Markets as Connected Networks

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

July 2022

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

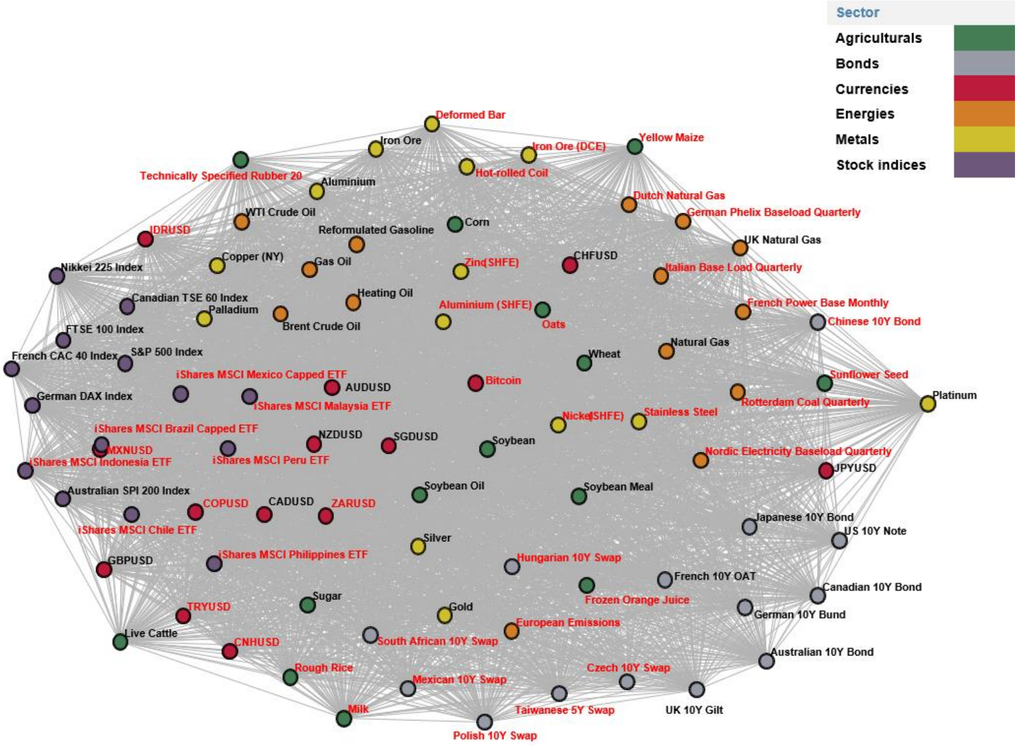
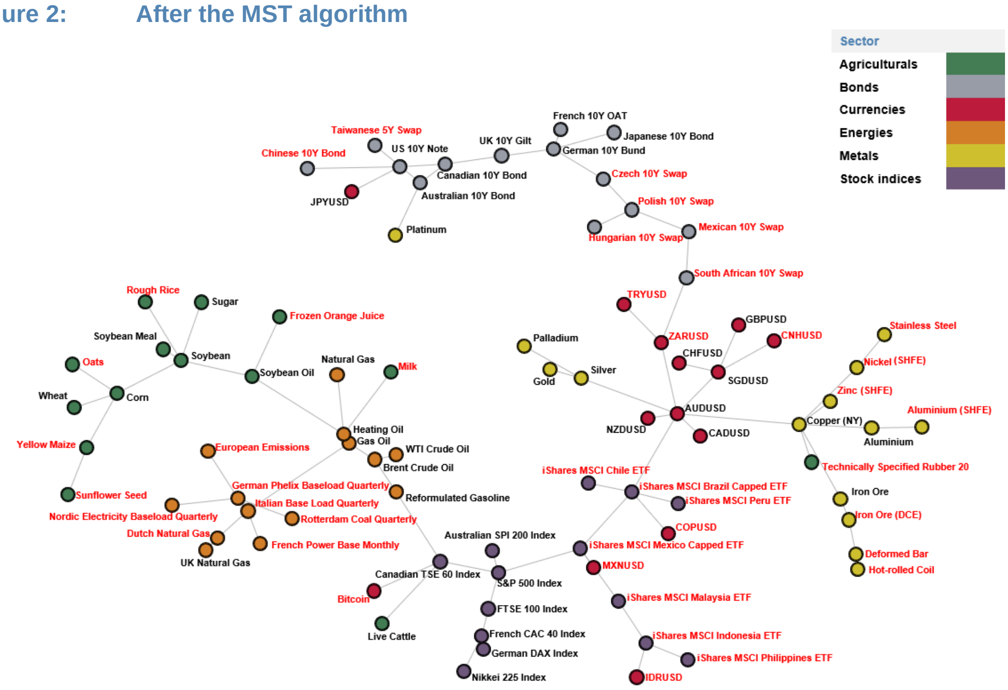


