# From Particles To Electronic Trading

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# Introduction

- For the first few slides we will aim to give you a feeling of what high frequency trading means and the arguments for and against it.

- We will then move our focus towards describing market analysis and how this can be used for trading.

- Finally we will describe the technology involved.

- Please interrupt and interact.

# What is High Frequency Trading?

- Trading can be split into two camps – market making (supplying liquidity to the market) and risk taking (trying to predict the direction of the market).

- As a rule of thumb large banks are the market makers (MM) and hedge funds are the risk takers.

- Traditionally MM was done by voice traders manually quoting markets or executing trades. Now it is driven by quants using mathematical models.

- These mathematical models have proved amazingly successful and as a result the market is in the process of seismic shift towards electrification and high frequency trading.

# The Trend
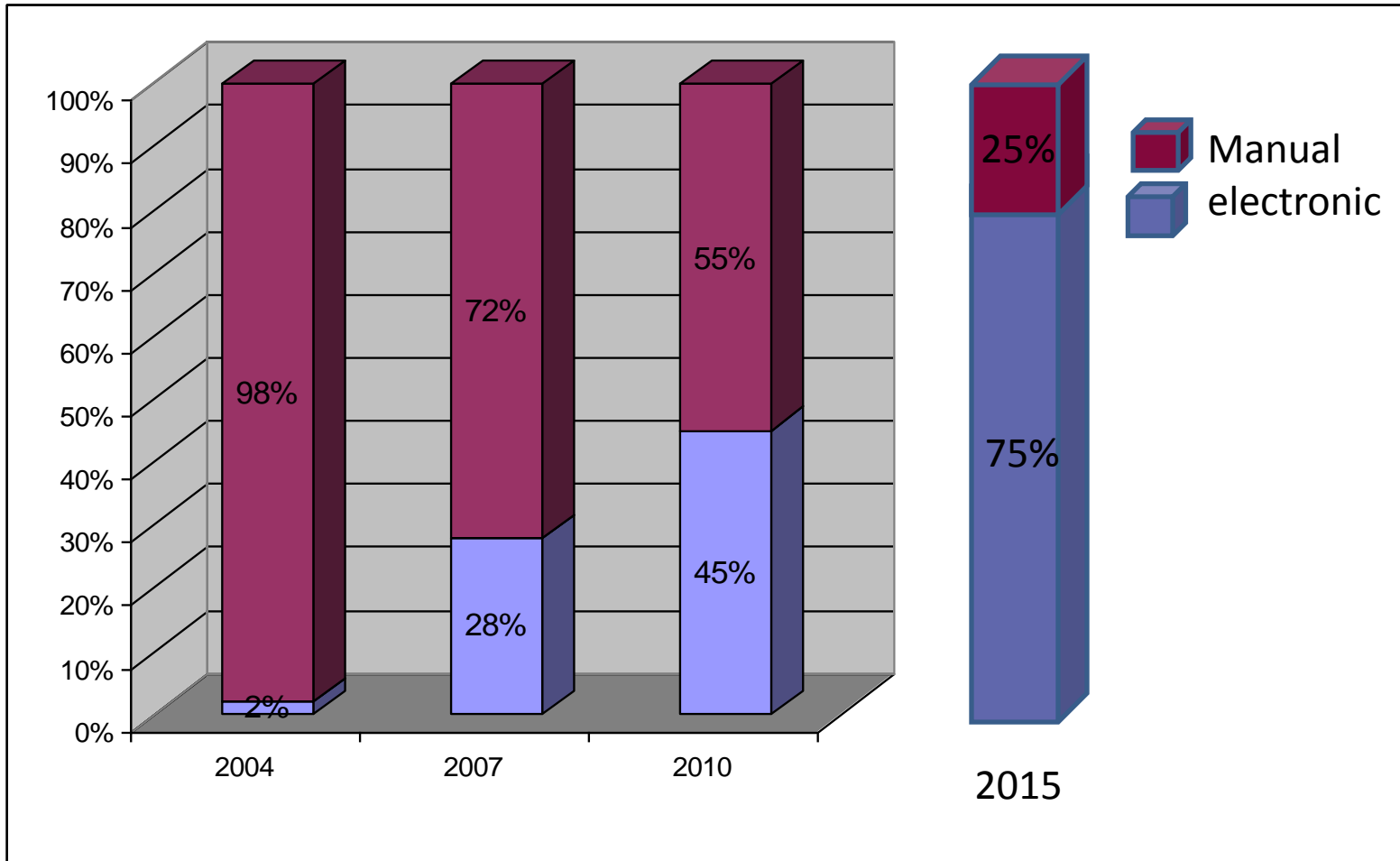
# Arguments For High Frequency Trading

- Computers interact with the market more strategically than humans – lower volatility

- Smaller trade size

- Price compression

- Positive, additional liquidity – benefits all market participants

- Streaming support – market making

