

DIVERSIFICATION DASHBOARD

June 2020

Diversification Ratios®

TOBAM's Diversification Ratio [®] (DR) measures to what extent a portfolio is diversified. The DR ² (square of the diversification ratio) measures the number of independent sources of risk to which a portfolio is exposed. As the table shows, the "broad market" indices do not fully utilise diversification capabilities. In addition to a snapshot of each market's DR ² , the table shows the DR ² of a well-diversified portfolio, and the fraction of available diversification used by the index.	Universes	DR ² Benchmark	DR ² Anti- Benchmark®	% diversification captured by benchmark
	MSCI World ex USA	2.27	5.13	44.2%
	MSCI All Countries World	2.16	4.98	43.5%
	MSCI Japan	2.50	4.87	51.4%
	MSCI Emerging Markets	2.79	4.71	59.3%
	MSCI World	2.03	4.26	47.7%
	MSCI EMU	1.96	4.25	46.0%
	MSCI Pacific Ex-Japan	2.17	4.06	53.4%
	MSCI Switzerland	1.75	3.82	45.8%
	MSCI US Equity	1.73	3.72	46.5%
	MSCI UK Equity	2.13	3.14	67.9%
	ICE-BofA-ML Global High Yield	2.56	3.18	80.6%
	ICE BofA ML Global Corporate	1.95	2.52	77.5%

Sources: TOBAM and Bloomberg, figures as of May 29, 2020. Warning: Past performance is not an indicator or a guarantee of future performance, allocations are subject to change. The value of your investment and income received from it can go down as well as up and you may not get back the full amount invested.

Stability of the Pairwise Correlations Hierarchy

In this Diversification Dashboard, we discuss the stability in the hierarchy of correlations. Long-time followers of our dashboards may be familiar with this subject as we have published a dashboard on this very topic five years ago. As correlations are at the heart of TOBAM's portfolio construction approach, we decided to provide a refresher on the subject given the various changes in the market environment over the years. This topic is particularly interesting to revisit in the current market environment of the Covid-19 pandemic. The magnitude and speed at which the markets reacted to the crisis provides a real-life stress testing environment based on live data to assess the robustness of some of our old findings.

Introduction

Correlations play a role in several portfolio optimization, risk assessment and asset pricing techniques. In particular, the construction methodology of most portfolios that aim to be well-diversified including TOBAM's Anti-Benchmark[®] portfolio relies on correlations among the assets. It is also well-known that market conditions do have an impact on correlations and so stock correlations vary with time. The rapid rise in correlation levels of all the assets during periods of market stress is well-documented in both academic and applied finance literature (see, Figure 1). What is not so well-known, but of utmost relevance to the investors seeking to build a well-diversified portfolio, is the remarkable stability of the hierarchy of correlations – that is, the tendency of those stocks that are on average lowly correlated to all other stocks to remain lowly correlated and of those that are on average highly correlated to all other stocks to remain highly correlated.

A portfolio comprising of lowly correlated stocks tends to be well-diversified relative to a portfolio comprising of highly correlated stocks. Because the stocks that are lowly correlated tend to remain

lowly correlated and the stocks that are highly correlated tend to remain highly correlated, the portfolios constructed based on those stocks also remain very stable regardless of the prevailing levels of correlations. The hierarchy of correlations is all the information we need and not the absolute levels of correlations in order to build a well-diversified portfolio. While this is not necessarily the case for diversification seeking strategies, from the Anti-Benchmark[®] portfolio construction standpoint, the hierarchy of correlations takes precedence over the absolute levels of correlations. The fact that the correlation hierarchy remains stable implies that the Anti-Benchmark[®] portfolio, which relies on the correlation hierarchy, is also very robust.





Source: Bloomberg and MSCI. Period of Analysis: December 2002 to May 2020. Daily USD Total Returns of all the stocks in MSCI USA universe are used to compute 1-year rolling correlations. The plot shows the average pair-wise 1-year rolling correlations.

In this dashboard, we discuss some empirical results that illustrate the stability of the hierarchy of correlations through time from a practical perspective.

