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QUANTICA CAPITAL

QUARTERLY INSIGHTS

WHAT DRIVES A TREND-FOLLOWER'S TRADING ACTIVITY?

Understanding the key drivers behind trend-following exposure changes

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Executive summary

In this note, we show that the buying and selling of any market by a trend-following strategy is driven by changes in three key complementary factors: its signal or trend-strength, its risk or volatility, and a "portfolio-scaling factor" that reflects adjustments due to the applied portfolio construction or risk management methodology. This portfolio-scaling factor is driven by changing cross-asset correlations (or more generally by the cross-signal correlations) and is used to actively manage the overall portfolio risk exposure.

We introduce a simple analytical formula that attributes the change in an instrument's dollar exposure to the change in each of the three factors across time in a generic trend-following context. This approach allows us to identify and quantify the key drivers behind any noticeable increase or reduction in exposure to a single instrument, a group of instruments, an entire asset-class, or the full portfolio across time.

We take a closer look at the relative contribution of these three factors during the most recent period between January and March 2022, which has been characterized by a substantial expansion of trend opportunities, coupled with a sharp rise in volatilities across fixed-income and commodity markets.

Furthermore, we illustrate how changes in trend-signals, individual market volatilities, and the portfolio-scaling factor have each contributed to the overall portfolio turnover of a generic trend-following strategy since 2005.

We conclude this note by highlighting that in the long-run, changes in individual market trend-signals only account for little more than half, or on average 60%, of a typical trend-follower's portfolio turnover. The remaining trading activity is driven by risk-management and portfolio construction. Over shorter periods, risk-management factors, e.g., driven by a sudden volatility spike or correlation shifts across one or more asset-classes, may even explain up to 80% of the turnover of a medium-to-long-term trend-following portfolio.

A trend-follower's exposure to WTI Oil in Q1 2022

Against a backdrop of escalating geopolitical tensions and generally tight global supply chains, the first quarter of 2022 saw some dramatic price moves across most commodity markets. Such a market environment translated into a number of powerful trends that directly impacted a trend-follower's positioning. By way of illustration, Figure 1 displays the allocated net notional exposure to the WTI Oil futures contract of a generic trend-following strategy[1] across this year's first quarter compared to the price history of this contract over that period.

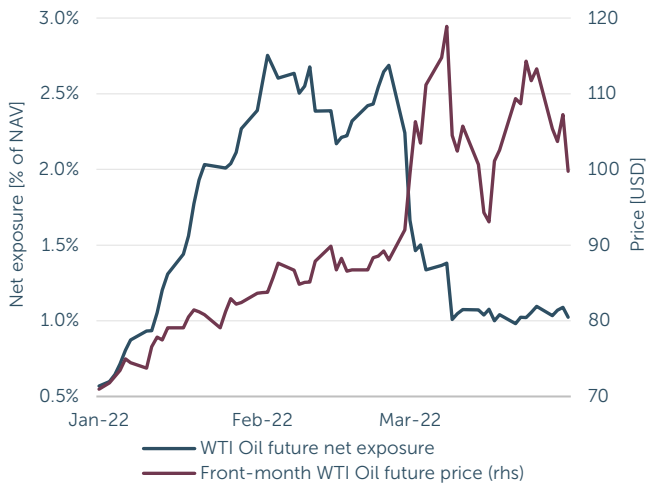

Figure 1: Net notional exposure (as a percent of NAV) of the WTI Oil future contract in a generic trend-following strategy and corresponding contract price during the first quarter of 2022. Source: Quantica, Bloomberg.

The price of WTI Oil started the year by rising steadily until February 24. The rise then continued subsequently on much higher volatility to reach a price of around $100 (or a 40% increase from the start of the year) at the end of the first quarter after peaking at $119 on March 8. Interestingly, the weight allocated by the generic trend-following strategy to front-month WTI Oil, while increasing continuously throughout January, already peaked on February 3rd, when the contract was trading at around $85 "only". Between February 25 and March 9, despite a sharp move higher in oil prices, our generic trend-following strategy more than halved its notional exposure to WTI from 2% to 0.8% of its NAV!