- Participation consistent even in less active markets

# Arguments Against High Frequency Trading

- Liquidity Mirage

- Increase cost of ticket processing

- Opportunistic strategies at the cost of real business

- Market Makers come and go as they please

- Last look enables cherry picking

- Flashing

- Manipulation is harder to police

# Risk Taking

- This can simply be described as placing a trade in the direction you think the market is going to move.

- But why use computers:

  - There is no computer that can beat the human brain for processing complex information, finding patterns and making decisions.

  - But we can only process a few data sets at a time, at a limited speed, and for a limited time. We are also prone to emotions and selective memory.

  - However a computer does not tire, can do a very large number of calculations in a very short time, has a perfect memory , and is emotionless.

- Strategies can be very simple to very complex. In the next few slides we will construct a very simple strategy and briefly describe techniques people use.

# Constructing a Risk Taking Strategy
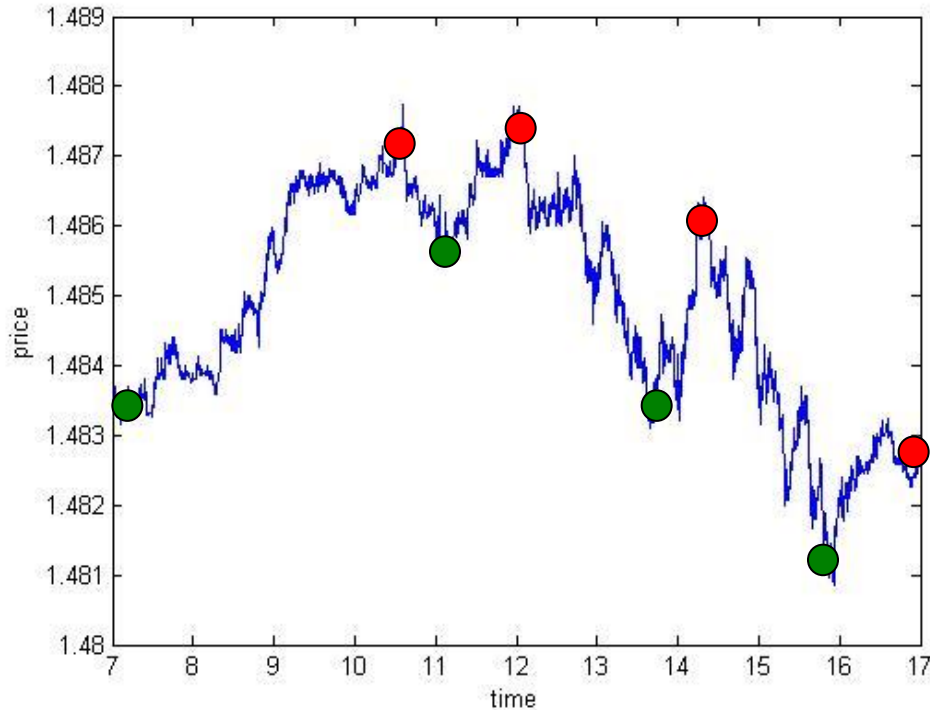


- Consider the plot to the left. This is a time series for EUR from 2012. Maybe at the beginning of that day you came in economic data from Europe was bad so you decided to sell the EUR.

