contrast to Australia, the rest of Asia offers an inhomogeneous mix of market participants.

- Markets traded
 - Japan, Hong Kong, Taiwan, Korea, Singapore, Australia
 - China, Thailand, Malaysia, Indonesia, New Zealand, Philippines, India, Pakistan
- Due to the much larger population, Asia offers a much larger selection of companies. It is not unusual to find tens if not hundreds of companies that do very similar (if not the same) things.
- Have to work longer hours...

Quantitative World

In the past quantitative roles in the industry were filled by people from a cross section of science and mathematics and engineering. The tasks they performed were often quite diverse. In recent times these roles have become more specialised and more defined in the tasks and duties they perform. As a result a more industry specific/vocational form of training is needed for quantitative roles.

Course such as MFinMath are excellent at preparing people for the industry as they teach the basic skills and concepts needed to function in a quantitative role. Its important to know the *buzz words*.

Duties performed by 'quants' can vary a great deal. Biggest difference in what you will be doing depends on which side you're on.

Life on the Sell-Side

The sell-side is really where quantitative analysts were first utilised. It still offers a good opportunity to do quantitative work.

1. Quantitative analysts

Large investment banks usually have a quantitative division that develop the pricing models for the derivatives and structured products team. Typically they will be solving differential equations (e.g. Black-Scholes) using mix of analytic and numerical techniques. Create and maintain a suite of pricing tools that will be used by the traders to price contracts and work out the exposures of their option books. This is the classic role of the quantitative analyst.

2. Risk management

Risk management is another area where much financial mathematics is used. Sell-side firms usually have contracts/stock on their books in order to provide liquidity. To make sure they are not exposing themselves to market moves they employ sophisticated risk management tools to work out what they can and cannot hold. Implementing *value-at-risk* models and portfolio optimisation tools.

3. Quantitative research

Quantitative research analysts build models that are used by clients of the firm (investors) to work out what to buy and sell. Centres around developing models that accurately represent stochastic processes that drive the market. This area is relatively unexplored and the current efforts in this area are clumsy and unsophisticated. This is because of a few reasons:

- traditionally the mathematicians have gone into the quantitative division where the use of mathematics is more defined and accepted.
- its only been recently that studies have been done using techniques appropriate to this field. eg high frequency data models
- the buy-side beckons...

Life on the Buy-Side

Before the modern hedge fund revolution the buy-side was a lonely place for a mathematician. As the industry has awoken to the idea of using mathematical techniques to generate trading ideas the demand for financial mathematicians has exploded.

Hedge funds employ quantitative analysts to develop and implement cutting edge pricing models in order to exploit instances of mispricing in the market.

Due to the advanced methods used by many hedge funds, standard portfolio risk models used by the industry are rendered incompatible. This is due to contradictions between the assumptions used by the hedge funds pricing model and the assumptions used by the risk model. This means custom solutions are needed.

My Roles

Deutsche Securities - Sell-side

Opportunity to apply my research.

- One of two quantitative analysts at Deutsche.
- Built tools that executed orders automatically. Much of what traders do can be automated.
- Built some more tools to help with providing liquidity.
- Developed trading models to search and exploit market inefficiencies
- SEATS operator licence. Proprietary trader.
- Pairs trading is hard in Australia. Not enough opportunities.

Voyager Funds Management - Buy-side

Market neutral Pan-Asia hedge fund. Half owned by Westpac.

- 200%-400% leverage, self funding trades
- Relative value trading
 - pairs trading
 - basket trading
 - opportunistic trading (including IPO's)
- Profit on market inefficiencies caused by people buying/selling too heavily
- Most investors are unsophisticated

There are four people in our investment team,

- Andrew Cormie - Partner
- Ivan Kaverzine
- Jim Clark
- Will Bertram

What sort of things do I do? In short a bit of everything!