Correlations are time-varying but correlation hierarchy is stable

1. Correlations vs correlation hierarchy - an illustration

This simple intuitive illustration demonstrates how correlation hierarchy is stable and why the hierarchy and not levels of correlations matters to build a diversified portfolio before we move on to some advanced empirical illustrations.

Figure 2 shows the one-year rolling correlation among three stocks – Bank of America, JP Morgan Chase and Ford Motor Company – Two financial institutions and one automobile company. Intuitively, we would expect that the two financial institutions be more correlated between themselves than they are to the automobile business given the overlapping nature of their business operations. This is what we see in Figure 2.

The levels of correlations among these companies vary from as low as 10% to as high as 97% over time but the correlation between BofA and JPM is always higher than the correlation between either



BofA and Ford or JPM and Ford. This order of correlations is what we refer to as hierarchy of correlations.

This stylized example shows that building a portfolio with either BofA-Ford combination or JPM-Ford combination would be more diversified than a portfolio with BofA-JPM combination. We do not need the actual correlation levels to be stable over time, but the order or hierarchy of correlations to be stable over time, in order to build a diversified portfolio.



Figure 2: Correlation hierarchy: 1-year rolling correlations

2. Low turnover of stocks from extreme correlation quintiles

In section 1, we have seen that the correlation hierarchy is stable using occasional empirical evidence. In this section, we analyse this occasional evidence more rigorously over the entire spectrum of stocks. In order to do so, we build quintile portfolios based on the past one-year average pair-wise correlations of all the stocks in the MSCI USA universe and assess what percentage of stocks move out of the extreme correlation quintiles, i.e., the lowest and the highest correlation quintiles for each monthly rebalancing (the typical rebalancing period of an Anti-Benchmark[®] portfolio).

We expect a well-diversified portfolio to predominantly allocate into stocks from the lowest correlation quintile and to avoid holding stocks from the highest correlation quintile.

Figure *3* exhibits the proportion of stocks that belong to the lowest, middle (third) or the highest correlation quintile and that remain in the same quintile or that move to a different quintile in each monthly rebalancing. What we observe is that, on average, the lowest and highest correlation quintiles retain about 90% of their stocks in each rebalancing.

It is also interesting to observe that the periods of crisis tend to impact the correlation hierarchy. During the periods of major market turbulences (2001, 2008 or the most recent 2020 crisis), the probability of a stock moving out of the extreme correlation quintiles increases by four times before quickly reverting to the normal 10% levels in the subsequent rebalancing. Overall, throughout the over two-decade time sample we analysed, the extreme correlation quintiles remained stable.

Source: Bloomberg. Period of Analysis: December, 1998 to May, 2020. Daily USD Total Returns of Bank of America, JP Morgan Chase and Ford are used to compute 1-year rolling correlations.



Figure 3 : Percentage of stocks moving out of extreme correlation quintiles during every subsequent monthly rebalancing





PANEL B - Percentage of stocks moved from the middle (third) correlation quintile to other quintiles







Source: Bloomberg. Period of Analysis: December, 1998 to May, 2020. Daily USD Total Returns of all the stocks from MSCI USA are used to compute one-year correlation quintiles. The quintiles are recomputed every month.



3. Stability in correlation hierarchy across correlation quintiles

In the previous section, we focused on the extreme quintiles and observed their stability over time. In this section, we look at the full sample and consolidate the stability across all of the five correlation quintiles.

Figure 4 summarises the historical transition frequencies observed during the full sample (December 1998 to May 2020) across the five correlation quintiles. We observe that the extreme correlation quintiles are the most stable ones with nearly 90% of stocks remaining in their respective quintiles. Even across other quintiles, nearly 70% of stocks remained in their respective quintiles. Even the remaining 30% movement has been mostly to the adjacent quintiles.

This result is qualitatively very similar even during periods of market crisis. These empirical findings suggest that the correlation hierarchy is very stable over time regardless of the levels of correlation.





PANEL A: Full period transition frequency among various correlation quintiles

PANEL B: Crisis period transition frequency among various correlation quintiles



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It is interesting to note that the correlations increase during market crisis (see, Figure 1). Also, more stocks tend to move from the extreme correlation quintiles than usual during periods of market crisis (see,

Figure 3). However, such movements are limited mostly to the adjacent quintiles (see, Figure 4) highlighting that the correlation hierarchy remains remarkably stable even during periods of market stress.