- By the end of the day you would have a profit of 10 ticks.

- Profit is good, but now consider the dots.

- If we had traded at these points we would have made 200 ticks

- The smaller time scale we look at the more potential ticks profit we can capture

- But how do we identify when to place the trade. Let's look at probably the most famous algo trading strategy – the simple moving average.
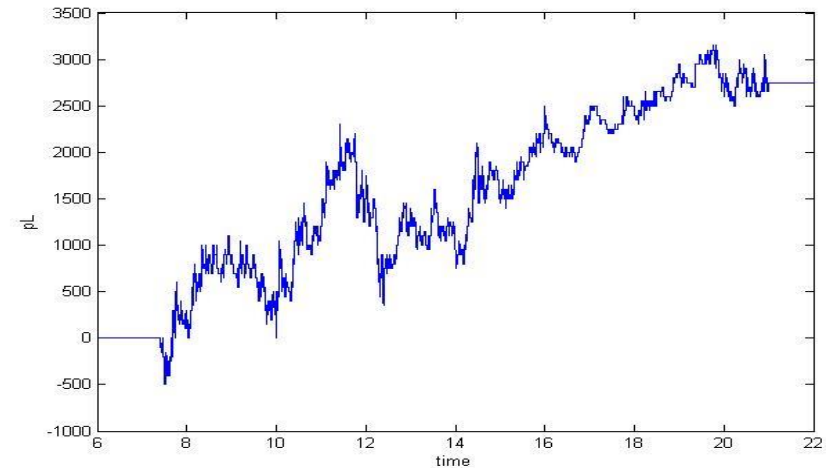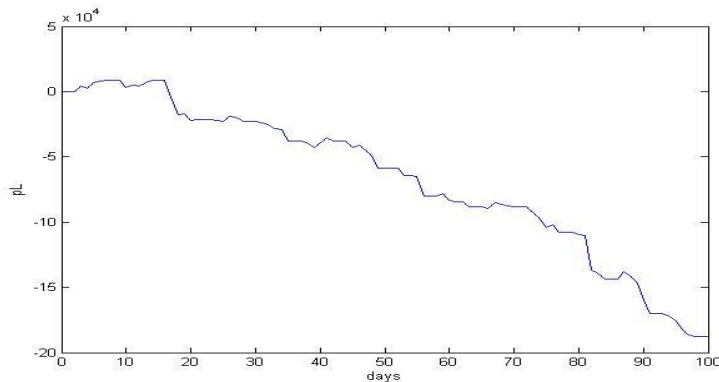
# Simple Moving Average
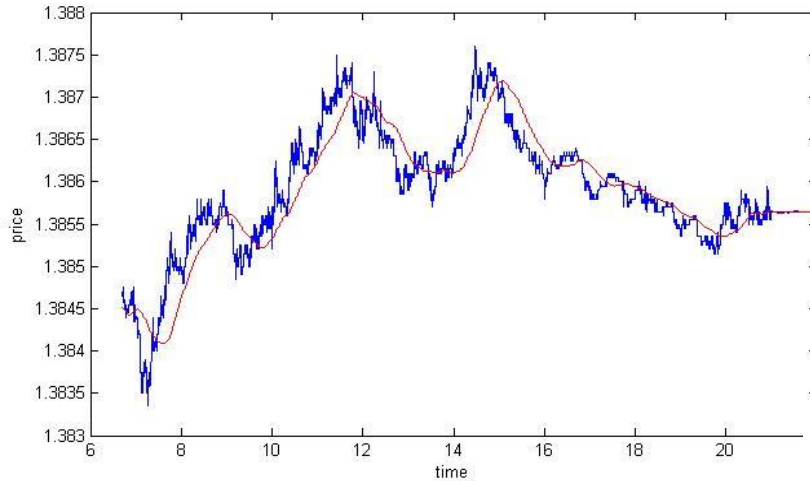


The plot on the left shows a time series with a 10 minute moving average.

