# ON SHAKY Ground

BY MARK KRITZMAN AND SÉBASTIEN PAGE

**Turbulent times reveal the cracks in our risk parameters. Where to from here?**

> THE WORD "RISK" DERIVES FROM THE EARLY ITALIAN RISICARE, WHICH MEANS "TO DARE". IN THIS SENSE, RISK IS A CHOICE RATHER THAN A FATE.
>
> —PETER L. BERNSTEIN, AGAINST THE GODS, THE REMARKABLE STORY OF RISK.

When both the U.S. and World ex-U.S. stock markets are one standard deviation above their mean, the correlation between them is -17%. When both markets are one standard deviation below their mean, the correlation between them rises to +76%.[1] This example highlights what many investors have learned during the recent crisis: risk parameters estimated from full samples provide unreliable measures of the hedging and diversification properties of assets during turbulent markets.

We show that it is possible to use multivariate outliers to measure market turbulence. Multivariate outliers coincide with well-known market events. By measuring turbulence, we can estimate risk parameters more reliably and construct portfolios that are more resilient to turbulent markets. Moreover, we can enhance alpha by scaling exposure to risk as a function of market turbulence. A critical feature of our methodology is that it takes into account not only unusually volatile returns but also returns that interact in strange ways.[2]

## MEASURING TURBULENCE

Typically, we calculate rates of return by subtracting the price at the beginning of the period from the price at the end of the period, adding income, and dividing by the price at the beginning of the period. In many periods, however, there are no significant events that should cause prices to change; hence the returns we observe merely reflect the fact that prices are noisy. In other periods, such as August 1998 and September 2008, prices legitimately shift in response to significant events. Despite this difference in return generation, the formulas often used to calculate standard deviation and correlation assign as much importance to periods with no events as they do to periods with significant events.

It is therefore useful to partition historical returns into those that reflect noise and those that are driven by events. An outlier in a return series for a single asset is straightforward to identify. It is simply a return that falls outside a chosen confidence interval around the expected return. A multivariate outlier is more difficult to identify. It represents a set of contemporaneous returns that is collectively unusual for one or more reasons. A day or a month is turbulent if the returns across a set of assets behave in a significantly uncharacteristic fashion. One or

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more assets' returns, for example, may be unusually high or low, or two assets which are highly positively correlated may move in the opposite direction. Thus, a multivariate outlier may result from the unusual performance of an individual asset or from the unusual interaction of a combination of assets, none of which are particularly unusual in isolation.

Exhibit 1 illustrates the difference between turbulence and volatility. It shows a scatter plot of returns for two correlated assets with unequal variances. Observation A is closer to the centre of the ellipse and therefore less volatile than observation B. But observation A is more likely than observation B to be associated with market turbulence because it represents an unusual interaction between the two assets. This illustration makes it easy to visualize the methodology with two assets, and we can visualize multivariate outliers in three dimensions as well (imagine a football-shaped three-dimensional ellipsoid). Although we can't visualize above four dimensions, the math can be applied to as many assets as we like.

We use this multivariate outlier methodology to build a turbulence index. This turbulence measure is superior to common measures of volatility such as the VIX because 1) it considers not only high volatility but also unusual correlations, and 2) it can be measured for any collection of assets (not just U.S. equities).

## INVESTING IN TURBULENT TIMES

Exhibit 2 shows 30-day moving averages of turbulence indices for three sets of assets: U.S. equity sectors, currencies, and global assets including stocks, bonds, and commodities. It shows each index for February 1995 through March 2009. The recent crisis is the most extraordinarily turbulent and statistically unusual period we have ever encountered, no matter which assets we choose to measure turbulence. The turbulence we've been experiencing in the U.S. equity markets, for example, is as high as it was during the tech bubble. And for currencies, it rivals the turbulence following Russia's default on its sovereign debt in 1998. For global assets, it's significantly higher than any period in recent history.