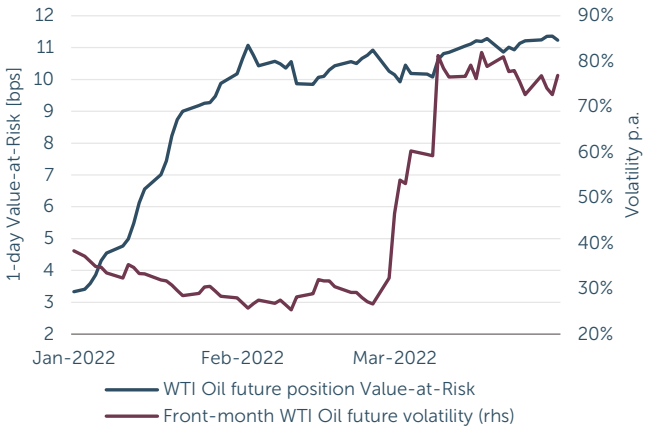

Figure 2: Rolling exponentially weighted volatility of front-month WTI Oil futures and rolling 1-day 99% Value-at-Risk of the WTI Oil position of a generic trend-following strategy during the first quarter of 2022. Source: Quantica, Bloomberg.

While the underlying trend-signal is a natural driver of building up exposure to WTI Oil in a market environment like the one observed during the first quarter of 2022, the spike in volatility observed in late February and early March (as depicted in Figure 2) led the trend-following strategy to reduce exposure to maintain its risk budget. At constant trend-strength, the doubling of an instrument's volatility leads to a reduction in half of its notional exposure in the portfolio. The overall risk allocated to the instrument, however, remains unaffected in such case, as can be further seen from Figure 2. The above simple case study is the most recent real-world illustration on how signal and risk interact to

[1] Quantica'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 83 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.

influence the positioning of a trend-follower. It also provides a compelling example of a trend-follower selling a market despite the rise in the underlying price.

So far, we have illustrated how two factors – signal and volatility – do affect the positioning of a trend-following strategy in an isolated market context. In the next section, we derive a simple mathematical formula to decompose the portfolio turnover of all instruments in a generic trend-following strategy into the changes of three factors: trend-signal, volatility, and cross-correlations.

Trend-following exposures are driven by three main factors

Systematic trend-following relies on the assumption that persistent trends are recurring events in all types of financial market environments and across all asset classes. In order to capitalize on such trends, a trend-following strategy takes long and short positions across a diversified set of markets. In most trend-following approaches, the weight or dollar exposure of each instrument[2] is typically a function of the following three key variables:

- The instrument's **trend-signal or trend-strength**, which captures the direction (long or short) and conviction level in the trend. The trend-signal is a function of the trend-following model being used as part of the investment strategy. For instance, the chosen set of lookback windows to measure trends will impact the speed at which the model will react to new or fading trends[3].
- The instrument's estimated risk or **volatility**. The higher (lower) the instrument's volatility, the lower (higher) the required dollar exposure to meet its risk allocation target.
- A **portfolio-scaling factor**, which scales all positions up or down according to the specific portfolio construction rules in order to meet and actively manage the portfolio's overall risk target. It is a direct reflection of (1) the cross-instrument correlation structure and (2) the overall trend-opportunity set of the underlying investment universe. Indeed, higher (lower) average cross-correlations lead to a higher (lower) portfolio volatility (all else being equal), which results in a lower (higher) portfolio-scaling factor to control the portfolio volatility. A greater trend-opportunity set (i.e., a greater number of concomitant trends) across universe constituents will also lead to a higher average risk exposure across individual instruments, which implies a higher portfolio volatility. In turn, this results in a lower portfolio-scaling factor.

The above three variables may be combined into the below mathematical formulation of the weight of an instrument in a trend-following strategy:

$$\text{weight} = \frac{\text{signal} \cdot \text{portfolio-scaling factor}}{\text{volatility}}$$

Put differently, an instrument's notional-weight exposure w_t in a trend-following portfolio at time t is the product of three distinct and complementary factors

$$w_t = s_t \cdot \frac{1}{\sigma_t} \cdot \lambda_t \,,$$

[2] The weight of an instrument in a portfolio is defined as the dollar exposure of that instrument divided by the portfolio's net asset value.
[3] For more information on the relationship of lookback windows and reaction speed please refer to Quantica Capital, "Why speed matters", Quantica Quarterly Insights, April 2020.

where:

- s_t is the instrument's trend-strength at time t, which may be positive (long position) or negative (short position)
- $\frac{1}{\sigma_t}$ is the instrument's inverse volatility at time t
- λ_t is the portfolio-scaling factor at time t (i.e., a function of the cross-instrument correlation structure and the overall trend opportunity set), which works in combination with a portfolio risk-target (e.g., 12% p.a.).