Now every time the time series goes above the line we buy the currency, when it goes below we

- Easy!

- Sadly I cheated. I just picked a day that works as an example.





- The plot on the left shows the cumulative profit over 100 days.

- And that doesn't include costs of trading.

# Quiz

- In the previous slide I showed an example of using a 10 minute window, but why 10? Why not 9, 11, 1, or 30? Each will give different trading signals and hence profit.

- What we find is that the parameter that gives the maximum profit moves around on a daily basis.

- So the question I ask you to think about for the remainder of the presentation, and there will be Citi prizes up for grabs, is how do we select the best parameter(s) to trade?

- What happens when we have more than 1 parameter?
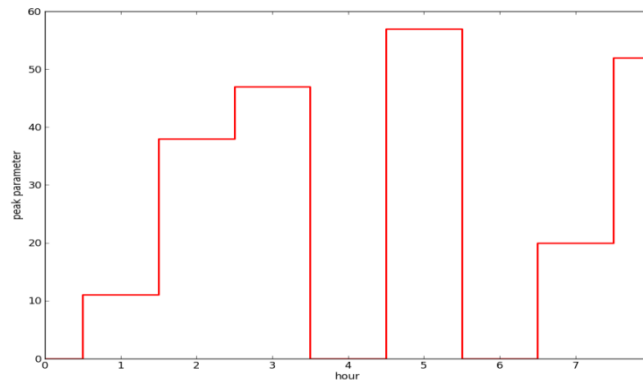
# High Frequency Strategies

- For those with a keen eye you could see the example on the previous slide was only trading on the hour scale. Not particularly high frequency. What is generally meant by high frequency is trading on the mille second scale.

- Although the previous strategy (and others similar) can be scaled down, high frequency trading also opens up a whole host of new strategies based on market micro structure.

- These include:

  - Latency Arbitrage - Observing market moves and dealing on prices before market makers have a chance to update pricing

  - Systematic response to economic data releases

  - Cash futures - Capturing the value of arbitrage opportunities between spot and futures markets

  - Imbalance - Trade decisions are based on relative amounts on the bid and offer

  - Queue Priority - Utilizing the structure of an market's order book optimize order placement within a market

  - Market Correlation - Trading generated by correlated price moves between currency pairs between other liquid markets

  - Market Specific Knowledge - Use of knowledge of flows/players in the market to dictate positioning
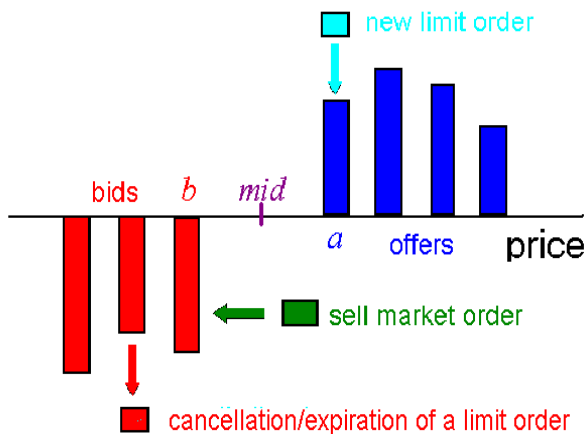
# Market Making

- As a market maker our clients expect us to always be showing a price that we will buy (bid) and sell (offer) the currency at.

- To do this we look take the bid and offer from all reliable market sources, create where we think the mid point we is, and add our own spread to this mid.

- If the market didn't move, and our clients had an unbiased view we would expect to make money from the spread we show. i.e. we buy a currency from a client at a rate of 1 and then sell it to another client at a rate 2, making a profit of 1.

- However the market does move and we need technology that allows us to adapt to these changes and alter our price instantaneously (more on this later).

- Also clients are biased and have views, and as a result we can quickly build up risk and be exposed to market moves.

