**Detecting an Unusual Performance of Individual Trader and Account**

**Yoshimasa Satoh, CFA**

Yoshimasa Satoh, CFA, is a Lead Account Manager of Buy and Sell Side Solutions, Market Technology, Nasdaq.

yoshimasa.satoh@nasdaq.com

*The author introduces a new application of financial turbulence, which was introduced by Kritzman and Li in 2010. The new application, Performance Turbulence Index (PTI), is used for detecting an unusual relative (or absolute) return of a trader (or an account). The PTI can be calculated for any group of return series banks and brokers (or asset managers) may choose. The PTI does not need any estimates or future forecasts as inputs; the PTI only needs historical realized returns.*

*When the PTI detects unusualness of a set of returns, the following phenomena are observed: [A] an extreme positive or negative return of a trader (or an account) compared to the historical norm, and/or [B] the divergence of correlated returns and/or the convergence of uncorrelated returns.*

*The PTI is expected to work at any market circumstances if parameters, such as lookback time periods for returns, volatilities, and correlations, are set appropriately. It should be advised that rogue traders might try to take advantage of highly volatile markets and hide in the noise, but it is highly likely that the PTI could detect it. It is beneficial for further investigations by banks and brokers (or asset managers).*

**Introduction**

One of the goals of trade surveillance of banks and brokers and asset managers (hereinafter referred to as “banks and brokers”) from a performance perspective is to detect unusualness of performance achieved by an individual trader/account/portfolio manager, hereinafter referred to as a “trader.” Usualness can be defined by [A] an individual trader’s own long-term performance and [B] long-term mutual relationships in performance amongst traders. [A] is a time-series analysis while [B] is a cross-sectional analysis.

If a trader’s short-term performance is very different from his/her own track record as in [A], and/or strange given the past relationships with other traders as in [B], it should be detected and investigated. When he or she achieves far better short-term performance, which is hard to explain and also unusual based on [A] and/or [B], then it needs detection and investigation because he/she might have done something dubious, for instance, insider trading. In another case, he or she might perform very differently in terms of [A] and/or [B], and also incur a heavy loss in a short period of time due to excessive risk taking.

The vast majority of traders, as a whole, wins and loses compared to a benchmark, e.g., VWAP (or total market index returns) and these traders’ performances are eventually in line with the benchmark in the long run; namely, their long-term relative performances versus a benchmark are almost zero. On the other hand, only a minority of some traders might keep winning and other traders could continue to lose.

If a top-class trader wins in a continuous and legitimate manner, there is no problem at all. However, if an average trader significantly outperforms unlike other average traders and goes beyond his/her normal capability in the short run, it should be detected and investigated.

On the contrary, if a trader loses in a continuous and compliant manner, risk managers should be able to notice it and stop his/her trading once it breaches risk/loss thresholds. If another trader largely underperforms and goes beyond the expected level in the short term, then it should need detection and investigation before it’s too late, even if this trader has not breached his/her risk/loss threshold yet.

Thus, it’s very important for banks and brokers to detect an individual trader’s recent unusual performance.

Furthermore, it should be noted that order/trade alert parameters are usually set to appropriate levels and the workload on the surveillance analysts are at manageable level during periods of normal market activity. How do these surveillance processes perform when faced with the reality of strenuous market conditions? Inevitably, this will lead to a backlog of alerts to work through, which makes it harder to conduct the normal level of due diligence as usual. The author thinks banks and brokers understand the need for extra scrutiny and due-diligence on market abuse during times of high volatility, but the current highly volatile markets make timely and effective surveillance difficult. Bad actors are aware of this and will try to take advantage and hide in the noise.

Alert spikes could be simply a reflection of increased market activity and volatility, which could be expected responses of trading algorithms. In that sense, [A] shown above could be impacted by short-term market turmoil, not only in absolute terms, but also in relative terms. Also, banks and brokers can directly see traders’ relative and absolute returns.

On the contrary, [B] described above is considered to be less impacted by short-term changes in market conditions. What if a certain trader demonstrated a modest performance as he/she usually does while other traders performed unusually and very badly in the midst of market turmoil? His/her performance might be in line with his/her past track record, but it suddenly moved very differently from others. That should be detected and investigated.

That’s why we need to look at not only [A] individual traders’ own historical performances, but also [B] mutual relationships in performances amongst traders. When taking a closer look, there are certain performances that stand out from their own past history and/or others, not only at normal times, but also in times of wild volumes and high volatility.

In the following sections, the author introduces a new application of financial turbulence to detect unusual changes in both [A] and [B] simultaneously.

**Performance Turbulence Index**

Kritzman and Li (2010) introduced the measure of financial turbulence, including its derivation, empirical properties, and usefulness.1 It was originally developed to detect financial market turbulence from asset allocation, portfolio construction, and risk management perspectives, but the author thinks that it is also applicable to trade surveillance.