- Trading - giving orders via phone to brokers and manual execution
- Risk management
- Portfolio management - trade selection
- Prime brokerage relationship manager
- Analysis of past performance
- building tools for real time management of positions
- Built models and infrastructure for trade signal generation

Example: VWAP Engine

The task is: given a fixed volume of shares to buy or sell want to get them done at a price that looks reasonable relative to the days range of trading.

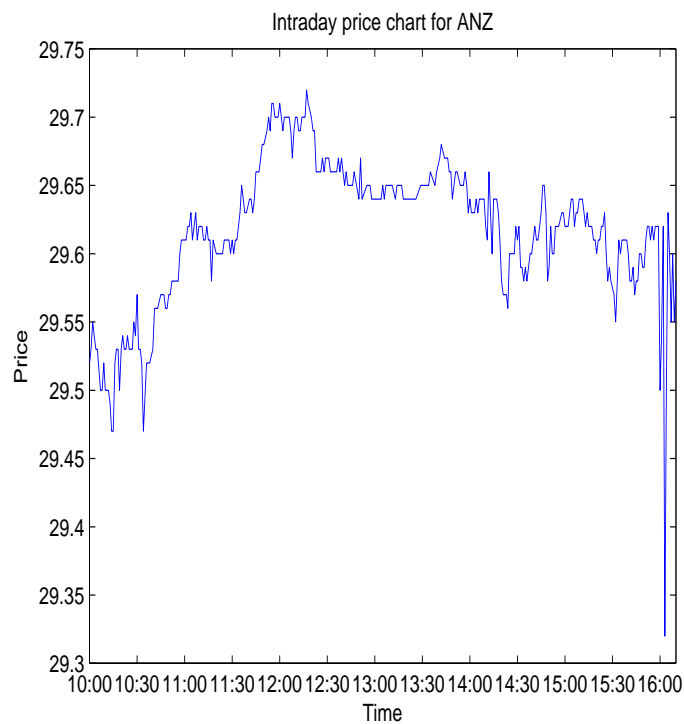


Figure 1: Intraday price chart for ANZ

Want to participate in all prices over the days range of trading.

Volume weighted average price is the benchmark execution strategy. It is used as a proxy for the price level at which liquidity was a maximum.

$$VWAP = \frac{\sum_i P_i V_i}{\sum_i V_i}$$

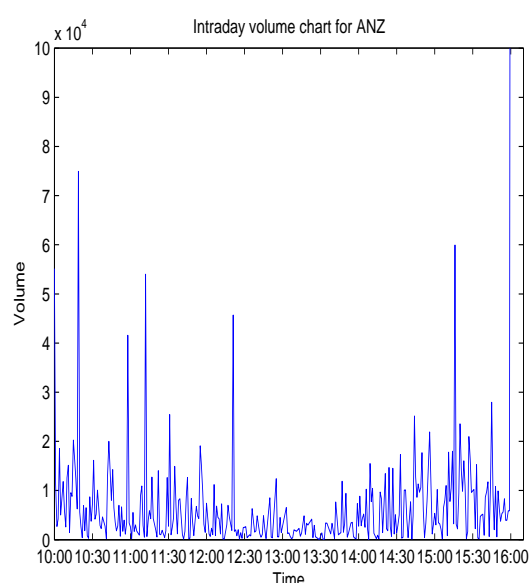


Figure 2: Intraday volume chart for ANZ

VWAP is the way most trades are executed. Most traders spend their lives filling VWAP orders.

The task is to automate this process. Freeing up people to focus on more important things.

When we examine the intraday behaviour of stocks we find that they contain some remarkably consistent behaviour.