- So as a market maker we need to be increasingly smart in what price we show and how we manage the risk

# Market Making - Pricing

- There is no such thing as the correct market mid. It is a subjective value to where people are willing to buy and sell.

- In constructing the mid we have to consider the source, consider the whole order book from each source, and make sure that the data we are receiving looks correct.

- We then have to add a very dynamic spread that we think correctly reflects the market conditions.

- Similarly we have to make very dynamic decisions on what liquidity we are willing to show,

- From these decisions we can then create an order book.

- Once we have an order book we then need to make decisions on how to regenerate liquidity once it has been taken from us.

- Finally as different clients have different requirements this process is repeated for many pricing streams.

# Market Making - Hedging

- This topic alone could take up a whole seminar.

- Market makers want as little exposure to the market as possible, and as a result do not want to build up risk.

- There are two ways we can do this, take the risk and trade with the market in other direction (costs as we have to cross the spread) or reduce/increase our bid/offer on the side we want to decrease our risk (no cost).

- We therefore have to make decisions on when to skew our spread and when to hedge in the market.

- We then have to make a decision on how to hedge

  - At what price do we want to hedge at

  - Where do we want to hedge

  - How do we trade in the market

  - Do we want look at our whole portfolio or just the single currency

# Trendy Tech Industry/Big Data Technique

- A/B testing. Tighten a clients price and perform statistical analysis on the results to decide the best price to show clients.
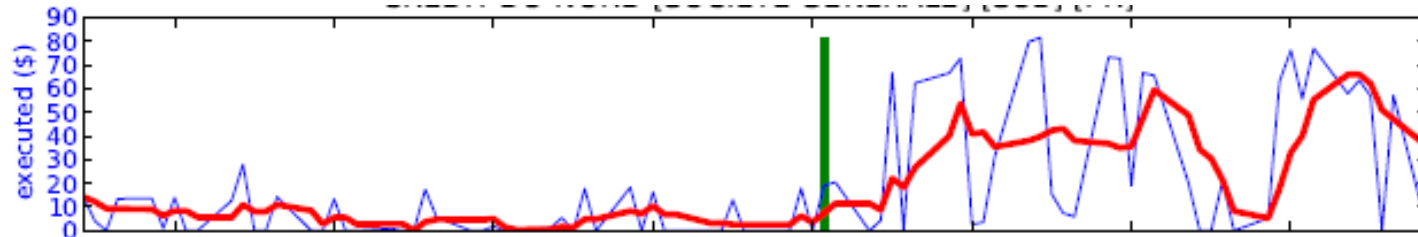


- Dimensionality reduction looking at what are the main drivers in the market or a clients trading behaviour

- Machine learning techniques – neural networks, decision trees, clustering, network theory (I would like to see if we can use game theory) to analyse client behaviour
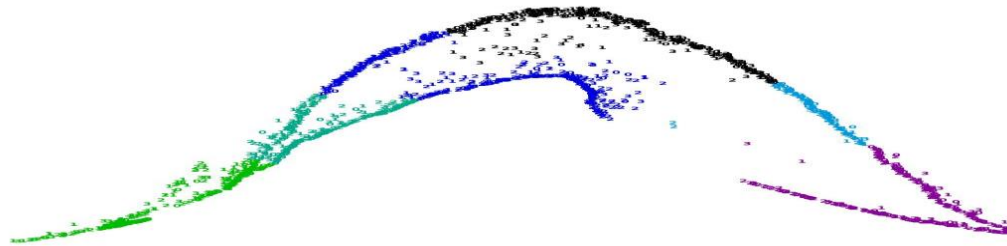


- Amazon style predictive engines, people who did this trade also did this.

