Lethame Capital Management

Technology : Research : Investing

Traders dilemma – *trading too aggressively can result in significant market impact whilst trading too conservatively introduces timing risk.*

Overview

Lethame Capital Managements global macro system is designed to capture risk premia from global futures markets. The strategy is a long-term growth strategy which has been carefully researched and tested with the purpose of maximising the growth rate of capital.

The position held in each instrument is adjusted daily as the strategy dynamically adjusts its exposure to the particular risk premia depending on the strength of that instruments signal. This is achieved by 'sampling' the market at pre-defined valuation points, in order to calculate the optimal position given the portfolios valuation. In doing so, positions are adjusted to account for both the volatility of the underlying instrument and the diversification benefits between instruments.

Having determined the optimal position, the system then executes the trades necessary to achieve the optimal portfolio. At this point the system manages the problem defined as the 'traders dilemma'.

1. Trading Impact

One of the issues with understanding the impact of trading activity is understanding where the transactions costs come from. For example, it is necessary to attribute between the actual impact of the order when it hits the market and the drift the asset displays irrespective of the execution.

It is understood in the theory that the development of assets prices is a Brownian motion, meaning that prices evolve as a function of the assets drift and volatility. These two factors are endogenous in that they are assumed to be as a result of market forces and occur randomly and independent of trading.

On the other hand, the change in market price caused by an order hitting the market, is market impact. Market impact can be broken down into a temporary impact which reflects the cost of demanding liquidity and a permanent impact which corresponds to the longer-term effect of the order. This longer-term effect represents the information content that the order has exposed to the market.

Kissell (2014), documents the essential properties of a market impact:

- Impact costs increase with size. Relatively larger orders will more likely leak information, or indicate increasing demand or supply, resulting the shift in demand or supply curves.
- Impact costs increase with volatility. Volatility serves as a proxy for price elasticity.
- Impact costs depend on trading strategy. More aggressive strategies will incur larger impact due to immediacy of trading at a larger relative percentage of volume (POV). Trading at a slower rate will have less impact, but more market risk.
- Impact costs are dependent on market conditions and trading patterns. Instruments with larger average daily volumes (ADV) will incur relatively lower impact costs for the same volume than less liquid Instruments.
- Impact costs have a temporary and permanent component.
- Trading costs increase with spreads. This is intuitive if you consider the cost for trading immediately is crossing a bid-ask spread. The larger the spread the larger the impact cost. Generally, less liquid Instruments will have larger spreads.

In the case of the Lethame Capital system, there is a more specific conclusion that can be derived as the assets the system manages are small relative to the highly liquid futures markets it trades. On the cost side, the fixed cost of commission is known in advance with confidence. We know from Kissell (2014) that the cost of immediate execution is crossing the spread which means that the system will pay

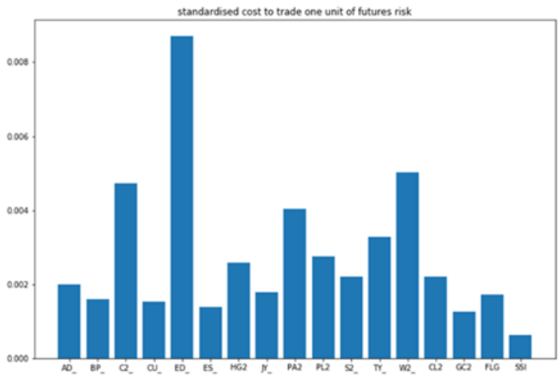
$$spread\ cost\ = \frac{bid - ask\ spread}{2}$$

for certainty.

The system understands these fixed costs in terms of the volatility of the underlying asset and therefore can calculate the cost of a particular futures contract in risk adjusted or Sharpe ratio terms:

$$standardised\ trading\ cost\ = \frac{\left(\frac{bid - ask\ spread}{2}\ +\ commission\ +\ fees\right)}{Instrument\ volatility}$$

The higher the standardised trading cost for an instrument, the slower the system should trade that instrument. Lethame Capital has tested hundreds of strategies on tens of instruments resulting in a database of many thousand trades. The conclusion is that on average a single trading strategy for a single instrument has a Sharpe ratio of approximately 0.3. The Eurodollar has low price volatility compared to other futures markets resulting in a relatively high standardised trading cost of 0.008 units per contract. It would therefore take just thirty-seven trades a year (0.3 ÷ 0.008) or just 3 trades a month to make this instrument unprofitable for the average single trading strategy and so strategies with turnover approaching this level have been rejected pre-trade as being too expensive for the system. The following chart illustrates this standardised cost of trading for all of the instruments in the portfolio.



