

Markets as Connected Networks

Alternative Markets Are Often Less Connected and That Might Be a Good Thing

July 2022

Private and Confidential

Using network theory, we show that one potential benefit of allocating to alternative markets within actively managed portfolios is the opportunity for diversification they offer, and that this diversification has remained more durable during recent crisis periods. This provides further evidence for the ideas of diversification outlined in our earlier paper “Better? Or Just Different?”¹ and, importantly, in our opinion emphasises the benefits of alternative markets during turbulent periods.

What comes to mind when the word ‘network’ is mentioned? Perhaps, computers, transport and social networks initially strike most but it may take a while before financial markets suggest themselves. Using the definition of a network as any group or system of interconnected things, choosing to visualise markets as networks could aid our understanding of them. If you are popular enough to have lots of friends on social media, you may be aware that these companies often map out your own personal social network to cultivate interaction and valuable data. Minimum spanning trees (MSTs) are a type of graphing algorithm which represent all users in a network as nodes and relationships as edges between them. The distance of each edge signifies the strength of the friendship: for instance, more page views, posts, similar shared likes mean a stronger friendship and smaller distances. MSTs search for the subset of edges in the graph which retains each node, but the sum of all edge distances is minimised. The MST is designed to show the representative relationships in the network which could potentially highlight how price information or shocks might propagate through a network of financial markets.

Construction and Evaluation of our Minimum Spanning Tree (MST)

Our financial network was constructed from 84 globally representative tradeable markets with 14 markets from each of 6 sectors (e.g., agriculturals, bonds, currencies, energies, metals, and stock indices) and where in each sector, 50% of markets were traditional and 50% were alternative.

There is no one accepted definition of an alternative market, but for this analysis we used the following guide for classifying markets as alternative:

- Markets that are currently actively traded but less commonly found in typical managed futures or global macro portfolios and are often less liquid.
- Within fixed income, currencies and stock index sectors, the aim was to select markets which have less of a G7 (developed market) focus and more of an emerging market one.
- For commodities, the preference is for markets not found in benchmark commodity indices such as S&P GSCI or the Bloomberg Commodity Index. Instead, the inclination is towards commodities traded on outside of major US or UK bourses but rather in venues such as onshore Chinese exchanges or other smaller venues.

Rolling 5-day returns (instead of daily returns, in order to address market time zone asynchronicity) were used to compute pairwise rolling correlations based on exponentially weighted moving averages (EWMA with a lambda smoothing parameter of 0.94). In order for all numbers to be above zero and approach zero with increasing similarity, correlations were converted to a distance metric:

$$d_{i,j} = \sqrt{2(1 - \rho_{i,j})}$$

where correlations (ρ) ranging from -1 to +1 were used to create distances (d) ranging from 0 (perfect positive correlation) to 2 (perfect negative correlation). The MST algorithm begins by finding the pair of markets with the smallest distance and adds the second smallest edge and node to the first two. This continues under the condition that no loops are formed until all nodes are shown and the sum of the distances is a minimum. Figures 1 and 2 are introductory diagrams to show the effects of going from the full graph to the MST and these two figures are based on long-term correlations of daily returns between 2008 and 2022 in order to show the long-term average picture. Distances between nodes are smaller with increasing positive market correlation and sector clusters can be seen in both figures. The MST reduces 3,486 edges from the full graph based on the original correlation matrix to

¹ Better? Or Just Different? Quantifying diversification in trend following portfolios of traditional and alternative markets

83 which represent the strongest connections that help describe the financial network. This has the benefit of improving data visualisation, analytics and interpretability through noise and complexity reduction.

