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A statistical analysis of the portfolio diversification benefits of trend-following

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Executive summary

In this note, we seek to quantify the portfolio diversification benefits of trend-following without making any assumption about the risk allocation structure of the reference portfolio. We show that the addition of a benchmark trend-following strategy to any well-balanced and diversified liquid institutional portfolio is likely to improve its risk-adjusted returns over a reasonable timeframe. We support this by demonstrating that the portfolio diversification of trend-following benefits are mostlv insensitive and robust to three key factors when considering investing in this type of strategy:

- 1. the existing risk allocation of the investor's portfolio
- 2. the timing of the investment in trend-following, and
- 3. the investor's expectations about future trend-following performance.

Relying on a large set of randomly generated portfolios covering a representative set of available liquid investment opportunities, we show that over a sufficiently long investment horizon, the addition of a benchmark trendfollowing strategy to any portfolio would have improved its Sharpe ratio over the past two decades.

Furthermore, when evaluated over a shorter, rolling five-year investment horizon, we demonstrate that the portfolio diversification benefits of trend-following have been (1) persistent over time, and (2) strongest when it's most needed, i.e., during periods of adverse market conditions for the underlying portfolio. that the We finally outline portfolio diversification benefits of trend-following are also to a large extent resilient to a hypothetical degradation of the trend-following strategy's returns, as the latter exhibit little to no correlation with traditional asset classes such as stocks and bonds

We conclude that this combination of robust portfolio diversification characteristics makes a (benchmark) trend-following program an ideal complement to any well-balanced and diversified institutional portfolio.

Introduction

Equity risk tends to be the most dominant risk factor in liquid institutional portfolios, and the recent inflationary market environment has made mitigating equity risk an even more challenging endeavor. Indeed, in the past 20 years, government bonds have provided a costeffective hedge against equity drawdowns thanks to a structural negative correlation between the two most important asset-classes. However, the recent sustained rise in inflation across developed economies to levels not seen since the 1970's has pushed the correlation between equities and bonds into positive territory, leaving most balanced institutional portfolios with a "nowhere to hide" scenario. The first six months of 2022 saw simultaneously the sharpest firsthalf-year rise in 10-year US Treasuries and global aggregate yields since at least the mid-1990s, and the largest declines in equities since the 1970s. As illustrated by Figure 1, a typical global 60/40 portfolio has lost -19.6% in the first six months of 2022.



Figure 1: Rolling drawdown of a 60/40 portfolio composed of a 60% allocation to the MSCI World Index and a 40% allocation to the Bloomberg Aggregate Bond Index between 1.1.1999 and 30.6.2022. Source: Bloomberg, Quantica Capital.

With global equity and bond prices moving in tandem, the merits of any strategy that is liquid and can provide regime-independent returns that are uncorrelated to equities and bonds, and agnostic to inflation, are clearly high. Such return characteristics are the hallmarks of a typical trend-following investment strategy.

Trend-following involves taking opportunistic long and short positions in a diversified universe of liquid exchange-traded futures, based solely on the strength of the price trend and agnostic of market fundamentals, in each of the instruments traded. In a year like 2022, such an approach is poised to successfully capitalize on multiple inflation-driven market price dynamics across all asset classes by taking a long risk exposure to commodities, a short risk exposure to government bonds and rates, and a short risk exposure to equities, as shown in Figure 2.



Figure 2: Net notional exposure per asset-class for a generic trend-following approach¹ in H1'2022. FI and SR exposure shown as 10y duration equivalent. Source: Quantica Capital.

Such risk allocation has translated into strongly positive and diversifying returns, agnostic to inflation dynamics and uncorrelated to both equities and bonds as illustrated by the year-to-

¹ Quantica Capital's generic trend-following model has been designed to closely track the SG Trend Index, an industry benchmark composed of the ten biggest trend-following programs and can be viewed as a realistic reflection of a typical trend-following approach. Its correlation with the SG Trend Index amounts to 0.89 since 2005. The strategy is applied to a universe of 97 of the most liquid futures markets across equities, fixed-income, interest rates, currencies, and commodities and its portfolio is scaled to target a long-term volatility of 12% per annum.

date returns of the SG Trend Index, a well-known industry benchmark composed of the ten largest trend-following programs. The index is up +28% for the first six months of 2022^2 .