Conclusion: Detailed analysis of thousands of backtested trades has allowed the Lethame Capital system to take a prescribed approach to dealing with market impact pre-trade. The intensity of trading in each instrument has been calibrated to the standardised cost to trade that instrument.

2. Pre-trade analysis – estimating potential transaction costs

Pre-trade analysis occurs before trading. The aim is to determine like price appreciation, market impact and timing risk for the particular transaction. Compared to a discretionary system of investment the detailed analysis on standardised trading cost allows the system to treat orders the same in terms of the pre-trade decision making process. However, consideration is still given to the pre-trade consideration of macro and micro level decision making.

Macro level decisions

- *Desired benchmark price:* Pre-trade benchmark prices are often referred to as 'implementation shortfall' prices and are those prices which are known before trading begins, for example the previous close. Post-trade benchmarks include any price that occurs after the end of trading
- *Implementation goal:* relates to the level of aggressiveness or passiveness. Aggressive trading is associated with higher costs and less risk, while passive trading is associated with lower market impact and higher risk.

The implementation goal is to solve the trader's dilemma. This means that the solution is finding the optimum balance between the trade-off of cost and risk based on the investors specified level of risk aversion:

$$\frac{Min}{\alpha} cost(\alpha) + \lambda . Risk(\alpha)$$

Where α represents the speed, or intensity of trading.

Micro level decisions

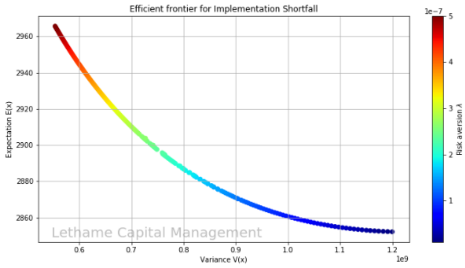
- *Specifying desired deviation rules*: how should algorithm deviate from prescribed strategy
- *Specifying order submission rules:* market/limit, display size, wait period, revision, modification, cancellation

The efficient trading frontier

The trade-off between risk and reward applies in the trading context. It is rational to seek to minimise expected cost of trading for a certain level of risk. A strategy which is the lowest cost for a particular amount of risk in the optimal strategy. This means that just as there is a Markowitz efficient frontier for portfolios there is a theoretical efficient frontier for trading. This frontier was suggested by Almgren and Chriss (2000) who concluded that there should be a single trading solution that is optimal for every possible level of risk. In order to determine this efficient frontier, they proposed optimising for the expected cost E(x):

$$^{min}_{\ x}(E(x) \ + \ \lambda . V(x))$$

Where V(x) corresponds to expected risk and λ is a Lagrange multiplier introduced to relate to the various levels of risk. Solving for the various levels of λ will result in numerous trading strategies each with a different cost and risk, the set of all these points represents the efficient trading frontier.



To solve the optimisation problem and construct the efficient trading frontier it is necessary to formulate the cost and risk of execution. It is necessary, therefore, to model the expected average execution price at the commencement of trading:

$$P_0\,(\alpha) \;=\; P_0 \;+\; f(x,\alpha) \;+\; g(x) \;+\; \varepsilon(\alpha)$$

Where x is the number of units to trade, P_0 is the market price at time of order entry, $f(x,\alpha)$ is the temporary impact cost due to demanding liquidity from the market, $g(x)$ is the permanent impact cost due to the information content of the order and $\varepsilon(\alpha)$ is the price volatility. The cost function is:

$$cost(\alpha) \;=\; \mathbb{E}(\bar{P}(\alpha) \;-\; P_0)$$
$$risk(\alpha) \;=\; \sigma\big(\,\varepsilon(\alpha)\big)$$

in the case of the system, the price used for valuation is the price which derives the attractive return distribution it is trying to achieve.

Minimising the overall cost of trading is made more difficult by the fact that its two main components move in opposite directions. Impact cost can be reduced by more passive trading, while timing risk may be lowered by trading more aggressively. This is the trader's dilemma.