Whilst the first factor reflects the conviction of the model in the trend that a given instrument exhibits, the other two factors represent the risk-management portion of the strategy. The second factor will for instance lead to a reduction (an increase) in an instrument's exposure if its volatility increases (decreases). The third factor may lead to a similar reduction (increase) if (1) the average correlation or if (2) the average trend-strength in absolute terms across all universe constituents increases (decreases). Note that the first two factors are instrument-specific, while the last factor is mostly dependent on the entire set of instruments composing the strategy's investment universe[4].

A formula for explaining the change in trend-following exposures

The previous weight decomposition formula may be used to obtain the following mathematical formula explaining the *change* of an instrument's weight in a trend-following strategy in terms of *changes* of the three factors:

$$w_t - w_{t-1} = \alpha_t(s_t - s_{t-1}) + \beta_t\left(\frac{1}{\sigma_t} - \frac{1}{\sigma_{t-1}}\right) + \gamma_t(\lambda_t - \lambda_{t-1}),$$

for suitable α_t, β_t and γ_t, which are the sensitivities of the weight to the trend-strength, inverse volatility, and portfolio-scaling factor, respectively. The precise definition of α_t, β_t and γ_t, including the derivation of the formula may be found in Appendix 1.

Using the above formula, we show in the subsequent sections how the three factors have recently contributed to the overall portfolio turnover of a generic trend-following strategy.

Trend-following turnover implications from rising energy prices during Q1 2022

Returning to our initial example, we first look at how recent changes in trend-signals and volatilities of individual instruments, as well as changes in the portfolio-scaling factor, have contributed to impacting the net aggregate Energy exposure of our generic trend-following strategy during the first quarter of 2022[5].

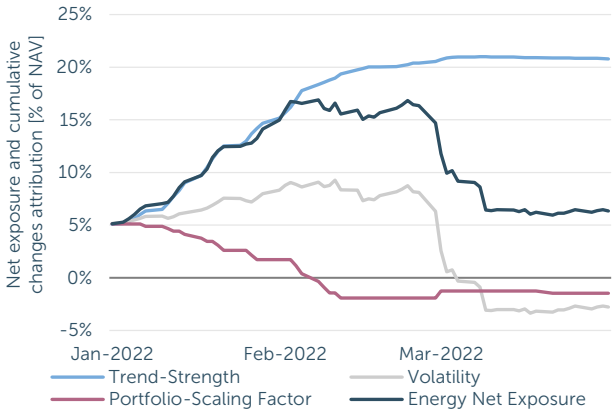

Figure 3: Energy overall net notional exposure attribution by cumulative changes in instrument trend-strength, instrument volatility, and portfolio-scaling factor in a generic trend-following strategy with a long-term 12% annualized volatility target during the first quarter of 2022. The sum of the three factor's cumulative changes equals the change in net notional exposure at any point in time. Source: Quantica Capital.

[4] In practice, other factors additionally impact the instrument weight such as trading costs, liquidity, exposure, and risk allocation constraints.
[5] Energy includes the following highly liquid futures markets: WTI Crude Oil, Brent Crude Oil, Gasoil, Heating Oil and Gasoline.

As Figure 3 shows, during January and until February 3, the increase in Energy exposure from 5% to 17% was mostly signal-driven, as the volatility and the portfolio-scaling factor contributions were relatively small and offsetting each other. From February 3 to February 10, the further rise in the overall Energy trend-strength got offset by a decline of the portfolio-scaling factor, leading to a stabilization of the weight allocated to Energy at around 17% until February 25. The declining portfolio-scaling factor, leading to an Energy exposure reduction of around 7% until February 10, is the reflection of an expanding trend opportunity set, characterized at that time by a general increase in the average trend-strength across multiple commodity markets (not just Energy)[6]. The subsequent reduction of the Energy exposure from 17% to less than 7% between February 25 and March 9, was entirely driven by the spike in volatility witnessed across all underlying instruments during that period. The remainder of the quarter saw no further trading activity from the strategy in the underlying instruments, as the three factors remained mostly constant.