The portfolio diversification benefits of a trendfollowing allocation in a well-diversified and balanced institutional portfolio in a year like 2022 are undeniable. In this note, we aim to quantify these portfolio diversification benefits in the longer-term context and without making any assumption about the underlying portfolio, its constituents, and their respective exposures. We seek to analyze the robustness of these portfolio diversification benefits to three key considerations from an investor's perspective:

- its portfolio risk allocation structure,
- the timing of its investment into trendfollowing, and
- its expectations about future trendfollowing returns

To this end, relying on a representative set of liquid asset-class proxies, we generate the space of all available liquid investment opportunities that can be achieved over a given period by combining these proxies into portfolios. We then quantify and analyze the incremental long-term risk-adjusted return benefit of combining a benchmark trend-following program (as proxied by the SG Trend Index) with any of these simulated portfolios. This allows us to first assess the sensitivity of a trend-following allocation to the risk-allocation structure of the portfolio it is added to.

In a subsequent step, we repeat the analysis, but over a shorter timeframe, and on a rolling timewindow basis. Specifically, we evaluate the optimal Sharpe-ratio maximizing allocation to trend-following at the end of each calendar halfyear period over the preceding five years. This allows us to assess the variability of trendfollowing portfolio diversification as a function of the risk/return characteristics of the underlying portfolio over time and across different market environments.

Finally, in the last step, relying on the previously generated sample of representative portfolios, we challenge the robustness and evaluate the sensitivity of a trend-follower's portfolio diversification benefits to different assumptions about the level of its expected returns.

Modelling the opportunity set of available liquid investment portfolios

When it comes to allocating risk among the liquid array of investment opportunities, no two investors are likely to follow the same approach. As it is impossible to reflect all available individual liquid investment opportunities, we restrict ourselves in this note to a set of nine common basis instruments, as depicted in Table 1, which we believe to be representative of the main available liquid asset-classes.

	Return p.a.	Volatility p.a.	Sharpe ratio	Max. drawdown
DM Equities (NDDUWI Index)	4.4%	16.3%	0.27	-57.8%
NASDAQ 100	5.0%	27.6%	0.18	-82.9%
EM Equities (NDUEEGF Index)	5.5%	18.7%	0.29	-65.2%
Global Real Estate (NDUWREIT Index)	8.3%	20.5%	0.40	-74.1%
Global IG Bonds (LEGATRUU Index)	3.3%	5.2%	0.64	-19.7%
Global HY Bonds (LG30TRUU Index)	6.3%	5.1%	1.23	-35.2%
EM Bonds (EMUSTRUU Index)	6.7%	5.4%	1.24	-31.2%
Commodities (BCOM Index)	1.0%	16.0%	0.06	-75.0%
Gold (GC1 Comdty)	5.9%	17.2%	0.34	-45.6%

Table 1: List of nine liquid asset proxies used in this note that are representative of the main available liquid investment options, including their key risk/return statistics over the period 1.1.2000 – 30.6.2022. Source: Bloomberg, Quantica Capital.

² SG Trend Index: <u>https://wholesale.banking.societegenerale.com/en/prime-services-indices</u>

To account for the diversity of risk allocation approaches among these asset classes, instead of creating a single proxy portfolio, we chose to create 10'000 different portfolios by randomly combining the nine basis instruments introduced above. Specifically, each portfolio is constructed by allocating a random positive weight between 0% and 100%³ to each of its nine constituents, such that the sum of the weights equals 100% (i.e., each portfolio is fully invested without leverage, shorting is not allowed to be representative of an institutional portfolio).

The 10'000 portfolios may be represented in the risk/return space as in Figure 3, in which each dot corresponds to the annualized return and volatility of a single portfolio over the full period 2000 – 2022. Amongst the 10'000 portfolios there are also the "single fully invested instrument" portfolios (composed of a 100% allocation to one of the nine instruments), which are specifically tagged on the chart and happen to shape the corners of the risk/return space for some.