Figure 1: Before the MST algorithm

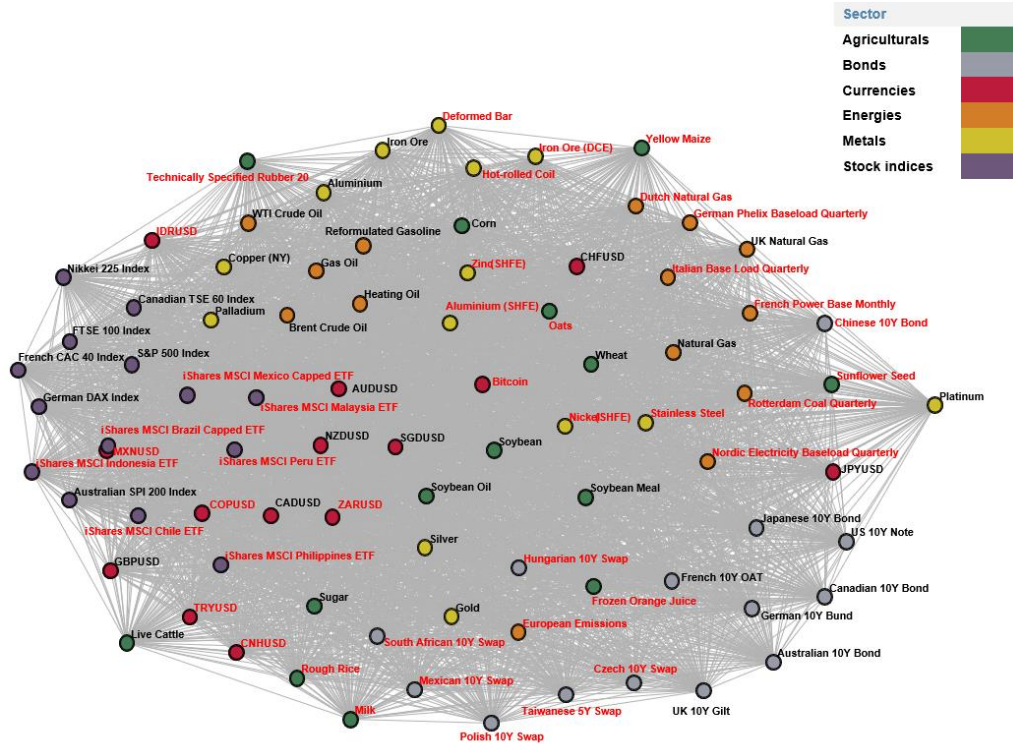


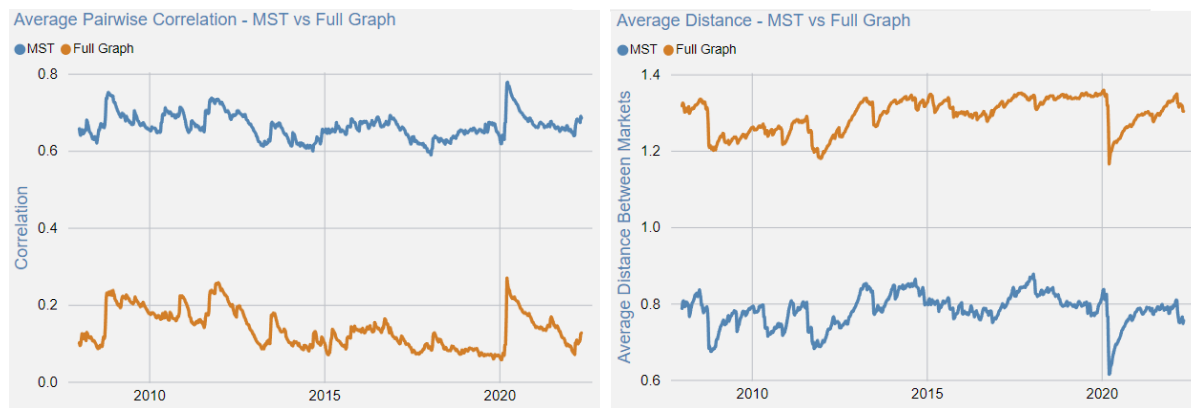
Figure 2: After the MST algorithm



Note: Please see important disclaimers at the end of this document.