Is there anything we can do to protect our investments or at least limit the damage during turbulent markets? The short answer seems to be yes. There are two features about turbulence that could prove to be useful to investors. First of all, turbulence is not random. It may arrive randomly, but once it arrives it persists for a while, just like the turbulence we encounter when we fly. The good news in this otherwise bleak story is that investors have time to react to turbulence. Exhibit 3 provides evidence of the persistence of turbulence. It records the average daily turbulence score during the following week, two-week period, and month following the appearance of a turbulent day, defined as one of the 10% most turbulent days in the sample. Consider, for example, U.S. equity sectors. A turbulence score of 15.99 separates the 10% most turbulent days from the rest of the sample. In the week following a turbulent day, the average daily turbulent score was 22.66, well above the 10% cutoff for

**Exhibit 1: TURBULENCE VS. VOLATILITY**

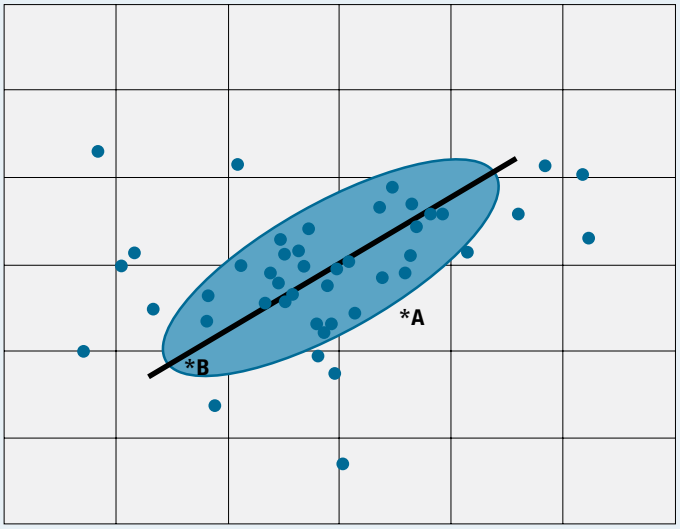
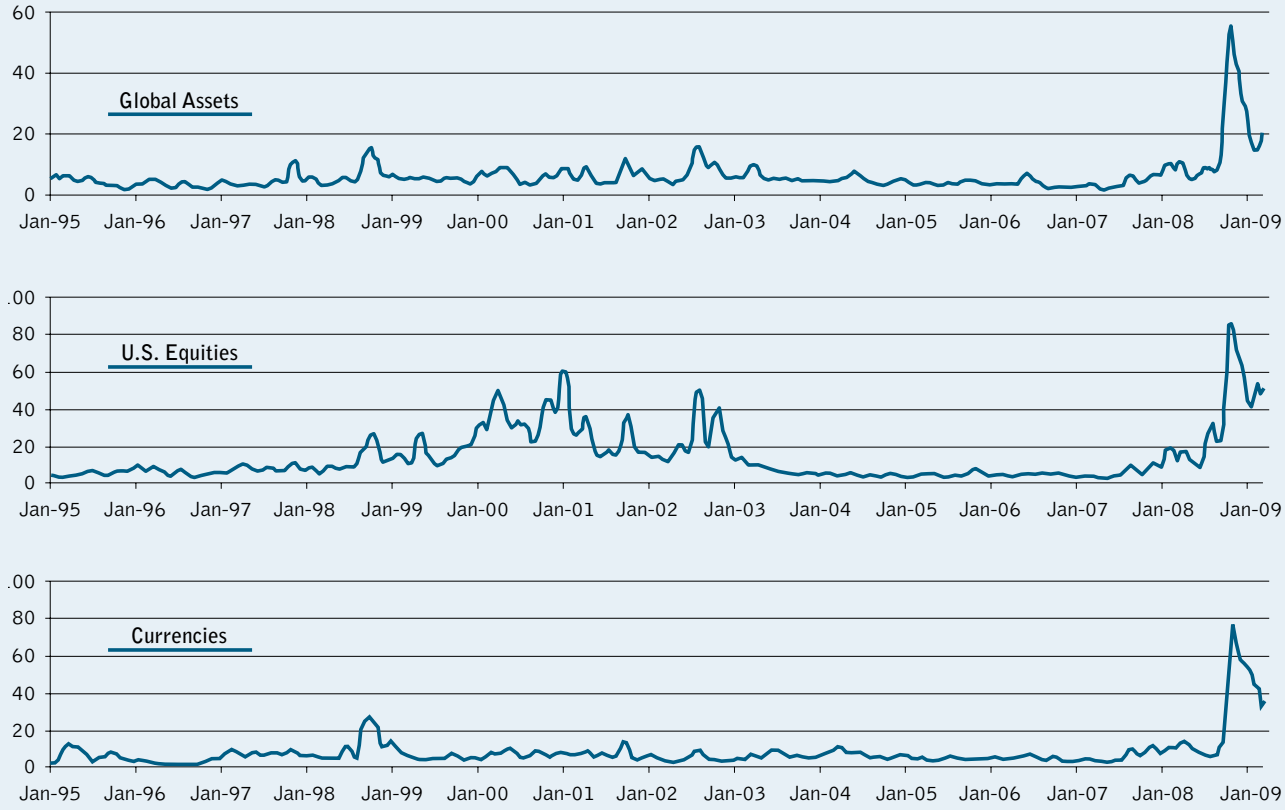