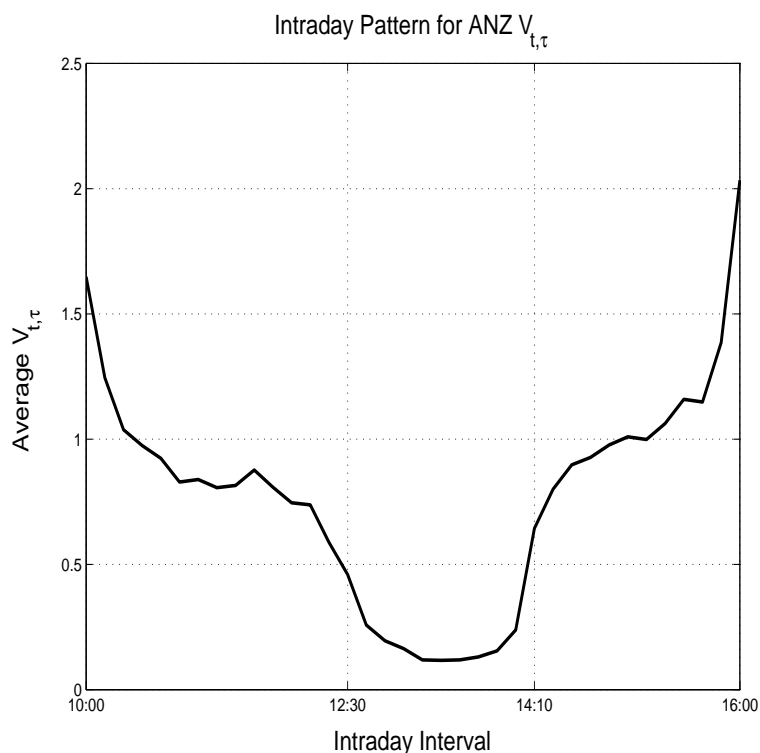


Figure 3: Pattern of average intraday volume traded for ANZ bank.

We have a density function for traded volume. Most volume is done in the first and last half hours of trading. From 12.30pm to 2.00pm very little volume is traded.

If we integrate we obtain the cumulative volume distribution. This tells us how much volume we should have done up to time t .

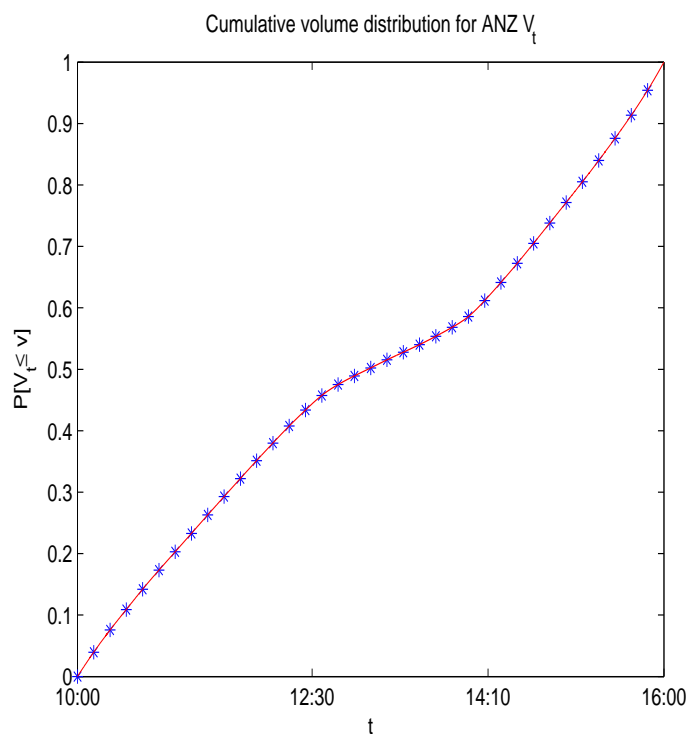


Figure 4: Cumulative distribution of volume traded for ANZ bank.

Divide the day up into time steps Δt work out how much volume we should do in each interval. On average this should keep us close to VWAP.

Implementing the Strategy

Idea seems sound, but practically requires some extra pieces.