Trend-following turnover implications from rising global yields during Q1 2022

The rise in energy prices witnessed during the first quarter of 2022 was accompanied by a general rise in global government bond yields across the duration spectrum. Both the front- and the long-end rose sharply, with 2-year US Treasury yields increasing from 0.73% to 2.33%, and 30-year US Treasury yields increasing from 1.9% to 2.45%.

Starting the year with an already negative net aggregate 10-year duration equivalent exposure to fixed-income[7] of -51%, our generic trend-following strategy would have – assuming constant instrument volatilities and a constant portfolio-scaling factor – more than quadrupled this exposure to -227% by February 17, driven by an increasingly aggregate negative trend-strength. However, overall net aggregate short fixed-income exposure never exceeded -152% in the first quarter of 2022, as an expanding commodities opportunity set (i.e., declining portfolio-scaling factor) has offset any further fixed-income trend-strengthening between mid-January and mid-February, as is shown in Figure 4.

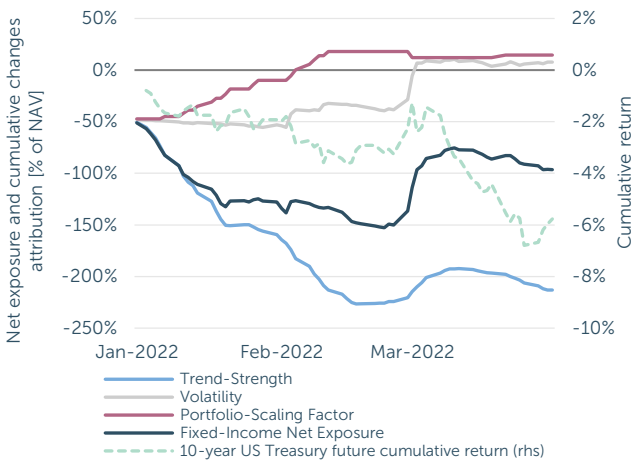

Figure 4: Fixed-Income net notional exposure attribution by cumulative changes in instrument trend-strength, instrument volatility, and portfolio-scaling factor in a generic trend-following strategy with a long-term 12% annualized volatility target during the first quarter of 2022. The sum of the three factor's cumulative changes equals the changes in net notional exposure at any point in time. Source: Quantica Capital, Bloomberg.

On February 25, the sudden safe-haven government bond rally translated into a general spike in bond volatility across the duration spectrum. This spike in volatility resulted in an immediate sharp reduction in fixed-income net short exposure in the generic trend-following strategy, from -150% to -114% at the beginning of March. The bond rally had only a marginal

[6] As the number of investment opportunities increases, but the overall portfolio risk budget remains at 12% p.a., the average exposure allocated to each investment opportunity decreases by construction.
[7] All subsequent fixed-income exposures are expressed in 10-year duration equivalents. The strategy's underlying fixed-income universe is composed of 15 global government bond futures spanning durations from 2 to 30 years.

impact on trend-signal contributions, and like the energy exposure, the strategy's aggregate fixed-income weight stabilized towards -100% at the end of the quarter. Notably, the general build-up in long commodity exposure between mid-January and mid-February[8] (i.e., expanding commodity opportunity set) accounts for an equivalent -70% of foregone short fixed-income exposure at the end of March 2022.

We provide a further illustrative example in Appendix 2, covering the first quarter of 2020, which was characterized by the sudden and significant spike in equity volatility following the outbreak of the COVID-19 pandemic.

A three-factor attribution formula of overall trend-following portfolio turnover

Our previous observations naturally lead us to ask the following question: what portion of a trend-follower's portfolio turnover is explained by each of the three factors previously listed this year so far, or over a much longer period, such as the past 17 years?

The turnover of a portfolio between two consecutive periods $t-1$ and t is equal to the sum of the absolute changes in weights of its individual constituents i between the two periods: $\sum_i |w_t^i - w_{t-1}^i|$. Please note that such definition does not account for any turnover due to the rolling of futures positions from one expiry to the next. As it is purely operational in nature, we ignore it in the context of this note.