The author defines financial turbulence divided by the number of traders N as the Performance Turbulence Index (PTI):

(1)

where

The Performance Turbulence Index at a particular time period *t* (scalar)

Relative returns of a trader versus a benchmark for period t (1×N vector) (\*1)

Sample moving average of historical relative returns at a period t (1×N vector) (\*2)

Sample moving average covariance matrix of historical relative returns at a period t (N×N vector) (\*2)

**N** = Number of traders

(\*1) One day relative return in this case, but it could be absolute returns and/or any arbitrary number of days for the best detection of dubious trading.

(\*2) The author chose a moving average time window of 60 trading-day (~ 3 month) without decay, but this could be arbitrarily chosen for the purpose of the best trade surveillance. This window defines a duration of time for standardization of returns, i.e., mean, standard deviations, and correlations of returns.

Simply speaking, if there is a trader who is performing differently compared to his/her past and/or his/her peers in an unusual manner, then this PTI is expected to increase and indicate the high degree of unusualness.

A pair of **(yt - μ)** terms capture extreme positive or negative excess returns of each trader compared to his/her historical norm **μ** and are located on both sides of **Σ-1**. **Σ-1** is an inverse matrix of a sample covariance of historical relative returns **yt**. This inverse matrix of a sample covariance(**Σ-1**) works as a standardization term by historical patterns of volatilities and correlations of relative returns. To put it differently, the characteristic deviations are scaled by the covariance matrix **Σ**. The PTI is a measure to detect unusualness of each trader performance (pair) in terms of standard deviations of individual relative returns **yt** (not actual relative returns) and directions of excess returns **(yt - μ)**, which are positive or negative.

By definition, the PTI gets higher by [A] individual trader’s extreme excess returns **(yt - μ)**, which are positive or negative compared to the historical norm and/or [B] decoupling of correlated traders and coupling of uncorrelated traders.

Here is the beauty of the PTI.

First, it can be calculated for any set of traders with frequent historical relative (or even absolute) returns **yt**.

Second, this single measure captures interactions among combinations of traders in addition to the magnitude of individual traders’ own relative returns. The number of correlation pairs, **(N2-N)/2** where **N** = number of traders, can significantly increase as you swell **N**.

Third, “returns” can be arbitrarily defined. For instance, if you would like to monitor changes in an order-to-trade ratio, the number of order messages divided by the number of trade message, these changes are considered to be “returns” and the PTI of the returns can be calculated accordingly. In this case, you are looking at a trader’s behavior rather than performance as a result of that behavior.

Fourth, the PTI keeps redefining what is unusual and what is usual, depending on the time window chosen. If markets stay highly unstable for a long time, usualness would be re-defined by recent market conditions. It could capture both cyclical and structural changes.

Finally, although the PTI is a measure that provides absolute numbers, it can be converted to a relative one, such as percentile ranking in a certain period of time. That would be powerful if the relationship amongst traders becomes more unstable compared to the past on a continuing basis, the absolute value threshold of the PTI for separating usual periods from unusual periods will eventually rise.

These features are quite a contrast to currently popular indicators, such as, realized or estimated nominal returns, realized or implied volatilities, correlations, and other old-fashioned traditional risk metrics.

It should be noted that the PTI is not meant to offer a reliable estimate of when and how a rogue trader will appear; rather, as a coincide index based on realized relative returns without forecasts, it emits a more reliable warning signal. Unusually better (or worse) performance may arrive unexpectedly, but it provides you a warning signal and time to investigate dubious trading and orders.

**PTI: A Hypothetical Case Study**

Let’s think about a very simplified hypothetical case here.

**Table 1. Relative Returns (versus a Benchmark)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Trader | A | B | C | D | **X** |
| Description | Outperformer | Outperformer | Average Trader | Underperformer | **Underperformer** |
| Day 1 | 0.00322859 | -0.00016386 | 0.0006422 | 0.00091598 | 0.00126529 |
| Day 2 | -0.00017795 | 0.00044133 | -0.00060675 | -0.00007491 | -0.00093834 |
| … |  |  |  |  |  |
| Day 199 | -0.00090122 | -0.00015031 | 0.00173868 | 0.00009688 | 0.00136267 |
| **Day 200** | 0.00124258 | 0.00067429 | -0.00013808 | -0.00075302 | **(\*3) 0.03389437** |
| Day 201 | -0.00040230 | 0.00086738 | -0.00616061 | 0.00120357 | 0.00247461 |
| … |  |  |  |  |  |
| Day 250 | -0.00464734 | -0.00071359 | -0.00555133 | 0.00093111 | 0.00295311 |
|  |  |  |  |  |  |
| Mean (\*1) | 0.00097687 | 0.00034491 | 0.00001335 | -0.00038771 | -0.00061466 |
| SD (\*2) | 0.00288750 | 0.00078096 | 0.00319980 | 0.00126486 | 0.00380527 |

(\*1) Mean return of relative returns, Daily

(\*2) Standard deviation of relative returns, Daily

(\*3) This is a dubious trading performance to be detected.