We will use three main elements in our implementation

1. Passive algorithm - follows the distribution
2. Catch up algorithm - for when we fall behind
3. Opportunistic algorithm - uses statistical methods to improve average price

We implemented this VWAP trading engine in Australia, Hong Kong, Taiwan, Korea and Singapore. On average it is within $\pm 0.08\%$ of VWAP.

Example: Pairs Trading

Pairs trading is a relative value based strategy whereby securities can be identified as being over or under priced relative to a similarly behaving security.

The relative price difference between the pair of stocks is known as the spread. If the spread is at an extreme value then a miss pricing has occurred one (or both) of the stocks. It is possible to profit from this situation by taking a long position in the undervalued stock and a short position in the over valued stock. Such a trade is said to be market neutral as it should carry no exposure to general market moves.

Modelling the spread

In order to successfully implement pair trading it is necessary to be able to model the dynamics of the component securities and accurately estimate the parameters that define the relationship. Construct the spread,

$$S_t = x_t - \gamma y_t = \epsilon_t$$

where x_t and y_t are the log-prices of two securities and $\epsilon_t \sim \mathcal{N}(\mu, \sigma)$. The value of γ represents the amount of stock y needed to offset day to day movements in stock x .

We model the spread in order to locate the equilibrium point and extreme values. General model use an Ornstein Uhlenbeck process,

$$dS_t = k(\mu - S_t)dt + \sigma dW_t$$

Here k is the reversion rate, μ is the long term equilibrium value and σ is the volatility of the spread.

Estimating Parameters

Kerry Properties and Sino Land are both Hong Kong property stocks of roughly the same size. They have the same exposure to Hong Kong and China.

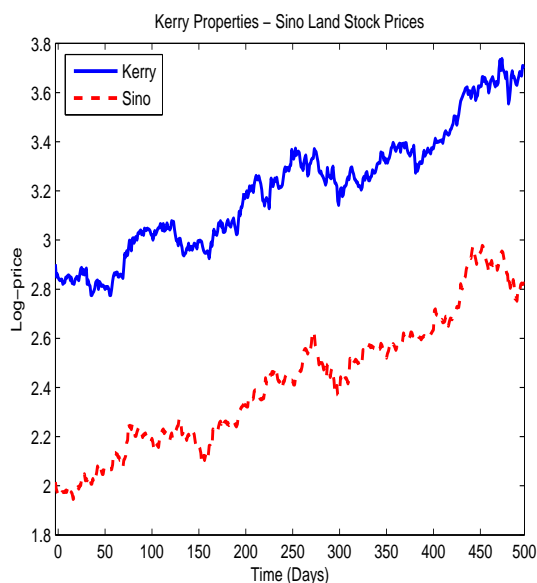


Figure 5: Log-price series for Kerry Properties and Sino Land.

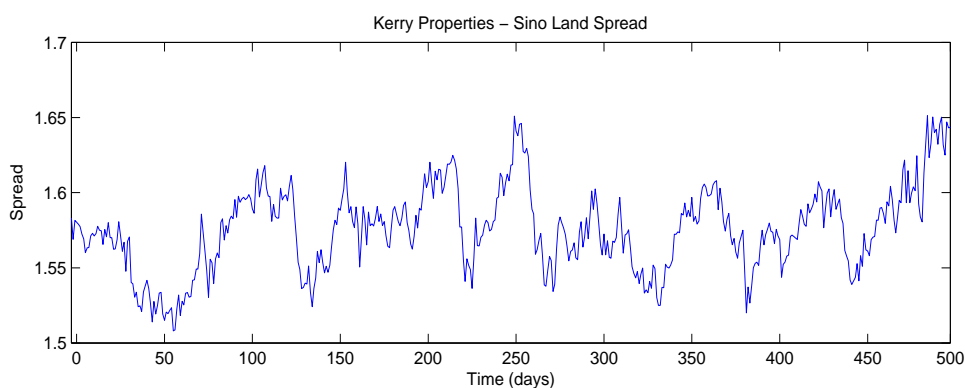


Figure 6: Kerry-Sino spread.