As Figure 3 & Table 1 highlight, over the past 22 years, depending on the combination of weights attributed to the nine instruments, the returns generated from such a portfolio would have annualized at a rate between 1.1% (for a commodity-heavy portfolio) and up to 8.6% (corresponding to a portfolio dominated by listed real estate stocks).

Correspondingly, realized sample portfolio volatility ranged from 5% p.a. for bond-heavy portfolios to 28% p.a. for a portfolio composed mostly of tech equities.

Despite the diversity of their constituents, the main risk factor exposure of most "diversified" portfolios remains equity risk

By construction, as four out of the nine selected instruments provide exposure to listed equities, the average notional equity exposure across the whole set of randomly sampled portfolios stands at 44% (i.e., 4 / 9). Remarkably, however, the average correlation for all these portfolios with



Figure 3: Risk & return space of investment opportunities over the period 1.1.2000 - 30.6.2022 achieved by randomly combining 9 assets representative of the main available liquid asset-classes. Each portfolio is constructed by allocating a random positive weight between 0% and 100% to each of its 9 constituents, such that the sum of the weights equals 100% (e.g., no leverage). Source: Bloomberg, Quantica Capital.

³ The chosen sampling methodology draws sample weights from a symmetric Dirichlet distribution with concentration parameter α equal to 1, which means the distribution is uniform over all points in its support. In particular, the sampled weights fulfil the condition that $w_i > 0$ and $\sum_{i=1}^{9} w_i = 1$.

the MSCI World Index is much higher, at 82%, as shown in Figure 4. At the same time, the minimum average correlation to the MSCI World of any of the 10'000 portfolios over the period 2000 – 2022 remains at an impressive 29%! This confirms that equity risk is indeed by far the dominant risk factor in any liquid and wellbalanced, diversified investment portfolio.

It also highlights the value of identifying and incorporating complementary investment solutions that show little to no correlation with equity markets in order to increase portfolio diversification and protect against a more prolonged decline in equity markets, such as witnessed in the first six months of 2022.

In the remainder of this note, we aim to quantify and characterize the portfolio diversification benefits of a typical benchmark trend-following strategy.



0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% Figure 4: Distribution of notional equity exposure and historical average correlation to the MSCI World (measured on daily returns over the period 1.1.2000 – 30.6.2022) for 10'000 randomly sampled portfolios combining 9 assets representative of the main available liquid asset-classes. Source: Quantica Capital.

The portfolio diversification benefit of trend-following is independent of the underlying portfolio structure

Now that we have generated a representative sample of hypothetical liquid investment portfolios, how does adding trend-following to each of these portfolios affect the risk/return space? To answer that question, we modify each of the randomly sampled portfolios by adding an allocation to the SG Trend Index, a realistic proxy for a benchmark trend-following strategy. Importantly, the weight allocated to the SG Trend Index in each portfolio is calculated such that it maximizes the Sharpe ratio of the resulting portfolio (simulated since 2000 to match the lifespan of the SG Trend Index), while maintaining a 100% total weight allocation and keeping all other relative instrument weights. That means for instance that if, and only if, the addition of trendfollowing does not increase the Sharpe ratio of the portfolio, the resulting allocation weight to the SG Trend index will be equal to 0.

The distribution of optimal Sharpe ratio maximizing allocation weights to the SG Trend Index across all 10'000 randomly sampled liquid investment portfolios is shown in Figure 5.



Figure 5: Distribution of the optimal Sharpe ratio maximizing allocation weight to the SG Trend Index in combination with any of 10'000 randomly sampled portfolios obtained from combining 9 assets representative of the main available liquid asset-classes, over the period 1.1.2000 – 30.6.2022. Source: Quantica Capital.

Strikingly, in none of the 10'000 portfolios is the allocation to trend-following less than 10%. Moreover, the average optimal allocation to the SG Trend Index over the past 22 years would have equaled 40% across all portfolios.

Put differently, an allocation to a typical benchmark trend-following program over the past 22 years would have improved the risk-adjusted returns of all 10'000 liquid multi-asset portfolios! As further shown in Figure 6, an optimal addition of a benchmark trend-following program would have increased the Sharpe ratio of the portfolio by 0.16 on average (i.e., corresponding to a 31% increase), from 0.51 (i.e., the average Sharpe ratio of the 10'000 portfolios without trend-following inclusion) to 0.67.