In the MST, it is rather encouraging to see markets within the same sector form tree branch clusters highlighting their innate similarities. Alternative markets are highlighted in red and also tend to group together. Clusters and linkages appear mostly intuitive such as shorter distances within traditional energies and stock market sectors as well as precious metals and commodity currency groupings. We also see interesting regional huddles between emerging market stock indices and their related currencies. Between Figures 1 and 2, the average distance between markets shrinks from 1.33 to 0.79 and the corresponding average pairwise correlation (APC) is 0.09 for the full graph and 0.66 for the MST. For the remainder of the analysis, we base our graphs and MSTs on the rolling exponentially weighted correlations described earlier to show how the network changes through time. Figure 3 shows that over time, the MST experiences comparable perturbations to the full graph and this similarity provides some confidence that we can use the MST to represent the full set of relationships. Additionally, the parsimony and clarity provided by the MST's focus on the closer relationships is accompanied with a higher statistical significance and perhaps more confidence with which to draw conclusions from the financial network.

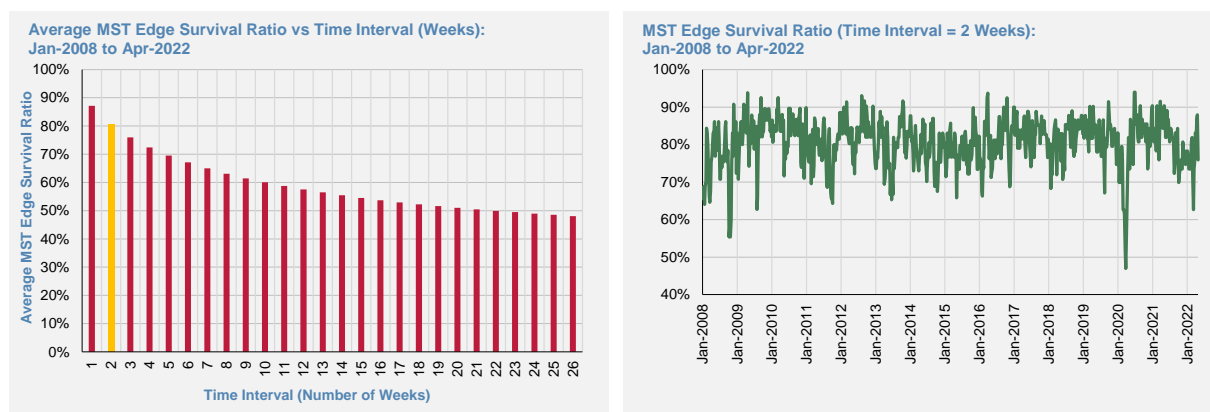
Figure 3: MST versus the full graph



Note: Please see important disclaimers at the end of this document.

The stability of links within the MST gives us an indication of strength as enduring connections are less likely to be random. With our daily MSTs, we compute a survival ratio based on the number of MST edges each week that existed in previous time periods (weekly time interval lags). The figure 4 bar chart shows that MST links themselves are relatively robust with over half the links remaining on average for nearly 6-month time periods. The figure 4 line chart shows that at 2 week time intervals, MST relationships are somewhat robust, but they are vulnerable to market shocks such as the global financial crisis in 2008 and the onset of COVID-19 in 2020.