When parameters are relationship between stocks is stable and parameters are relatively constant then we can use least-squares methods.

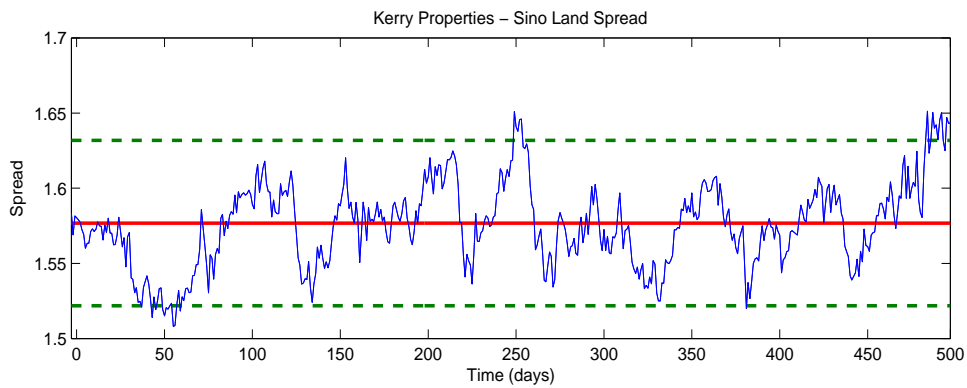


Figure 7: Estimates of Kerry-Sino spread parameters.

In most cases we can't assume that parameters are constant...

Time dependent parameters

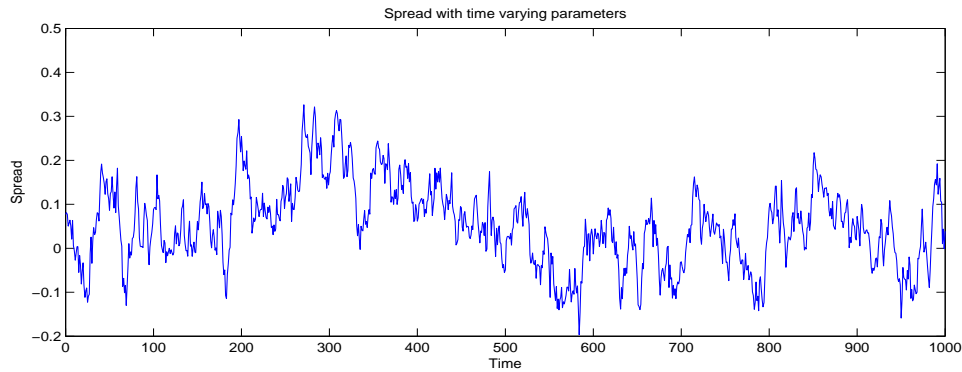


Figure 8: Spread with time dependent equilibrium point.

The problem of time dependent parameters is addressed by the stochastic parameter model,

$$dS_t = k_t(\mu_t - S_t)dt + \sigma_t dW_t \quad (1)$$

The parameters k_t, μ_t and σ_t are modelled by a second system of equations. This problem can be resolved in state space form by the *Kalman filter*.

The Kalman filter was originally developed by Kalman (1960) for the purpose of trajectory estimation in the Apollo space program.

We assume that the parameters are random walks and estimate them using the Kalman filter.