**Exhibit 2: TURBULENCE INDICES**




turbulence and far above the full-sample average of 10. Moreover, average daily turbulence remained high even one month after its arrival. Similar patterns prevail for currencies and global assets. This persistence is welcome news because it implies investors have time to react to continued turbulence.

The other welcome feature about turbulence is that assets and strategies perform differently during quiet and turbulent periods. Most assets and strategies experience sharply higher returns in quiet periods than in turbulent periods.[3] This finding is extremely welcome news, especially in light of the persistence of turbulence. The combination of persistence and differential performance suggests that we should be able to enhance return by scaling exposure to these strategies according to the relative turbulence we observe.

For example, consider the example of the forward rate bias strategy, which is commonly referred to as the "carry trade." To follow this strategy, the investor overweights forward contracts of countries with high interest rates and underweights currency forwards of countries with low interest rates. Many global macro strategies rely in part on the carry trade. Although this strategy over the long run has been a very reliable source of alpha, it is commonly

**Exhibit 3: PERSISTENCE OF TURBULENCE**

| | U.S. Sectors | Currencies | Global Assets |
|---|---|---|---|
| 1 Week | 22.66 | 14.39 | 6.47 |
| 2 Weeks | 22.19 | 13.09 | 6.23 |
| 1 Month | 21.33 | 12.18 | 6 |
| Sample Average | 10 | 9 | 4 |
| 10% Threshold | 15.99 | 14.68 | 7.78 |
| 15% Threshold | 14.53 | 13.29 | 6.74 |
| 20% Threshold | 13.44 | 12.24 | 5.99 |

**Exhibit 4: BACKTEST RESULTS**

| Strategy | Information Ratio |
|---|---|
| Constant Carry Exposure | 0.51 |
| **Strategies with Dynamic Exposures:** | |
| Turbulence Index | 0.98 |
| VIX | 0.43 |
| 2y Swap Spread | 0.66 |
| 5y Swap Spread | 0.61 |
| TED Spread | 0.63 |
| Bond Yield Spread | 0.62 |

known to perform best in relatively quiet markets and poorly in extreme or risky markets. During the quietest periods (or, 90% of the time), it has an annualized return of 3% with annualized risk of 1%. During the 10% most turbulent periods, it has an annualized return of -9% and annualized risk of 3%.[4]

To investigate if we can time our exposure to the carry trade to avoid turbulent periods and thereby protect alpha, we perform a simple out-of-sample backtest that scales risk exposure to the sample carry strategy conditional on the 30-day average Turbulence Index and on other factors including the VIX, two-year and five-year USD swap spreads, the TED spread, and a bond yield spread.[5] These backtests implement a simple systematic decision rule in which we invest in the carry strategy when the relevant factor is below its three-year median value (representing more calm markets), and we scale risk exposure to zero whenever the factor is above the three-year median value (representing more extreme markets). We assume a one-day implementation lag to ensure that there is no look-ahead bias in the results. The backtests span the sample period October 2, 1990 through November 28, 2008.