In short, we have quantified - with the benefit of hindsight - how an allocation to a benchmark trend-following program over the past 22 years would have increased the risk-adjusted returns of any liquid institutional portfolio, regardless of its risk allocation structure. We conclude that over the long-term, trend-following comes with strong portfolio diversification characteristics thanks to its attractive risk-adjusted returns that have little correlation with traditional markets such as equities and bonds.

The portfolio diversification benefit of trend-following is time-consistent and most pronounced in times of adverse market environments

We have so far quantified the portfolio diversification benefits of a benchmark trendfollowing approach over an arbitrary but extended 22-year period mentioned earlier. Our previous analysis assumed a constant exposure to trend-following since the year 2000 to achieve such diversification benefits. As trend opportunities naturally fluctuate over time, we turn onto analyzing how these portfolio diversification benefits have historically varied over time. Specifically, we seek to quantify the net gains in the Sharpe ratio of the portfolio obtained from adding exposure to the SG Trend Index over a rolling five-year investment horizon. The timeframe of five years is chosen to align with the typically recommended minimum investment horizon associated with a trendfollowing allocation.

Figure 7 shows the heatmap of the evolution over time of the distribution of the Sharpe ratio maximizing weight allocated to the SG Trend Index across the 10'000 randomly sampled



Figure 6: Comparative Sharpe ratio distributions for two sets of portfolios (left) and distribution of corresponding difference in Sharpe ratios (right): (1) Sharpe ratio distribution for 10'000 randomly sampled portfolios by combining 9 assets representative of the main available liquid asset-classes. (2) Sharpe ratio distribution of the same 10'000 portfolios but with adding an optimal Sharpe ratio maximizing allocation to the SG Trend Index, over the period 2000 – 2022. Source: Quantica Capital.

portfolios. The distribution is recalculated at the end of each calendar half-year for the previous five calendar years⁴.

The above procedure allows us to quantify the portfolio diversification benefit of trend-following over a sample of 360'000 (i.e., 18 * 2 half-year periods * 10'000 portfolios = 360'000) different portfolio risk-allocations and market scenarios. As such, the average optimal allocation to the SG Trend Index across these 360'000 sampled portfolios turns out to be 30%. Compared to the previously analyzed fixed long-term investment horizon of 22 years, the dispersion of optimal trend allocation weights over a rolling five-year time window is naturally

higher, and the distribution has wider tails. For instance, in about 20% of all portfolios, an allocation to a benchmark trend-following strategy would not have improved the Sharpe-Ratio of the overall portfolio over the five-year investment horizon.

While this is not an insignificant fraction of all portfolios, it is worth examining the market environment in which these cases occurred, as well as the risk/return characteristics of the underlying portfolios during these market periods.



Figure 7: Distribution of optimal Sharpe ratio maximizing allocation weights to the SG Trend Index in combination with any of 10'000 randomly sampled portfolios obtained from combining 9 assets representative of the main available liquid assetclasses over a rolling 5-year investment horizon, recalculated at the end of each calendar half-year (30.6. & 31.12.) from 2005 to 2022. Source: Quantica Capital.

⁴ On 31.12.2004, for each of the 10'000 portfolios, we calculate the optimal weight to the SG Trend Index that would have maximized the portfolio Sharpe ratio from 01.01.2000 to 31.12.2004. The process is repeated for every calendar year until 30.06.2022.

As shown in Figure 7, most of these cases are concentrated in the following three specific five-year periods:

- 2003 2007
- 2009 2013
- 2015 2019

These periods coincided with a generally positive market environment for both equities and bonds, as Table 2 further highlights. Indeed, the average Sharpe ratio across our set of randomly sampled portfolios was in a range between 0.76 and 1.87, averaging at 1.22, across these three five-year periods. This compares to a five-year average Sharpe ratio of 0.70 for all 10,000 portfolios over the past 22 years. Moreover, if we restrict the set of portfolios to those for which the addition of trend-following results in a higher Sharpe ratio, the average Sharpe ratio of these portfolios is only 0.61. In other words, trend-following leads to portfolio diversification when it matters, i.e., when the underlying portfolio performs below its historical average. Similarly, the stronger the riskreturn characteristics of the underlying portfolio, the smaller the benefit of a complementary trend-following allocation.