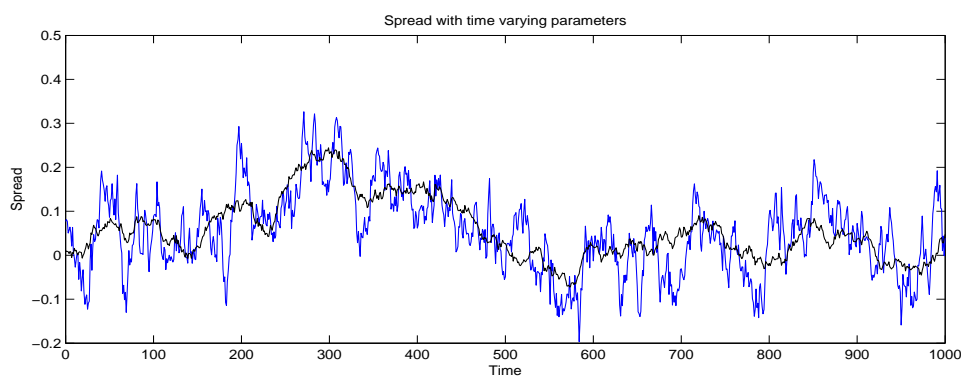


Figure 9: Spread with time dependent equilibrium point.

In order to generate a trading signal we need to identify what movement in the spread is due to the changing equilibrium point and what due to tradable noise.

We can measure the expected time of reversion, so work out limits for where the equilibrium point can be. If we're outside these bounds, then trade.

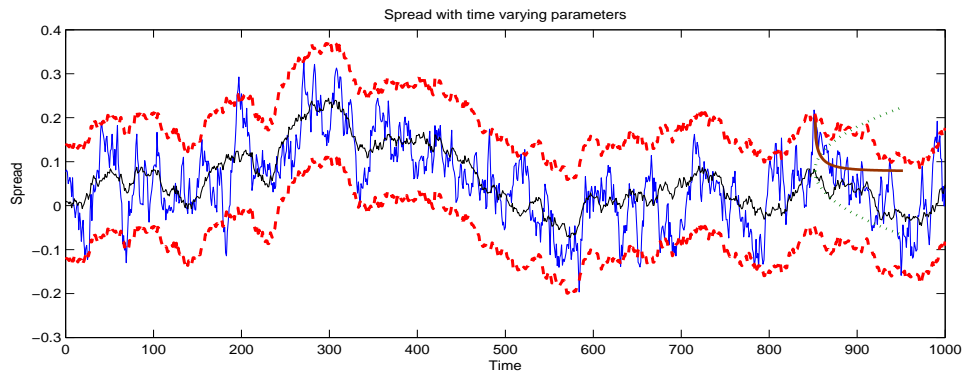


Figure 10: Spread and trade signals.

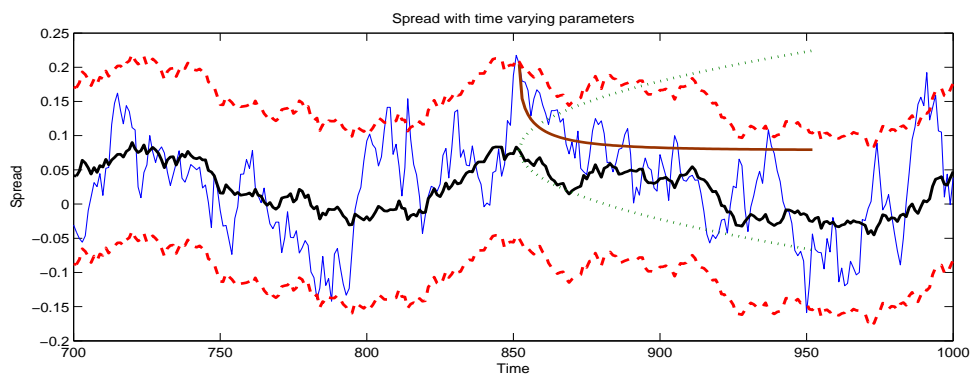


Figure 11: Spread and trade signals.

Implement strategy, automate trading and go!

Conclusion

- Work is exciting
- Lots to do
- Difference between working on sell-side or buy-side
- Working at the coal face
- Paid well
- Asia Pacific is the frontier