Exhibit 4 shows the information ratio of each of the filtered carry strategies. The regime-shift trading rule significantly improves results and the Turbulence Index performs better than other risk indicators—perhaps because it is the only indicator to incorporate unusual interactions as part of the definition of turbulence.

## STRATEGIC ASSET ALLOCATION

While sophisticated investment managers can focus on dynamic allocation to alpha strategies to enhance their information ratio, plan sponsors must focus on long-term considerations such as how to allocate the policy portfolio. Can our methodology help plan sponsors allocate assets? The first article to define market turbulence as a function of multivariate outliers was published in 1999 by George Chow, Eric Jacquier, Mark Kritzman, and Kenneth Lowry.[6] In this article the authors propose partitioning historical returns into two sub-samples: one associated with quiet periods and one characterizing times of turbulence, and computing standard deviations and correlations that are specific to these regimes.

Assume we apply this approach to a typical Canadian portfolio allocation, comprised of 25% Canadian equity, 29% global equity, 29% bonds, 21% real estate, and 4% cash. Most investors would agree the current crisis has been outside the realm of anything they could have predicted using historical data. However, the turbulent regime

RECENT EXPERIENCE HAS HIGHLIGHTED THE FACT THAT RISK PARAMETERS ARE HIGHLY UNSTABLE.

covariance matrix, using data from January 1990 through June 2007, revealed that exposure to loss was almost twice as high as predicted by the full-sample risk parameters. It showed that within a five-year horizon, exposure to a 10% loss was 42% during a turbulent regime, as opposed to 23% as estimated from the full sample covariance matrix.

Why such a difference? When we calculate full-sample standard deviation and correlation, we assign as much importance to periods with no events as we do to periods with significant events. Not only does this approach underestimate volatility, but it also greatly underestimates an asset's diversification properties in market environments when diversification is most needed. Therefore, to construct portfolios that are resilient to market turbulence plan sponsors should overweight turbulent risk estimates.

To summarize, recent experience has highlighted the fact that risk parameters are highly unstable. It is possible to measure turbulence statistically by accounting for unusual return patterns across a set of assets. Using this methodology, we introduce a turbulence index that provides significant advantages over conventional risk indicators such as the VIX index. We show that periods of high statistical turbulence coincide with well-known turbulent events in financial history. We observe that turbulence is highly predictable, which is good news for investors with enough flexibility to scale risk exposures dynamically. For strategic investors, we show that it is possible to construct portfolios that are more resilient to periods of market turbulence than those constructed using full-sample risk parameters. ∎

## ENDNOTES

1. See Chua, Kritzman, and Page, "The Myth of Diversification," forthcoming in the *Journal of Portfolio Management,* Fall 2009.
2. If we associate a turbulent regime only with returns that are unusually volatile, we might conclude falsely that there are multiple regimes. This mathematical effect is referred to as "spurious regimes."
3. *Windham Investment Review*, Fall 2008, www.windhamcapital.com
4. See Mark Kritzman, "Managing Assets in Turbulent Markets," CFA Institute Conference Proceedings Quarterly, March 2009, Volume 26, No 1.
5. The authors would like to thank David Turkington for his assistance with this section of the article.
6. Chow, Jacquier, Kritzman, and Lowry, "Optimal Portfolios in Good Times and Bad," *Financial Analysts Journal*, May/June 1999.