Figure 4: MST Edge Survival Ratios

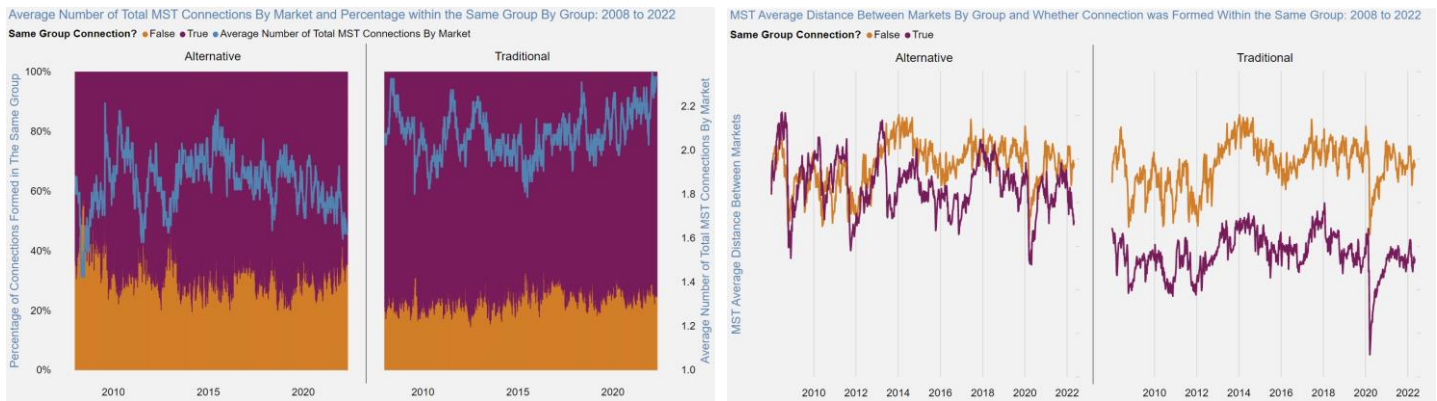


Note: Please see important disclaimers at the end of this document.

Traditional versus Alternative Markets in the MST

Remember that choosing to interpret data as points in space that form a network allows us to find natural groupings and the distinction between alternative and traditional markets is noticeable. Figure 5 highlights that, on average, alternative markets have fewer and weaker connections to other markets. Traditional markets consistently form more connections to other traditional markets and these relationships are markedly closer. Alternative markets seem to correlate with each other but much less so than traditional markets do and these connections are not much stronger than links to traditional markets. It is also worth mentioning that MST edge survival ratios are marginally lower for alternative markets regardless of the time interval. The inclination of alternative markets to form fewer and weaker links has the potential to increase the number of independent factors that investors can exploit within their portfolios.

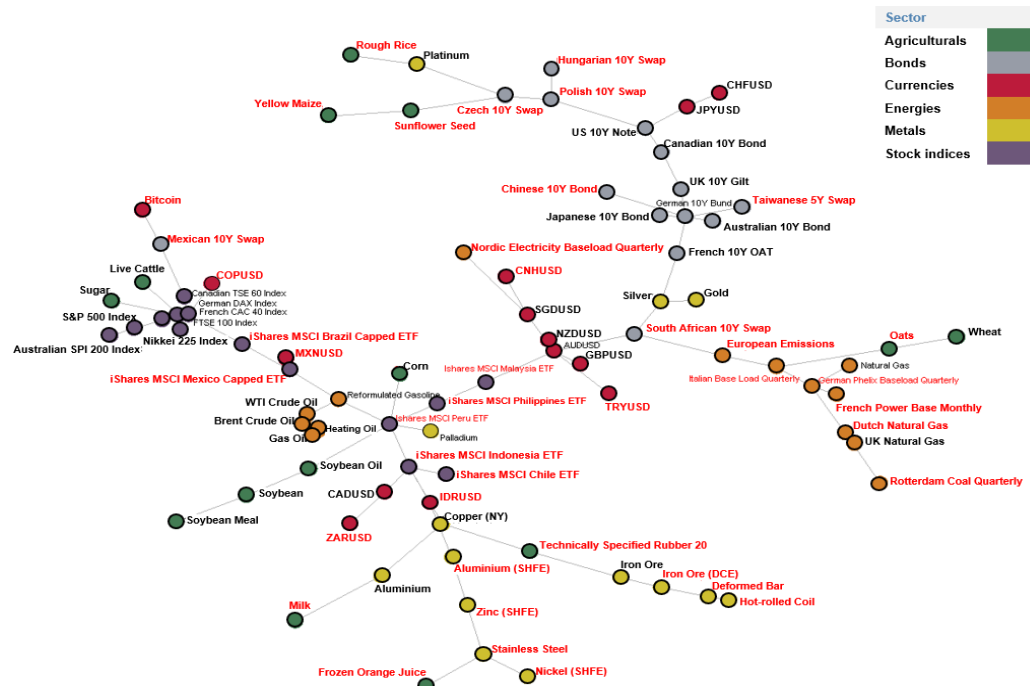
Figure 5: Traditional vs Alternative: differences in quantity and strength of MST connections