From the previous formula expressing the change in weight of an instrument $\Delta_t^i = w_t^i - w_{t-1}^i$ as a function of the three factors, we can infer an analytical expression that attributes the turnover of a generic trend-following portfolio $\sum_i |\Delta_t^i|$ to each of the three factors:

$$\sum_i |\Delta_t^i| = \sum_i \tilde{\alpha}_t^i (s_t^i - s_{t-1}^i) + \sum_i \tilde{\beta}_t^i \left(\frac{1}{\sigma_t^i} - \frac{1}{\sigma_{t-1}^i}\right) + \sum_i \tilde{\gamma}_t^i (\lambda_t - \lambda_{t-1}),$$

for suitable $\tilde{\alpha}_t^i$, $\tilde{\beta}_t^i$ and $\tilde{\gamma}_t^i$, which have the same absolute value as α_t, β_t and γ_t for instrument i, respectively, but might differ in their sign. As a reminder, these variables denote the sensitivities of the weight to the trend-strength, inverse volatility, and portfolio-scaling factor, respectively. We provide a detailed mathematical derivation of this formula, including the definition of the three accompanying constants in Appendix 3.

Trend-following turnover attribution dynamics in Q1 2022

Based on the above formula, Figures 5a and 5b outline how changes in the trend-signal, the individual instrument volatilities and the portfolio-scaling factor have contributed on a relative and absolute basis to the overall portfolio turnover (across all asset-classes) of a typical trend-following strategy since the beginning of this year.

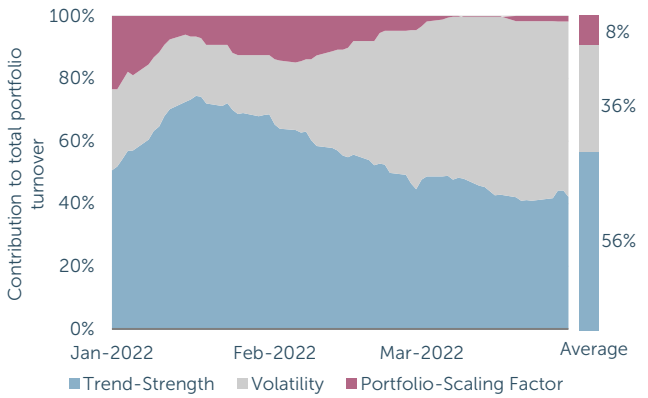

Figure 5a: Rolling average one-month contributions to the portfolio turnover (measured as the sum of the changes in weight of its individual components in absolute terms) of a generic trend-following strategy of changes in instrument signals, in instrument volatilities, and changes in the portfolio-scaling factor, respectively. Source: Quantica Capital.

[8] Note that the overall portfolio net exposure of equities and currencies were mostly stable over the period.

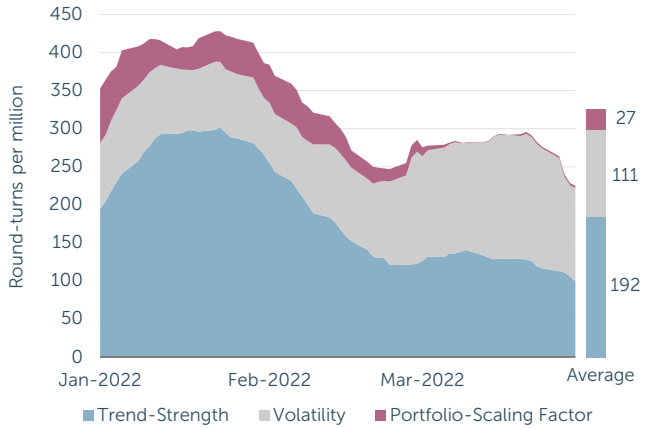

Figure 5b: Rolling average one-month round-turns per million (number of contracts traded per million of notional) traded by a generic trend-following strategy (excluding any roll trades) due to changes in instrument signals, in instrument volatilities, and changes in the portfolio-scaling factor, respectively. Source: Quantica Capital.

Consistent with our previous observations on the drivers of energy and fixed-income exposure changes this year, Figure 5a outlines a majority contribution from signal changes of up to 70% during January. However, in February the relative contribution of instrument volatility changes to portfolio turnover increased and in March on average around 55% of the strategy's trading activity was driven by risk management rather than changes in individual trend dynamics. For the entire quarter, more than half of the overall portfolio turnover was driven by changes in signals on the underlying universe constituents, and 36% of it was driven by changes in their underlying volatilities. The portfolio-scaling factor, i.e., cross-instrument correlation and overall trend opportunity dynamics, accounted for 9% of the total portfolio turnover in Q1 2022.