<u>Conclusion: The risk in Lethame Capital's trading strategy is very straightforward and is an issue of minimising implementation shortfall.</u>

3. a) System Execution in Theory

The market price of an instrument used at the valuation point is the systems arrival price. However, because of the delay between the valuation and sending the order to the market this price is theoretically similar to the previous day's closing price, as follows:

$$cost(\alpha) = \mathbb{E}(\bar{P}(\alpha) - P_0)$$
$$= P_0 + f(x,\alpha) + g(x) + \mathbb{E}(\varepsilon(\alpha)) - P_d$$

But since, $P_0 = P_d + \varepsilon$, where ε is the price change from the valuation point to the time of the system sending the order with $\mathbb{E}[\varepsilon(\alpha)]$ = 0 and $Var[\varepsilon] = \sigma^2(\varepsilon)$ we have:

$$cost(\alpha) = P_0 + f(x,\alpha) + g(x) + \mathbb{E}[\varepsilon(\alpha)] - (P_0 - \varepsilon)$$
$$= f(x,\alpha) + g(x)$$

And:

$$R(\alpha) = \sqrt{\sigma^2(\varepsilon(\alpha)) + \sigma^2(\varepsilon)}$$

In this case the risk associated with executing the trade are greater than with simple arrival price to take account of the fact that there is potential for movement in the price of the future between the valuation point and the system sending the order to the market.

While this delay cost is a function of a stochastic process with an expectation of zero, given this risk, the systems trading objective is to reduce this trading cost as much as possible.

Liquidity risk

The liquidity of a given asset can be measured as a function of trading volume. The percentage of Average Daily Volume (ADV) gives an indication of how difficult a particular order is likely to be. For example, anything less than 20-25% should be achievable within a day however, anything over this may have a more significant impact on the market.

Johnson (2010) suggests the instruments Horizon as a measure of liquidty risk:

$$Horizon = \frac{Order\ Size}{ADV \times \alpha}, where\ \alpha = desired\ trading\ rate$$

For example, if our order size is 25 with an ADV of 1,000 and the restriction is imposed that the system will not participate in more than 10% of the volume then the trading horizon is one quarter of a day. This requires trading volume on the day of our order to closely match the historical volume profile. The Coefficient of Variation is a metric used to measure this and is based on the standard deviation of ADV.

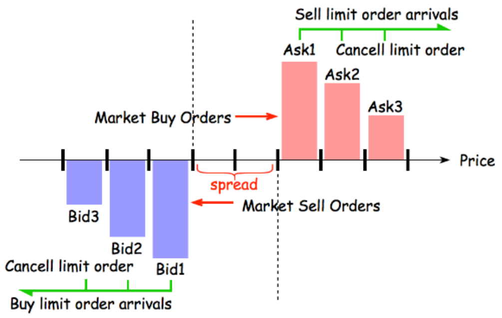
$$CV = \frac{\sigma\ ADV}{ADV}$$

A high value indicating that a sizeable variation from historic average is possible. However, given the size of the system in the context of liquid futures markets this risk is not currently a primary consideration.

Conclusion: as previously identified the two risks that require management by the system are the delay cost and the spread cost. Liquidity risk is less of a consideration given the assets presently under management.

3. b) System Execution in Practice

When the system interacts with the market, it is sending orders into the limit order books of various futures exchanges. A limit order book is constructed of two priority queues. At each point in time we can get a snapshot of the order book, including $bid_{1,} bid_2, bid_3 \ldots ask_1, ask_2, ask_3$.



Order book pressure is a metric which is used to summarise the dynamic shape of the order book. At time t, if the total size of the orders at the sell side is bigger than the side at the buy side by a threshold, we expect the mid quote:

$$\left(mid \; = \left(\frac{bid_1 + ask_1}{2}\right)\right)$$

to go down in the short term and vice versa; if the queue size difference is within upper and lower thresholds, we expect that the mid quote will not change. To formalise Order Book Pressure, we have:

$$OBP(n,l) \; = \frac{\sum_{\tau=0}^{n} \sum_{j=1}^{l} BidSize_{j,t-\tau}}{\sum_{\tau=0}^{n} \sum_{i=1}^{l} AskSize_{i,t-\tau}}$$

Where AskSize denotes the queue size at sell side and BidSize denotes the queue size at buy side. Specifically, OBP(n,l) is to measure the ratio between ask queue size and bid queue size, where argument l controls the number of order book levels used, and n controls the number of history order book snapshots used.

Cao, Hansch and Wang(2008) concluded there is a strong link between order book imbalances and future short-term returns. Hellstrom and Simonsen (2006) study of the Stockholm Stock Exchange showed that a positive skew in the order book imbalance (essentially a greater value of sell orders compared to buy orders) increased the probability of a subsequent decrease in price. Conversely a surplus of demand from buy orders was linked to subsequent price increases. Cont et al (2011) found a linear relation between order flow imbalance and price changes, with a slope inversely proportional to the market depth.