Figure 2: After the MST algorithm



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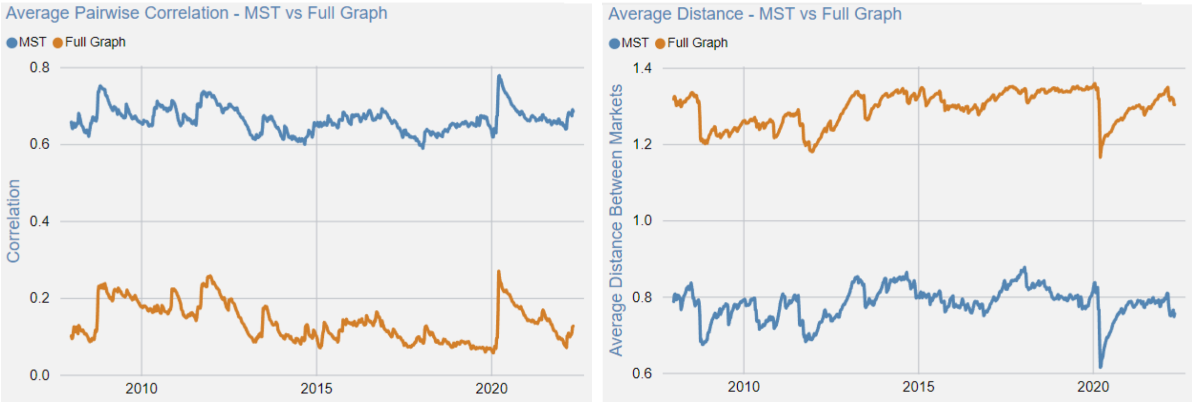
In the MST, it is rather encouraging to see markets within the same sector form tree branch clusters highlighting their innate similarities. Alternative markets are highlighted in red and also tend to group together. Clusters and linkages appear mostly intuitive such as shorter distances within traditional 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



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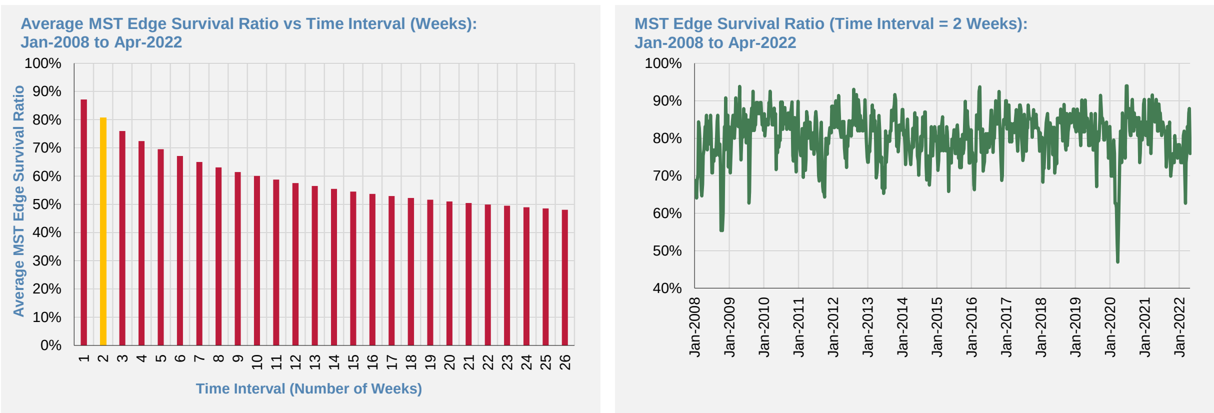
The stability of links within the MST gives us an indication of strength as enduring connections are less likely to be random. With our daily MSTs, we compute a survival ratio based on the number of MST edges each week that existed in previous time periods (weekly time interval lags). The figure 4 bar 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