Long-term trend-following turnover attribution dynamics since 2005

If we look beyond the last quarter, going back to 2005, the relative contribution of each factor has displayed significant variation over time, as can be seen in Figures 6a and 6b, in combination with Table 1.

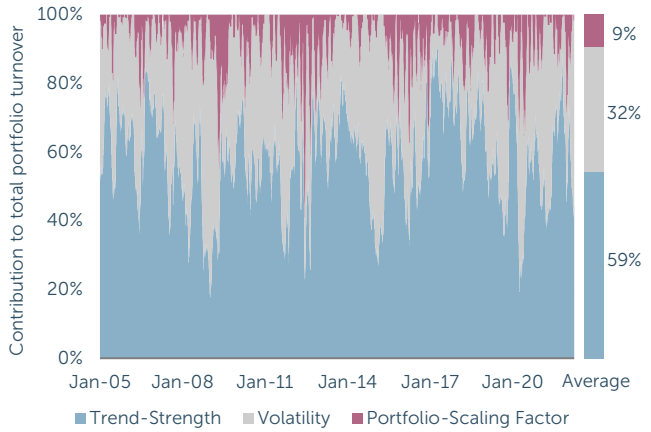

Figure 6a: Rolling average one-month contributions to the portfolio turnover of a generic trend-following strategy of changes in instrument signals, in instrument volatilities, and changes in the portfolio-scaling factor, respectively. Source: Quantica Capital.

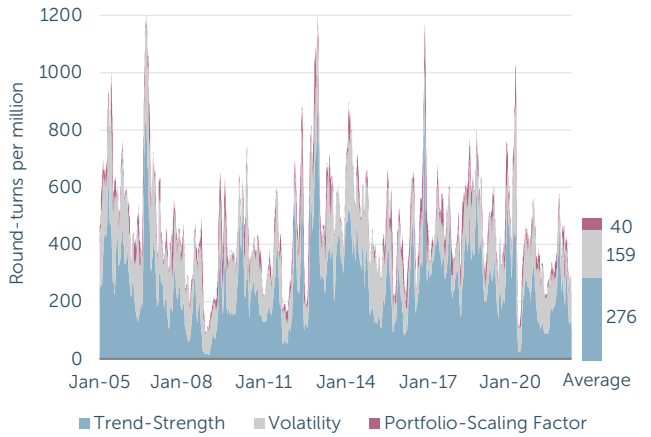

Figure 6b: Rolling average one-month round-turns per million traded by a generic trend-following strategy (excluding any roll trades) due to changes in instrument signals, in instrument volatilities, and changes in the portfolio-scaling factor, respectively. Source: Quantica Capital.

In late 2008 for instance, 77% of a trend-follower's exposure changes were primarily driven by changes in the underlying instruments' volatilities. A similar pattern could be observed in March 2020 around the outbreak of the COVID-19 pandemic. More generally, in any period of heightened volatility, risk-management factors rather than changes in trends are the dominant drivers of a trend-follower's changes in underlying instrument exposures.

Inversely, changes in the trend-strength of individual instruments may at times explain up to 90% of the overall turnover of a trend-following portfolio (such as in April 2017, early 2020 and more recently during the second half of 2021).

Finally, changes in the portfolio-scaling factor never accounted for more than 60% (achieved in June 2012) of overall portfolio turnover in the past 17 years. It is by far the factor that has the least amount of impact on strategy turnover.

	Maximum	Date	Minimum	Date	Average '05 - '22
Trend-Strength	91.7%	Apr-17	17.7%	Jan-09	58.8%
Volatility	76.7%	Dec-08	6.4%	Apr-17	32.6%
Portfolio-Scaling	59.1%	Jun-12	0.0%	Apr-07	8.6%

Table 1: Maximum, minimum, and average one-month contributions to portfolio turnover of a generic trend-following strategy of changes in instrument signals, in instrument volatilities, and changes in the portfolio-scaling factor, respectively. Period: 2005 – 2022. Source: Quantica Capital.