Note: Please see important disclaimers at the end of this document.

The 3rd week of March 2020 consistently stands out in figures 3,4 and 5. Risk aversion measured by the VIX almost broke its record as the pandemic spread determinedly. Figure 6 zooms into our MST topology on the 20th of March 2020:

Figure 6: The MST in the teeth of the COVID-19 crisis: 20th March 2020



Relative to figure 2, markets in figure 6 generally appear closer to each other. In addition to previously seen natural sector clusters, broader clusters seemed to form between riskier assets such as traditional energies, traditional agriculturals and developed and emerging market stocks. These markets experienced the heaviest selloffs around March 2020 possibly on account of their liquidity and volatility, making them more obvious candidates for liquidation in a crisis. Safer havens were found in North American bonds, the yen, and Swiss Franc. Interestingly, central emerging market European debt also rose in this period alongside a few alternative agriculturals such as sunflower seed where idiosyncratic news stories drove unique reactions.

Usually, alternative markets have formed fewer connections, but March 2020 was so unprecedented, that numerous markets moved in tandem amid almost indiscriminate selling and market panic. Despite forming almost as many connections as traditional markets, alternative markets in the MST maintained larger distances on average (0.69) from other markets compared to traditional markets (0.54). Bigger average distances between alternative markets implies weaker connections and correlations and this is typically associated with larger potential for diversification within a portfolio and useful additivity, especially in times of crisis.

Are Average MST Distances related to Average Market Returns?

Perhaps shrinkages or contractions within the MST could tell us something about the market environment. After all, markets have been known to melt-up or melt-down, possibly due to investor stampedes stemming from greed or fear. From 2008 onwards, changes in the average distance of MST links were sampled and plotted against contemporaneous market returns.

Figure 7: Relationship between MST Distance Variation and Average Market Returns



Note: Please see important disclaimers at the end of this document.

From figure 7, it would appear that periods accompanied by an increase in the distance (reduced strength) of MST links tend to be associated with higher returns of the underlying markets. Periods of crisis usually feature both MST contractions as well as negative market returns. The figure 7 scatterplot concentrates on 22-week period changes which exhibit the peak correlation between MST distance and market returns as seen from the figure 7 right-hand correlation chart. This chart also shows that traditional markets are more susceptible to this positive relationship over time. We have previously shown that portfolios of alternative markets provide better diversification on average. This result suggests that this superior diversification is also more robust and reliable, as it appears less sensitive to changes in the overall network of markets.

Conclusion

We analysed the similarities or connectedness of markets in a network. This was a useful visualisation method that reduced complexity and allowed us to focus on the strongest relationships. The main takeaways are:

- Over time, we saw that more traditional markets in similar sectors tended to form stronger and stickier links.
- Meanwhile, alternative markets were not as connected, and maintained their relative dissimilarity during both calm and calamitous phases. These markets still tend to do their own thing in crisis periods, which is when diversification can be hardest to find, and therefore potentially most valuable.
- The relationship between the connectedness of alternative markets in the network and their average returns was weaker than that of traditional markets over various timeframes. Alternative markets can provide access to more independent factors.