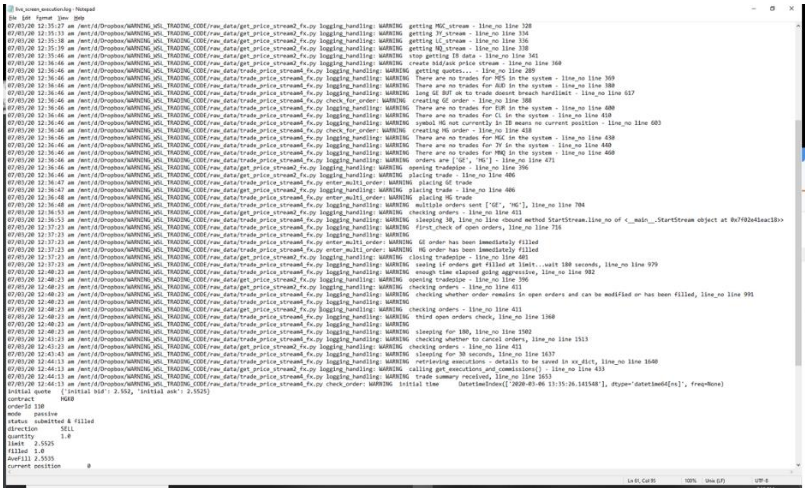
In addition to order book pressure there is considerable evidence that positive feedback trading, for example placement of stop-loss orders at round numbers creates an observable momentum. For example Osler (2003) found that stop-loss orders cluster in predictable ways near round numbers, he concluded 14.3 percent of executed stop-loss buy orders have requested execution rates ending in the range [01,10], while only 6.9 percent of those orders have requested execution rates ending in the range [90,99] exchange rates tend to move rapidly after reaching levels where stop-loss orders cluster dollar-mark moves an average 0.061 percent during the 15 minutes after crossing a round number, but only 0.054 percent after crossing an arbitrary number.

The Lethame Capital Trading Strategy

Lethame Capital uses an adaptive strategy in order to solve the issue of cost relative to risk. It has already been discussed that the signal for each decision is moderated as a function of the standardised trading cost for that instrument, in that way the trading conditions for each instrument are more standardised than they otherwise would have been.

The optimal portfolio is determined at the valuation point when the system determines what exposure to a particular instrument is required given the market price at the valuation point. The problem is therefore one of implementation shortfall which represents the difference between the price at which the trade decision is made by the system and the average execution price that is actually achieved.

Therefore, the Lethame Capital strategy works a limit order on the liquidity providing side of the bid-ask spread for a predetermined period of time. The time that the order sits on the limit takes account of the order book pressure. The order will sit at the limit for a maximum of 180 seconds at which time the strategy becomes aggressive and crosses the spread.



Conclusion: Lethame Capital's strategy is adaptive. Its aim is to try and capture the bid-ask spread and does this passively. However, it adapts as a function of the passage of time and signals generated from order book pressure to determine on which time scale it should become aggressive and cross the spread.

4. Post Trade Transaction Cost Analysis (TCA)

Much of the complexity in TCA is due to the need to handle large tick datasets and do calculations on them, this is really a software engineering problem. Rather than reinvent the wheel one would normally use an 'off the peg' software solution and apply proprietary transaction database information to it. Lethame Capital has two databases. The first is from polling and storing order book and tick level data in order to perform valuation. The second is tick data stored when the system enters orders and records the execution data that results. In a post trade transaction cost analysis environment, we are able to query our databases in order to perform calculations on our trade level data.

Implementation shortfall is simply the paper (or theoretical) return minus the actual return. The paper return represents the difference between the ending portfolio value and its starting value evaluated at the 'valuation' price. The actual portfolio return is the difference between the actual ending portfolio value and the value that was required to acquire the portfolio minus all fees corresponding to the transaction.

$$\text{Implementation Shortfall} = \underbrace{units.price_{e.o.d} - units.price_{decision}}_{paper\ return} - \underbrace{\left(\sum units_j\right).price_{e.o.d} - \sum units_j price_j - fees}_{actual\ return}$$

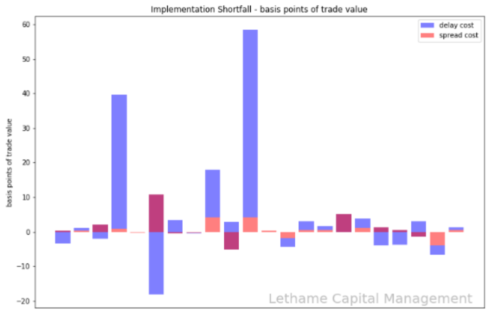
By way of example, the following 'Buy' trade was executed by the system in the June 2023 Eurodollar futures contract on 28th April 2020, the details of which and the TCA outputs from the Lethame algorithm are shown below.