Over the entire period, on average, changes in the trend-strength of individual instruments account for approximately 59% of the total portfolio turnover of a trend-follower, as can be seen in Table 1. Put differently, in the long-run, less than two-thirds of a trend-follower's trading activity is the result of trend-signal changes in the underlying markets traded.

Complementarily, risk-management accounts for the remaining 41% of such trading activity (with 33% of the latter driven by individual instrument volatility changes and 8% by portfolio-scaling).

In the short-run, however, risk-management factors (driven for instance by a volatility or correlation spike across one or more asset-classes) may account for up to 80% of the positioning changes of such a trend-following strategy.

Conclusion

We have introduced a simple analytical formula that decomposes the dollar exposure of any trade of a generic trend-following strategy into the relative contribution of the following three key factors:

- Single instrument trend-signal
- Single instrument market risk or volatility
- Portfolio-scaling factor, depending on cross-correlations and overall trend opportunity set across the whole investment universe

Sharply rising commodity prices and global interest rates have profoundly impacted the positioning of trend-following portfolios in the first quarter of 2022. Applying the derived turnover attribution formula, we have illustrated how these three factors have contributed to the change in a trend-follower's overall energy and fixed-income exposures over that period. In particular, we have provided two examples when a trend-following strategy significantly reduced its exposure to a group of instruments despite its increase in the underlying price trend.

Our decomposition approach also allowed us to derive an analytical expression for the total portfolio turnover based on the same three factors. We have highlighted how changes in trend-signals, in individual market volatilities, and in the portfolio-scaling factor each have contributed to the overall portfolio turnover of a generic trend-following strategy.

We find that on average over the past 17 years, changes in individual market trend-signals account for close to 60% of a medium-to-long-term trend-follower's total portfolio turnover. The remaining 40% can be attributed to active risk management.

Over shorter periods, e.g., during times of elevated market stress (such as 2008, March 2020 or Q1 2022), risk-management may account for up to 80% of the trading activity of a trend-follower. More generally, in any period of heightened volatility or cross-correlation dynamics, risk-management factors rather than changes in trends are the dominant drivers of a trend-follower's portfolio trading activity.

Appendix 1: Derivation of the instrument weight change attribution formula

Assuming very generally that the weight w_t of an instrument at time t is a product of n factors $w_t = \prod_{k=1}^{n} x_t^k$, we can apply the framework of Shapley values (Shapley, 1953) to obtain the following weight change decomposition:

$$w_t - w_{t-1} = \sum_{k=1}^{n} \phi_t^k \left(x_t^k - x_{t-1}^k\right),$$

where the ϕ_t^k are given by

$$\phi_t^k = \sum_{\substack{S \subseteq \{1,\dots,n\} \\ S \ni k}} \frac{(|S|-1)!\,(n-|S|)!}{n!} \prod_{l \in S \setminus \{k\}} x_t^l \prod_{l \in \{1,\dots,n\} \setminus S} x_{t-1}^l .$$

While the usual appeal of Shapley values is that they can be used to obtain an attribution of the change of *any* function of some number of variables to those variables, their application is particularly appealing in our case of a simple product of n variables, since the resulting attribution is very close to the usual linearization obtained in the differentiable continuous-time setting:

$$dw_t = \sum_{k=1}^{n} \left(\prod_{l \neq k} x_t^l \right) dx_t^k .$$

For the purpose of decomposing the weight change in a trend-following setting we apply the $n = 3$ case of the formula with $x_t^1 = s_t$, $x_t^2 = \frac{1}{\sigma_t}$ and $x_t^3 = \lambda_t$ to obtain:

$$w_t - w_{t-1} = \alpha_t (s_t - s_{t-1}) + \beta_t \left(\frac{1}{\sigma_t} - \frac{1}{\sigma_{t-1}} \right) + \gamma_t (\lambda_t - \lambda_{t-1}),$$

where

$$\alpha_t = \frac{1}{6}\left(2\frac{\lambda_t}{\sigma_t} + \frac{\lambda_t}{\sigma_{t-1}} + \frac{\lambda_{t-1}}{\sigma_t} + 2\frac{\lambda_{t-1}}{\sigma_{t-1}} \right),$$

$$\beta_t = \frac{1}{6}(2 s_t \lambda_t + s_t \lambda_{t-1} + s_{t-1} \lambda_t + 2 s_{t-1} \lambda_{t-1}),$$

$$\gamma_t = \frac{1}{6}\left(2\frac{s_t}{\sigma_t} + \frac{s_t}{\sigma_{t-1}} + \frac{s_{t-1}}{\sigma_t} + 2\frac{s_{t-1}}{\sigma_{t-1}} \right).$$