All things considered; the alternative markets picture is that of a more fragmented financial network. This allows portfolios access to more breadth and diversification. The fact that this result persists regardless of market environment, is in our opinion, a factor that could strengthen their case for inclusion in portfolios.

Document Disclaimer

PURSUANT TO AN EXEMPTION FROM THE COMMODITY FUTURES TRADING COMMISSION IN CONNECTION WITH ACCOUNTS OF QUALIFIED ELIGIBLE PERSONS, THIS BROCHURE OR ACCOUNT DOCUMENT IS NOT REQUIRED TO BE, AND HAS NOT BEEN, FILED WITH THE COMMISSION. THE COMMODITY FUTURES TRADING COMMISSION DOES NOT PASS UPON THE MERITS OF PARTICIPATING IN A TRADING PROGRAM OR UPON THE ADEQUACY OR ACCURACY OF COMMODITY TRADING ADVISOR DISCLOSURE. CONSEQUENTLY, THE COMMODITY FUTURES TRADING COMMISSION HAS NOT REVIEWED OR APPROVED THIS TRADING PROGRAM OR THIS BROCHURE OR ACCOUNT DOCUMENT.

The source of all data used within this analysis is Aspect Capital. These results are based on simulated or hypothetical results that have certain limitations. Unlike the results shown in an actual performance record, these results do not represent actual trading. Past performance is not necessarily indicative of future results.

This information has been prepared for circulation to investment professionals who are or would be classified as Professional Clients or Eligible Counterparties under the UK FCA rules and who, if they are US residents or citizens, are or would be qualified as "Qualified Purchasers" under the US Investment Company Act 1940 and "Qualified Eligible Persons" under the US Commodity Futures Trading Commission regulations and who if they are resident in Canada are "permitted clients" within the meaning of Canadian securities legislation, and is specifically not intended for any other persons including persons who are or would be classified as Retail Clients under the UK FCA rules. It is a confidential communication to, and solely for the use of such persons who, as set out above, are permitted to receive it. The information may be subject to verification or amendment and has been supplied for information purposes only. No representation or warranty is made, whether expressly or implied, by Aspect Capital Limited, its Directors or employees, as to the accuracy or completeness of the information provided. Any opinions expressed are subject to change and should not be interpreted as investment advice or a recommendation. An Aspect investment programme investor may lose all or substantially all of its investment.

To the extent that the term/s "systematic" and/or "automatic" is/are used in this document to describe Aspect Capital Limited's investment strategy and/or a number of related processes, it should be noted that human discretion is necessarily involved in the development of Aspect Capital Limited's operations (including the Aspect Diversified Programme and other programmes offered by Aspect Capital Limited from time to time) and in certain circumstances Aspect Capital Limited may also deviate from its automatic systems, for example as a result of external, unforeseen or dramatic events.

Note that any Assets Under Management ("AUM") figure for Aspect Capital Limited detailed in this document includes all AUM managed by Aspect on a discretionary basis. It does not include AUM managed by Aspect on a non-discretionary basis.

This information is neither an offer to sell an interest or otherwise invest in any fund or other investment vehicle including a managed account, sponsored or managed by Aspect Capital Limited whether as investment manager, commodity trading advisor or otherwise (each, an "Aspect Product"). Any such offer, if made, would be made only by way of the final offering documents, disclosure document and/or investment management agreement (together "offering documents") of such Aspect Product and only in jurisdictions where, and to such persons to whom, such an offer would be lawful. Any decision to invest in an Aspect Product should be made only on the basis of consideration of all of the final offering documents in respect of such Aspect Product. Such final offering documents contain important information concerning risk factors and other material aspects of such Aspect Product and must be read carefully before a decision to invest is made. This information must be accompanied or preceded by the final offering documents of the relevant Aspect Product. In accepting receipt of the information contained herein all recipients will be taken to have agreed with Aspect Capital Limited not to distribute such information to any other person save (i) in accordance with the above restrictions, and applicable law and regulation and (ii) without making any changes which would make that information inaccurate or misleading.