Time periods	MSCI World return p.a.	Global Agg. Bond return p.a.	60/40 return p.a.	Avg. portfolio Sharpe ratio
2003 – 2007	17.0%	6.5%	12.9%	1.87
2009 – 2013	15.0%	3.9%	10.8%	1.03
2015 – 2019	8.8%	2.3%	6.3%	0.76
2000 - 2022	4.5%	3.5%	4.5%	0.70

Table 2: Performance of global equities, bonds and a 60/40 portfolio over 3 different five-year periods during which a benchmark trend-following strategy displayed muted portfolio diversification benefits.

We can further confirm this relationship by comparing the Sharpe ratio of each of the 10'000 portfolios without and with the addition of a constant 10% allocation weight to the SG Trend Index over a rolling five-year investment horizon (recalculated every calendar half-year). While the choice of a fixed 10% weighting may seem arbitrary, it can be compared to the allocation weighting typically chosen by institutional investors for the so-called "risk-mitigating" sleeve (of which trend-following is often an important constituent) of their portfolios. It is a more realistic choice compared to the previously theoretically calculated optimal Sharpe ratio maximizing weight, which suffers (1) from a strong in-sample bias, and (2) varies significantly over time.

Figure 8 shows the average and confidence bands of the net Sharpe ratio benefit of adding a 10% SG Trend Index allocation to each of the 10'000 portfolios over all 5-year investment horizons between 2000 and 2022 as a function of the average portfolio Sharpe ratio without trend-following over the same time interval.





Figure 8: Average Sharpe ratio impact with 95% confidence interval of adding a 10% allocation to the SG Trend Index in combination with any of 10'000 randomly sampled portfolios over a rolling 5-year investment horizon, recalculated at the end of each calendar half-year (30.6. & 31.12.) from 2005 to 2022, versus portfolio Sharpe ratio before adding the SG Trend Index. Source: Quantica Capital.

First, the chart highlights that trend-following on average had a positive contribution to riskadjusted portfolio performance for any portfolio with a Sharpe ratio below 1.5 (before the addition of trend-following) over a five-year period. This corresponds to 90% of all simulated five-year portfolio scenarios between 2000 and 2005. Second, that risk-adjusted performance improvement has been statistically significant at a 95% confidence level for any portfolio with a 5year Sharpe ratio lower than 0.75, or 60% of all portfolio scenarios (first six buckets from the left in Figure 8).

On average, the addition of trend-following is only detrimental for the top 10% of all five-year portfolio scenarios considered. However, since the Sharpe ratios of these portfolios are relatively high (i.e., in a range between 1.5 and 3.2), the negative impact of trend-following in these cases remains minimal (i.e., less than 2%) and, moreover, statistically insignificant at the 95% confidence level.

To summarize, the portfolio diversification benefit offered by a benchmark trend-following program is not only persistent over time, but also

- leads to higher risk-adjusted returns over a reasonable investment horizon when the underlying portfolio performance is weak
- while not significantly negatively impacting portfolio performance when it is strong

Hence, trend-following offers consistent portfolio diversification benefits over time when it is most needed, without paying the price of lower expected returns during periods of strong portfolio performance.

The portfolio diversification benefit of trend-following is robust to a hypothetical weakening of its expected returns

So far, we have shown that the portfolio diversification benefit of trend-following is independent of the composition and risk allocation of the underlying portfolio and, over the past two decades, have been generally persistent during times when they are most needed.