Appendix 2: Trend-following turnover implications from the COVID-19 induced equity crash in March 2020

Looking at the period corresponding to the outbreak of the COVID-19 crisis in the first quarter of 2020, the generic trend-following program reduced its overall equity exposure from 115% to 30%, or 85% in just the last week of February 2020, as shown in Figure 7. Most notably, two-thirds of this reduction is to be attributed to pure risk-management, while a change in trend-strength accounted for the remaining exposure reduction. Conversely, the subsequent reduction in equity exposure to a slight net short exposure on March 12 was entirely due to a continuous decline in the program's aggregated equity trend-strength.

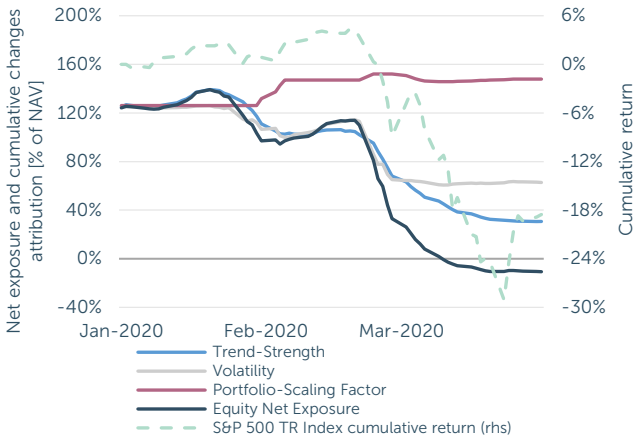

Figure 7: Equity net notional exposure attribution by cumulative changes in instrument signal, instrument volatility, and portfolio-scaling factor in a generic trend-following strategy with a long-term 12% annualized volatility target during the first quarter of 2020 and corresponding cumulative return of S&P 500 TR Index over the same period. The sum of the three factor's cumulative changes equals the changes in net notional exposure at any point in time. Source: Quantica Capital, Bloomberg.

Appendix 3: Derivation of the portfolio turnover attribution formula

Given the additive decomposition of an instrument's i weight change $\Delta_t^i = w_t^i - w_{t-1}^i$ into n components

$$\Delta_t^i = \sum_{k=1}^{n} \Delta_t^{ik} ,$$

we obtain a decomposition of the total portfolio turnover $\sum_i |\Delta_t^i|$ as follows:

$$\sum_i |\Delta_t^i| = \sum_i \operatorname{sgn}(\Delta_t^i)\Delta_t^i = \sum_i \sum_{k=1}^{n} \operatorname{sgn}(\Delta_t^i)\Delta_t^{ik} = \sum_{k=1}^{n} \sum_i \operatorname{sgn}(\Delta_t^i)\Delta_t^{ik} .$$

Here the sign of Δ_t^i is used to rewrite its absolute value, leading to an interpretable attribution where factors moving in the same (opposite) direction as the overall weight change contribute positively (negatively) to the instrument's turnover.

We apply the above to the case of generic trend-following:

$$\Delta_t^i = \alpha_t^i (s_t^i - s_{t-1}^i) + \beta_t^i \left(\frac{1}{\sigma_t^i} - \frac{1}{\sigma_{t-1}^i} \right) + \gamma_t^i (\lambda_t - \lambda_{t-1})$$

and thus end up with the following turnover decomposition:

$$\sum_i |\Delta_t^i| = \sum_i \operatorname{sgn}(\Delta_t^i)\alpha_t^i (s_t^i - s_{t-1}^i) + \sum_i \operatorname{sgn}(\Delta_t^i)\beta_t^i \left(\frac{1}{\sigma_t^i} - \frac{1}{\sigma_{t-1}^i} \right) + \sum_i \operatorname{sgn}(\Delta_t^i)\gamma_t^i (\lambda_t - \lambda_{t-1}) .$$

References

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