- Twitter Mining

# Statistics

- How do we test the robustness of a strategy. Has it been over fitted, how confident are we when if it loses money, how do we decide what a successful is strategy, correlation.
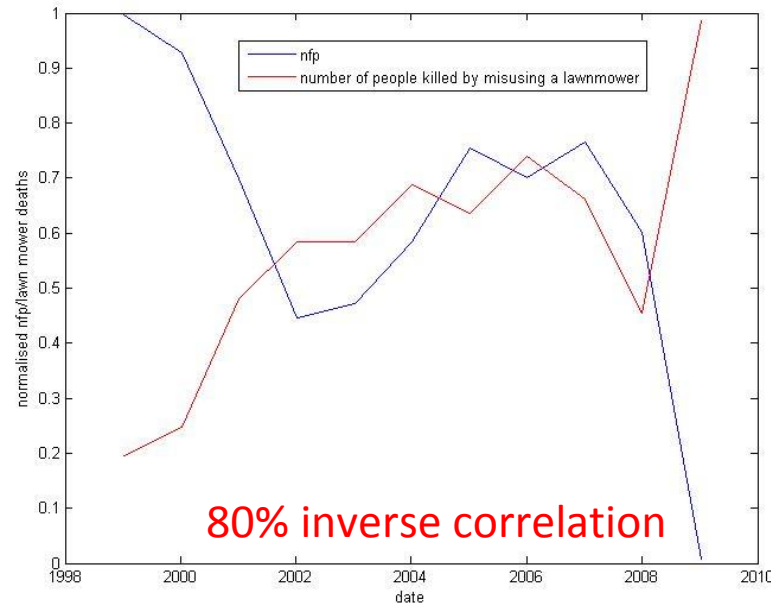


- We can also use statistics for risk taking strategies

- Given clients trades how likely is that they just got lucky or are they picking us off.

- Can we predict a clients behaviour from past behaviour.

# Data

- We trade in 3 regions – EMEA (Europe/Africa), NAM (North America), APAC (Asia/Pacific)

- Each region has it's own exchanges, offering products unique to the region and products that are traded in all regions.

- Also each exchange has it's own rules, for example the frequency they update, they way they match trades, or the rules for how long and how many trades we have to show on the venue.

- So let's look our top 3 venues, EBS, Reuters, and CME. In order they update every 100ms, 250ms, in real time.

- Now it also takes 35ms for a signal to get from NAM to EMEA, 95 ms to get from EMEA to APAC and 95 to get from EMEA to APAC.

- We are therefore presented with a big technology/data analysis problem of how to aggregate the prices from different exchanges in different regions to get an actual market.

- We then need to analyse this data, make pricing and trading decisions, then get back to the exchange as quickly as possible.

# Technology

- Examples of projects:
  - Market connection/aggregation – quick, stable
  - Trading systems – quick, adaptable, robust
  - Back testing system – intuitive, quick
  - Data visualisation – intuitive
  - Risk management – stable, reliable
- Data
  - We collect about 2TB a day
  - Needs to be easily accessed and analysed – specialised databases
  - We can analyse 7 billion records in 50 seconds
- We have 552 cores, 8TB ram, 120TB of disk across 23 servers
- FPGAs/GPUs for fixed tasks, investigating quantum computing and memistors
- No standard on language used, personally I use Java and Python

# So how have we used our PhD's?

- On a desk of 15, there are 3 PhD particle physicists – there's a reason
  - Practical problem solving skills. From theory, to research, to solution (you'd be amazed how rare this skill is)
  - Experience with large data set analysis
  - Technology skills, be that software or hardware
  - High performance computing
- Some personal examples
  - Signal processing – PhD looked for shrimp clicks, now I look for human signals
  - Matrix algebra – PhD correlating hydrophone signals, now correlating markets
  - Machine learning – PhD (trying to) classify neutrinos, now classify clients

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# Quiz Ideas

# Conclusion

- We have seen how the markets are becoming increasingly electronic and high frequency

- And as this happens the more and more quants (and in my opinion particle physicists) will dominate the banking landscape, be that on the buy side or the sell side

- Banks are quick to adapt to new technology and are always looking to improve their business

- Day to day work in a bank/hedge fund really isn't that different from that in physics

- Although the end result is very different!