**Table 2. Correlation Matrix of Relative Returns**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | A | B | C | D | **X** |
| A | 1.00 | 0.76 | -0.06 | -0.14 | -0.11 |
| B |  | 1.00 | -0.09 | -0.07 | -0.04 |
| C |  |  | 1.00 | -0.02 | -0.01 |
| D |  |  |  | 1.00 | 0.78 |
| X |  |  |  |  | 1.00 |

If we look at the trader X, he/she outperformed a benchmark to a large degree in a certain day (Day 200) compared to his/her long-term mean and standard deviation of relative returns. On the contrary, other traders (A, B, C, and D) achieved their relative returns that are in line with their long-term average and volatility of relative returns.

Moreover, although the trader X has been highly and positively correlated to the trader D, the trader X largely outperformed on the day 200 while the trader D underperformed.

If banks and brokers could detect this unusual performance of the trader X in a quantitative and objective manner, even in the midst of market turmoil, that would be very beneficial. That’s where the PTI comes in.

**Figure 1. Performance Turbulence Index (PTI): Trader A, B, C, D, and X**



**Figure 2. Performance Turbulence Index (PTI): Trader A, B, C, and D excluding X**



Figure 1 and 2 clearly show that the relative return of the trader X on day 200 was extremely unusual from the PTI perspective; once banks and brokers successfully detect it, then a next step is further investigation.

**Conclusion**

The author introduces a new application of financial turbulence for detecting an unusual relative (or absolute) return of a trader(, an account, or a portfolio manager), and named the Performance Turbulence Index (PTI). The PTI can be calculated for any group of return series banks and brokers (or asset managers) may choose. The PTI does not need any estimates or future forecasts as inputs; the PTI only needs historical realized returns.

When the PTI detects unusualness of a set of returns, the following phenomena are observed: [A] an extreme positive or negative return of a trader compared to the historical norm, and/or [B] the divergence of correlated returns and/or the convergence of uncorrelated returns.

The PTI is expected to work at any market conditions if parameters, such as a duration of time for return observation, are properly set. It should be advised that rogue traders might try to take advantage of highly volatile markets and hide in the noise, but it is highly likely that the PTI could detect unusual performance (and even behavior) if parameters are set appropriately. It is beneficial for further investigations by banks and brokers.

**Appendix: Correlation Surprise Index**

Kinlaw and Turkington (2014) extend Kritzman and Li’s study (2010) by disentangling the volatility and correlation components of turbulence to derive a measure of correlation surprise.2

Similarly, the author defines the Correlation Surprise Index (CSI) as follows:

(2)

The Performance Turbulence Index at a particular time period *t* (scalar)

The Magnitude Surprise Index at a particular time period *t* (scalar)

MSI is equal to the PTI, given in equation (1), where all off-diagonal elements in the covariance matrix are set to zero. This ‘correlation-blind’ turbulence measure captures magnitude surprises as in [A], but ignores whether co-movement is typical or atypical as in [B].

On the other hand, the PTI contains the component [A] and [B].

Since the CSI is the PTI divided by the MSI, the CSI is expected to evaluate the component [B] directly.

**Figure 3. PTI, MSI, and CSI: Trader A, B, C, D, and X**



The figure above shows that the spike of the PTI on Day 200 in this very simple case is mainly from the MSI, rather than the CSI.

Additionally, Kinlaw and Turkington showed a case of a single asset to understand the financial turbulence in an intuitive way. Similarly, if we consider a case of a single trader, the PTI, the equation (1), is simply equal to the squared z-score of the trader relative return **yt**, as shown in the equation (3) below.

PTI for a single trader (3)

**Notes**

The material presented is for informational purpose only. The views expressed in this paper are the view solely of the author and are subject to change based on markets and other factors; moreover, the views do not necessarily represent the official views of Nasdaq.

1. See Kritzman and Li (2010)
2. See Kinlaw and Turkington (2014)

**References**

Kritzman, Mark, and Yuanzhen Li. 2010. “Skulls, Financial Turbulence, and Risk Management.” *Financial Analysts Journal*, Vol. 66, No. 5 (2010), pp. 30-41.

Kinlaw, Will, and David Turkington. 2014. “Correlation Surprise.”, *Journal of Asset Management,* Vol. 14, 6(2014), pp. 385-399.