The systems valuation was based on a price for this contract designated as decision quote 99.545@99.555 giving a mid-price of 99.55. This data is retrieved from the systems tick database. The initial order was recorder in the transaction database which recorded that the order was sent to the market at which point the price was 99.505@99.515 which is a mid-price of 99.51. The market moved in the systems favour, it was trying to buy the contract and the price fell 0.04 representing $100 per contract. The system's trading protocol is to try and operate as a liquidity provider so it began working the buy order at the bid side of 99.505. Either the maximum 180 seconds elapsed or the system seeing buying pressure in the order book truncated the time it sat on the limit. The system polled the market again and it still showed 99.5050@99.515 and so the system got aggressive and moved onto the ask side with a limit order of 99.515 which was filled.

initial quote	{'initial bid': 99.505, 'initial ask': 99.515}
contract	GEM3
orderId	9
Mode	aggressive
status	PendingSubmit
direction	BUY
quantity	1
limit 1	99.505
filled	1
AveFill	99.515
Current Position	3
trade ref	99.505
Update Time	DatetimeIndex(['2020-04-28 04:05:32.202642'], dtype='datetime64[ns]', freq=None)
Update Quote	{'update bid': 99.505, 'update ask': 99.515}
Limit 2	99.515
final status	order filled
Commission	2.12
Exec Time	20200428 14:06:52
decision quote	{'bid': 99.545, 'ask': 99.555}
trade value	248787.5
delay cost $	100
delay cost (bps)	4.019
spread cost $	-12.5
spread cost (bps)	-0.502
IS $	87.5
IS (bps)	3.51705773
comm (bps)	-0.085
Total Cost $	85.38
Total Cost - cost(-ve)/gain(+ve) (bps)	3.432

In terms of Implementation shortfall, the benchmark was therefore 99.55, the delay cost was ((99.55 – 99.51) * contract value) which equals +$100. The spread cost on the other hand is the execution price – the mid-price on order arrival which is ((99.51 - 99.515) * contract value) which equals -$12.50. The total implementation shortfall is therefore $87.50 made up of a $100 benefit given the system was going long a future whose price fell between the valuation point and sending the order to the market and a $12.50 cost due to the fact that it had to cross the spread to achieve an execution. Including the $2.12 commission paid to the broker for the execution, the total transaction cost is 3.4 basis points of the value of the order.

The script performs this exercise post trade for each of the trades in the database. The following chart shows the implementation shortfall calculation for a snapshot of trades from the trading database in the month of May 2020.



In this period the mean delay cost was 8 basis points of trade value with a standard deviation of 16 basis points. The spread cost had a mean of 4 basis points and standard deviation of 9 basis points. In both case of the delay cost and the spread cost the average was a benefit rather than a cost, the trading strategy is allowing capture of the bid-ask spread which is one of the objectives. It has been identified that the delay cost is the biggest risk and it can be seen that the standard deviation of this cost is higher and more significant than that of the spread cost.

Conclusion: post trade analysis confirms the hypothesis suggested by the theory which was that delay cost is the largest risk faced by the system. This risk is stochastic with an expectation of zero but the sample data highlights the volatility potential of this risk. Nonetheless, it results in a net benefit in the sample investigated. The trading history of the system, includes a significant period where this level of tick data was not collected and so this analysis cannot be carried out from internal resources. There is evidence though, that the systems trading strategy captures the bid-ask spread greater than 60% of the time and trading activity has not cost the system to date.

There is not enough data to gain more insight than this. As the systems trading progresses, a larger database of trade and tick data will allow more detailed analysis. In particular, it will be informative to analyse execution performance on an asset by asset basis. In addition, it will be possible to draw more detailed conclusions about the current execution algorithm and ideas of areas where enhancements can be made. Furthermore, the development of a detailed database of executions will allow for insights into changes in market microstructure behaviour and consequent impact on strategy performance.

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