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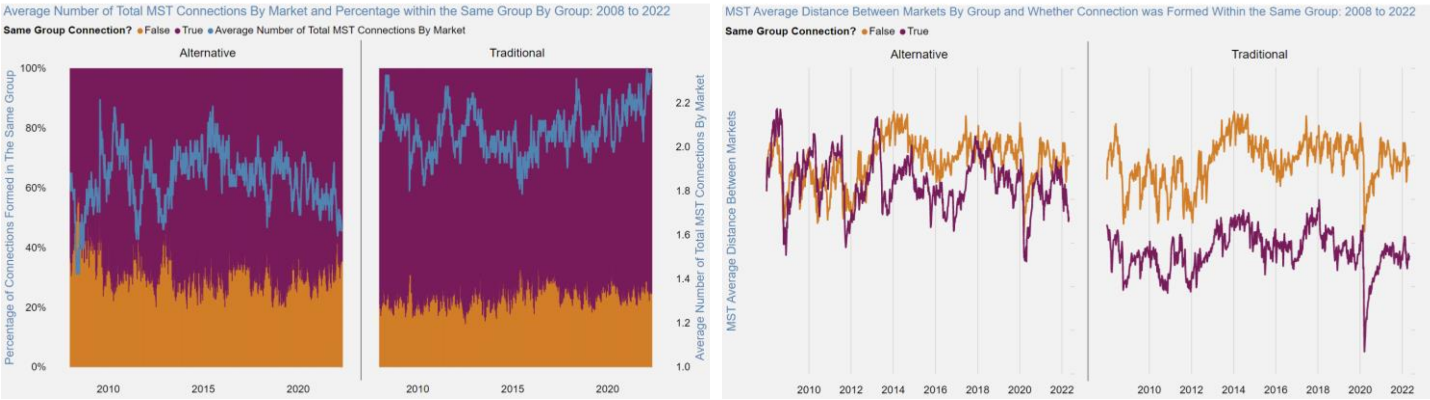
Traditional versus Alternative Markets in the MST

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



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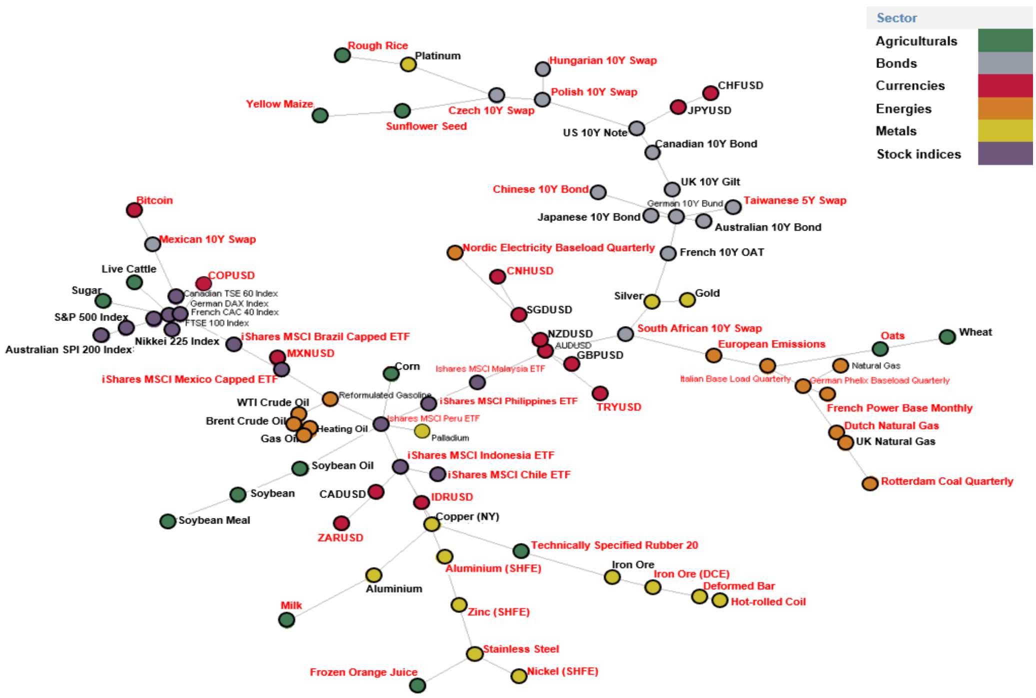
The 3rd week of March 2020 consistently stands out in figures 3,4 and 5. Risk aversion measured by the VIX almost broke its record as the pandemic spread determinedly. Figure 6 zooms into our MST topology on the 20th of March 2020:

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

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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.

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