Available online at www.sciencedirect.com

ScienceDirect

Journal of Financial Markets 17 (2014) 1–46

Journal of FINANCIAL MARKETS

www.elsevier.com/locate/finmar

VPIN and the flash crash ☆

Torben G. Andersen[a,b,c,*], Oleg Bondarenko[d,1]

[a]*Kellogg School of Management, Northwestern University, 2001 Sheridan Road, Evanston, IL 60208, United States*
[b]*NBER, United States*
[c]*CREATES, Denmark*
[d]*Department of Finance (MC 168), University of Illinois at Chicago, 601 S. Morgan St., Chicago, IL 60607, United States*

Available online 6 June 2013

Abstract

The Volume-Synchronized Probability of Informed trading (VPIN) metric is introduced by Easley, López de Prado, and O'Hara (2011a) as a real-time indicator of order flow toxicity. They find the measure useful in monitoring order flow imbalances and conclude it may help signal impending market turmoil, exemplified by historical high readings of the metric prior to the flash crash. More generally, they show that VPIN is significantly correlated with future short-term return volatility. In contrast, our empirical investigation of VPIN documents that it is a poor predictor of short run volatility, that it did not reach an all-time high prior, but rather after, the flash crash, and that its predictive content is due primarily to a mechanical relation with the underlying trading intensity. We also investigate a later incarnation of VPIN, stemming from Easley, López de Prado, and O'Hara (2012a), and reach similar conclusions. In general, we stress that adoption of any specific metric for order flow toxicity should be contingent on satisfactory performance relative to suitable benchmarks, exemplified by the analysis we undertake here.

☆We are indebted to the Zell Center for Risk at the Kellogg School of Management, Northwestern University, for financial support. We are grateful to the referee, Pete Kyle, for inquisitive comments on the earlier version of the paper that strengthened the empirical evidence, and to the editor, Tarun Chordia, for the help in obtaining details of the BV-VPIN implementation. We also thank Craig Furfine, Kathleen Hagerty, Andrei Kirilenko, Robert McDonald, Maureen O'Hara, Mark Ready, and seminar participants at the University of Illinois at Chicago, the Commodity Futures Trading Commission, the Federal Reserve Bank of Chicago, the High-Frequency Trading Leaders Forum, 2011, the Duke University Economics Department Brown Bag and the Kellogg Finance Department Brown Bag for discussions on this topic. Andersen also acknowledges support from CREATES funded by the Danish National Research Foundation. Finally, we are grateful to the CME Group for providing access to data from the CME DataMine system.

*Corresponding author at: Kellogg School of Management, Northwestern University, 2001 Sheridan Road, Evanston, IL 60208, United States. Tel.: +1 847 467 1285.

E-mail addresses: t-andersen@kellogg.northwestern.edu (T.G. Andersen), olegb@uic.edu (O. Bondarenko).

[1]Tel.: +1 312 996 2362.

1386-4181/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.finmar.2013.05.005

JEL classification: G01; G14; G17

Keywords: VPIN; PIN; High-frequency trading; Order flow toxicity; Order imbalance; Flash crash; VIX; Volatility forecasting

1. Introduction

In a series of articles, Easley, López de Prado, and O'Hara, henceforth ELO (2011a–c, 2012a) develop the "Volume-Synchronized Probability of Informed trading" (VPIN) metric as a proxy for the imbalance or "toxicity" of order flow. The construction of VPIN relies on an underlying trade classification scheme, and this choice has implications for the properties of the measure. In the initial papers, ELO use a version of the tick rule to classify trades into buy and sell volume, and we denote any metric based on this procedure TR-VPIN for "Tick Rule-VPIN." In ELO (2012a), they instead advocate a "bulk volume" classification strategy, and we refer to the associated metric as BV-VPIN. Another important feature is that VPIN captures the market dynamics in event time, i.e., equal increments of trading volume rather than calendar time. Hence, their analysis uses a transformed time scale where the basic unit is a fixed volume bucket rather than a constant stretch of calendar time. They find their VPIN implementation to produce a set of striking empirical results, using one-minute observations for the order flow on the E-mini S&P 500 futures contract at the Chicago Mercantile Exchange.

ELO (2011a) focus on the events surrounding the "flash crash" on May 6, 2010. First, they note that the TR-VPIN measure was unusually high in the week preceding May 6, 2010, and the situation worsened in the hours prior to the crash. In fact, they observe that the TR-VPIN metric for the E-mini S&P 500 futures contract reached an all-time historical high by 13:30 local Chicago Time, and the crash began at 13:32 according to the time line established by CFTC-SEC (2010). Second, they find that the TR-VPIN measure leads the Volatility Index (VIX) for the S&P 500 index, both prior, during, and following the dramatic events of May 6, 2010. As such, they suggest TR-VPIN provides a superior and more timely indicator of future short-term volatility, or emerging turmoil, than the option-implied volatility measure, VIX, which is otherwise often referred to as the "market fear" gauge.

The findings reported by ELO raise the prospect that TR-VPIN may serve as a reliable indicator of stress in the financial markets, thus providing regulators, brokers, and traders alike with a real-time warning signal of market malfunction. To allow the broader public access to this information in a timely fashion, they advocate introducing an exchange-traded futures contract written on TR-VPIN.

In this article, we take an in-depth look at the empirical performance of TR- and BV-VPIN applied to the E-Mini S&P 500 futures contract. We initially focus on first variant, TR-VPIN, and develop an empirical framework for assessing the properties of this metric.[2] Even within this set of measures, there are numerous alternative classification strategies. We document that the results hinge critically on the choice among those. We reach four main conclusions that, on key points, diverge from ELO. One, TR-VPIN is not a useful predictor for future return volatility. Traditional forecast variables, including the VIX index, are generally vastly superior to

[2]The algorithm for computing TR-VPIN, detailed in ELO (2011c), was submitted to the U.S. Patent and Trademark Office. For a discussion of potential contract design for a TR-VPIN futures contract, see ELO (2011b).