Aspect Capital Limited is exempt from the requirement to hold an Australian financial services licence under the Corporations Act 2001 (Cth). Aspect Capital Limited is authorised and regulated under the laws of the United Kingdom which differ from Australian laws. Aspect Capital Limited is not registered with any securities regulatory authority in Canada.

Certain Aspect Products are distributed in Switzerland. The distribution of shares in certain Aspect Products in Switzerland must exclusively be made to qualified investors. In respect of such products, Banque Heritage SA with registered office at 61 route de Chêne, 1208 Geneva (www.heritage.ch), is the representative (the "Representative") and the paying agent in Switzerland. The place of performance and jurisdiction for shares in those Aspect Products distributed in Switzerland are at the registered office of the Representative. Some Aspect Products are made available in Switzerland solely to qualified investors, at the exclusion of qualified investors with an opting-out pursuant to Art. 5(1) of the Swiss Federal Act on Financial Services ("FinSA"). In respect of these products, no representative or paying agent has been appointed in Switzerland.

Aspect Capital Limited is a company registered in England and Wales under registered no. 3491169. Its registered office is at 10 Portman Square, London W1H 6AZ. ASPECT, ASPECT CAPITAL, the ASPECT CAPITAL device and ASPECT CAPITAL: THE SCIENCE OF INVESTMENT are registered trademarks of Aspect Capital Limited. © Aspect Capital Limited 2022. All rights reserved.

Important Performance Information

An individual investor's performance may differ from the performance results set forth herein due to a number of factors, including (a) timing differences between subscriptions and redemptions, which may result in some investors being above their high watermark when others are below their high watermark, and (b) different expenses, fees, and other charges paid by investors. Any index presenting the performance of hedge funds generally or a hedge fund sector, may overstate performance and understate volatility because hedge funds generally, or those in the reported sector that have not performed well enough, are often excluded from such an index. Performance by sector is intended to be indicative and to give an estimate of winning and losing components of the relevant Aspect programme. Unless otherwise specified, all performance attribution information is specified on a gross basis. Gross performance attribution information is based on internal estimates of trading profits and losses and does not include management fees, cash or other expenses. Gross performance is based on information believed to be accurate. It has not been audited by a third party. The Aspect Diversified Programme and the other programmes offered by Aspect Capital Limited from time to time are quantitative, systematic investment programmes. The performance and other attributes of Aspect Products that are in the form of an investment fund may differ from those of the programme in which they invest including as a result of fees and expenses payable by such Aspect Products. All data is sourced from Aspect Capital Limited unless otherwise specified. **PAST PERFORMANCE IS NO INDICATION OF FUTURE PERFORMANCE.**

Investment Risks

Any person making an investment in an Aspect Product must be able to bear the risks involved and must meet such Aspect Product's suitability requirements. Some or all alternative investment programmes may not be suitable for certain investors. No assurance can be given that any Aspect Product's investment objective will be achieved. Among the risks which Aspect Capital Limited wishes to call to the particular attention of persons receiving this brochure are the following: Aspect Products are speculative and involve a substantial degree of risk; Aspect Products' performance may be volatile; Redemptions may be made only if an investor provides prior written notice of its desire to redeem in advance of the intended redemption date; There is no secondary market for the shares in Aspect Products that are in the form of an investment fund and none is expected to develop; There are restrictions on transferring shares in an Aspect Product that are in the form of an investment fund; An Aspect Product's fees and expenses are significant. Trading profits must be greater than such fees and expenses to avoid loss of capital; Aspect Products are not required to provide periodic pricing or valuation information to investors with respect to the Aspect Product's individual investments; Aspect Products are not mutual funds and are not subject to regulation under the US Investment Company Act 1940, as amended; Orders executed for Aspect Products will take place on non-US and US markets; Aspect Products may be subject to conflicts of interest, Aspect Funds utilise leverage through the use of margin-traded instruments. Use of leverage presents opportunities for increasing total returns, but may potentially increase losses.