In light of these empirical observations, one might ponder if the benefits of diversification are somewhat limited during periods of market crisis.

Actually, even if correlations increase during periods of market crisis, there are still benefits to being well-diversified especially during periods of market stress. One important reason for this is that the cross-sectional return dispersion¹ among stocks also rises (see, Figure 5) during such periods. Higher return dispersion indicates that there is a higher difference in the overall magnitude of realised returns among the stocks, i.e., the market premium is earned on a less homogenous set of returns and hence diversification becomes even more crucial to earn the full market premium.





4. Robustness check

We illustrated the stability of correlation hierarchy using correlation quintiles with monthly rebalancing, however, a potential issue with monthly rebalancing is that it carries significant overlap (11 months) in one-year correlations and one might question if the stability we observed in correlation hierarchy is merely an effect of the overlap in correlations.

As a robustness check we analysed the distribution of every pair of rank differences in correlations between two non-overlapping years. Every year all the pair-wise correlations are ranked (between 0 and 1) and the difference between the ranks on every consecutive year are observed. Figure 6 plots the distribution of these ranks. To obtain a better feeling for the interpretation of this distribution, we also plotted the distribution of ranks if the rank changes were completely random. We observe that the

¹ Cross-sectional return dispersion is the standard deviation of returns observed at any point in time of all the assets in the universe. It signifies the heterogeneity (or difference) in returns realized by the assets. Higher cross-sectional dispersion signifies bigger difference in return behavior of the assets or more heterogeneity among the assets and lower dispersion signifies all the assets have realized more homogeneous (similar) returns. It also signifies the aggregate market risk and usually increases during periods of high market stress.

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real correlation ranks are twice as likely to remain unchanged compared to a completely random distribution of ranks i.e. every rank is equally likely in the subsequent rebalancing independent of the current rank. This emphasizes the persistence of correlation hierarchy even at individual stock level and in non-overlapping periods.



Figure 6: Distribution in Rank Differences

Source: Bloomberg. Period of Analysis: December, 1998 to May, 2020. Daily USD Total Returns of all the stocks from MSCI USA are used to compute one-year pair-wise correlations. The correlations are computed every year with no overlapping. Every year all the pair-wise correlations are ranked (between 0 and 1) and the difference between the ranks on every consecutive year are observed distribution of these ranks is shown in the plot alongside the random distribution of rank differences.

Conclusion

- Over the course of time, markets experience significant changes in the absolute levels of correlations. There are periods when the market as a whole experiences low pair-wise correlation and there are periods when the market as a whole experiences high pair-wise correlation.
- While the correlations themselves have been varying over time, the hierarchy of correlations exhibited high stability over time.
- The hierarchy of the pair-wise correlations is particularly stable for lowest quintile of correlation, i.e. for the most diversifying one, or the one most commonly found in a well-diversified portfolio. This is also the case for the highest quintile of correlation.
- The stability of the correlation hierarchy is not primarily the consequence of overlapping periods, as non-overlapping rebalancing shows similar results.
- The stability of the correlation hierarchy can help understand the stability and robustness of the Anti-Benchmark portfolio.





For more information

TOBAM is an asset management company offering innovative investment capabilities designed to increase diversification. Its mission is to provide rational and professional solutions to long term investors in the context of efficient markets.

The Maximum Diversification[®] approach, TOBAM's flagship investment process founded in 2006, is supported by original, patented research and a mathematical definition of diversification and provides clients with diversified core exposure, in both the equity and fixed income markets.

In line with its mission statement and commitment to diversification, TOBAM also launched a separate activity on cryptocurrencies in 2017.

TOBAM currently manages close to US\$6.7 billion (at March 30, 2020). TOBAM's team is composed of 50 professionals.

Contacts

Paris 49-53, Avenue des Champs-Elysées 75008 Paris France

New York Dublin Hong Kong

Client Service clientservice@tobam.fr www.tobam.fr

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