In the final part, we explore the sensitivity of this portfolio diversification benefit to a third relevant

dimension: the returns generated by the strategy itself. The SG Trend Index has on average returned 6.3% per year since its inception in 2000, with an annualized volatility of 13.5%. While we remain confident that the future will not be short of various profitable trend opportunities, there is, of course, no guarantee that trend-following returns will match or even exceed historical realized returns in the years ahead. We aim to quantify the impact of the level of returns generated by trend-following in terms of portfolio diversification gains. For that purpose, we rely on our previous set of randomly sampled nine-instrument portfolios and their historical realized daily return time-series since 2000. The historical daily returns of the SG Trend Index are then penalized in incremental steps of 1% per annum over the full period, keeping the volatility constant. For each incremental step down we compute the optimal allocation weight to the SG Trend Index which maximizes the Sharpe Ratio.

The distribution of the optimal SG Trend index allocation and the associated net portfolio Sharpe ratio improvement for each index return hypothesis are provided in Figure 9. Our results show that even if the average annual return of a benchmark trend-following strategy were to be only half its historical average, the optimal allocation to the SG Trend Index would still be non-zero for 100% of all randomly sampled liquid portfolios. In fact, the average annual return of a benchmark trend-following program would need to persistently decline to a level below 2% p.a. to start questioning its long-term portfolio diversification benefits.

This type of result is the consequence of one key attribute of the returns of a trend-following program: their very low long-term correlation to equities and bonds.

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Figure 9: Distributions of the optimal Sharpe ratio maximizing allocation weight to the SG Trend Index in combination with any of 10'000 randomly sampled portfolios (left) and distributions of corresponding net portfolio Sharpe ratio improvement (right) for different SG Trend index return assumptions computed by discounting its historical long-term average return in incremental steps of 1% p.a. Source: Quantica Capital.

Low correlation with traditional asset-classes is indeed the critical contributor to portfolio diversification. It is of key importance when evaluating the benefits of complementing any well-diversified, balanced portfolio with an active investment strategy such as trend-following. A strategy with a demonstrated track-record of delivering uncorrelated returns to traditional asset-classes is likely to help improve the riskadjusted returns of any long-only balanced liquid portfolio, even if its returns fall short of expectations over certain time periods. Because trend-following exhibits such return characteristics, it will most likely remain an important source of powerful diversification for any liquid institutional portfolio in the future.

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Conclusion

By selecting a pool of assets covering a realistic range of the main available liquid investment opportunities, we modelled a representative space of risk-return outcomes that can be achieved by combining these assets in 10'000 randomly generated liquid portfolios. In this way, we were able to show that the average correlation of those portfolios to a global equity index is close to 85%, despite the diversity of its underlying constituents. As such, diversification of equity risk remains one of the biggest challenges of portfolio management, especially in a year like 2022. Therefore, trend-following should be part of any institutional portfolio manager's toolkit to mitigate equity risk and increase overall portfolio diversification.

From a purely statistical perspective, we have demonstrated that the addition of a benchmark trend-following strategy would have increased the Sharpe ratio, without exception, of any of the 10'000 randomly sampled liquid portfolios over the past two decades. Not only is the diversification benefit of trend-following highly independent of the composition of the underlying portfolio, but it is also stable over time. Furthermore, despite trend opportunities naturally fluctuating over time, trend-following would have improved the risk-adjusted returns of any liquid investment portfolio in any adverse market environment observed since the early 2000's over a five-year investment horizon. Thus, trend-following offers time-consistent portfolio diversification benefits when it matters most. And such benefits largely outweigh the very limited costs of maintaining an allocation to trendfollowing in times of generally favorable market environments that are driven by strong performance of traditional asset classes.

While the above conclusions were drawn from past realized returns of the SG Trend index (i.e., 6.3% p.a. since 2000), we also quantified the sensitivity of portfolio diversification benefits to a hypothetical weakening of future trendfollowing returns. We have highlighted that thanks to the proven low long-term correlation to traditional asset-classes, trend-following can still increase the risk-adjusted returns of any portfolio, even in a scenario where trendfollowing returns would be well below their historical long-term average.

In summary, trend-following not only offers an attractive risk/return profile on a stand-alone basis, but also provides persistent and robust portfolio diversification benefits that make it a powerful complementary investment solution for any diversified liquid institutional portfolio. Since 2003, Quantica Capital's mission has been to design and implement the best possible systematic trend-following investment products in highly liquid, global markets. To the benefit of our investors and all our stakeholders.

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