Please pay particular attention to the risk factors and conflicts of interests sections of each Aspect Product's offering documents.

HYPOTHETICAL PERFORMANCE RESULTS HAVE MANY INHERENT LIMITATIONS, SOME OF WHICH ARE DESCRIBED BELOW. NO REPRESENTATION IS BEING MADE THAT ANY ACCOUNT WILL OR IS LIKELY TO ACHIEVE PROFITS OR LOSSES SIMILAR TO THOSE SHOWN. IN FACT, THERE ARE FREQUENTLY SHARP DIFFERENCES BETWEEN HYPOTHETICAL PERFORMANCE RESULTS AND THE ACTUAL RESULTS SUBSEQUENTLY ACHIEVED BY ANY PARTICULAR TRADING PROGRAMME.

ONE OF THE LIMITATIONS OF HYPOTHETICAL PERFORMANCE RESULTS IS THAT THEY ARE GENERALLY PREPARED WITH THE BENEFIT OF HINDSIGHT. IN ADDITION, HYPOTHETICAL TRADING DOES NOT INVOLVE FINANCIAL RISK, AND NO HYPOTHETICAL TRADING RECORD CAN COMPLETELY ACCOUNT FOR THE IMPACT OF FINANCIAL RISK IN ACTUAL TRADING. FOR EXAMPLE, THE ABILITY TO WITHSTAND LOSSES OR TO ADHERE TO A PARTICULAR TRADING PROGRAMME IN SPITE OF TRADING LOSSES ARE MATERIAL POINTS WHICH CAN ALSO ADVERSELY AFFECT ACTUAL TRADING RESULTS. THERE ARE NUMEROUS OTHER FACTORS RELATED TO THE MARKETS IN GENERAL OR TO THE IMPLEMENTATION OF ANY SPECIFIC TRADING PROGRAMME WHICH CANNOT BE FULLY ACCOUNTED FOR IN THE PREPARATION OF HYPOTHETICAL PERFORMANCE RESULTS AND ALL OF WHICH CAN ADVERSELY AFFECT ACTUAL TRADING RESULTS.

Simulated results presented in this presentation for any Aspect Product are calculated by taking the historical market information available at the relevant point in time. Hypothetical trades relevant to each current strategy are generated on the basis of this information. Positions are valued using the prevailing market prices at each point in time. Performance is calculated using these valuations and subtracting the relevant management and performance fees (where applicable) of the Aspect Product, using standard methodology. Simulations are relevant to show the pattern of returns, but are not a forecast of future performance. There are many assumptions made, many of which may not prove to be accurate in actual trading. These figures are based on information believed to be accurate but have not been audited by a third party. Information is for illustrative purposes only.

The case studies included in this presentation are for illustrative purposes only and do not represent all of futures positions purchased, sold or recommended for advisory clients by Aspect Capital Limited during the periods shown. The case studies presented are intended to outline how certain investment ideas may be identified, developed and executed. Unless otherwise indicated, you should not assume that investments shown

and discussed were or will be profitable or that losses will not be incurred. In addition, due to changes in market conditions, similar opportunities may not be available currently or going forward. PAST PERFORMANCE IS NOT INDICATIVE OF FUTURE RESULTS.

This material has been prepared by Aspect Capital Limited which is authorised and regulated in the UK by the Financial Conduct Authority (FCA), registered as a Commodity Trading Advisor (CTA) and a Commodity Pool Operator (CPO) with the Commodity Futures Trading Commission (CFTC) and a member of the National Futures Association (NFA) and registered as Investment Adviser with the Securities and Exchange Commission (SEC) in the United States. Registration with the SEC does not imply a certain level of skill or training.

Aspect Capital Inc. is registered as a Commodity Trading Adviser (CTA) with the Commodity Futures Trading Commission (CFTC) and a member of the National Futures Association (NFA) in the United States.