Can VPIN Forecast Geopolitical Events? An Application to the Crimean Crisis

Felipe B G Silva*[1] and Ekaterina Volkova†[1]

[1]Johnson Graduate School of Management, Cornell University

August 31, 2014

Abstract

The study of the economic and financial outcomes due to geopolitical events has been widely studied in the literature, engaging direct interests of scholars, industry practicioners, policy makers and regulators. We take the recent Crimean Crisis and the sequence of outcomes that led to the intervention by the Russian Army which directly affected equity prices in Russia, investigating how informed traders may have used their advantage to trade pior to the moment the markets fell. We compute the Volume-synchronized Probability of Informed Trading (VPIN) for the Russian main equity index and for individual stocks, finding that for the index level and for most of the stocks it raises considerably between one and three trading days before market prices reflect the invasion. We also investigate whether informed traders are able to successfully select the individual stocks which are more likely to be affected by the odds of a lengthy war between both countries. Finally we take deposittary receipts corresponding of some of the Russian firms which are included in our sample to verify whether different markets vary in their flow toxicity. Our results provide additional support for the use of VPIN as a measure of monitoring the likelihood of undesirable (geopolitical) events.

JEL Classification: G14, G15
Keywords: Informed Trading, VPIN, Political Events, Crimean crisis

1 Introduction

The causal connection between (typically exogenous) geopolitical events and their effects on economic and financial variables has been widely studied by scholars and commonly taken into account by practitioners. Wars, conflicts, shocks to international relations between countries, social unrests, etc., definitely affect economic variables like oil prices, entrepreneurship, M&A activity, foreign investment, among others.

*Finance PhD student. 301L Sage Hall, Ithaca, NY, 14850. E-mail: fbs27@cornell.edu
†Finance PhD student. 301Z Sage Hall, Ithaca, NY, 14850. E-mail: ev99@cornell.edu

While one can arguably say that such events are not completely exogenous (as economic agents can anticipate the bets on future events to actually take place), it is often the case whenever the influence of market participants on global leaders and international policy makers (e.g. lobbying) is relatively limited. Such quasi-natural experiments perfect for event studies in economics and finance, since endogeneity problems are not considerably critical. A brief literature review on such event studies follows in the next paragraphs.

Amihud and Wohl (2004) analyzes the linkage between expectations of the fall of Saddam Hussein and stock prices by using prices of a prediction markets website. The author argues that before the event took place (before the U.S. Army intervened on Iraq's Saddam regime) market prices of such contracts were rising because of the expectations of a costly war, which consequently caused stock prices to fall, oil prices to boom, the U.S. Dollar to lose its value against the Euro, etc.. On the other hand, as the event actually happened the odds of a speedy war (and fall of Saddam Hussein) and the positive consequences for the U.S and Global economy (lower oil prices, lower risks of terror attacks, etc) gradually became priced (and were, therefore, reflected by the prediction markets contracts).

Still related to the same event, Leigh, Wolfers, and Zitzewitz (2003) extend the analysis of the price of prediction markets to macroeconomic variables, delving into US data (industry-wise effects of equity prices) and international stock markets (Turkey, Israel and several European nations). The authors find that countries which are highly globalized are oil net importers are more affected by the negative effects from the war.

From a historical perspective, Frey and Kucher (2000) study the behavior of bond prices of five European nations (Germany, France, Belgium, Austria and Switzerland), given a sequence of specific events that affect them in a pre-war (establishment of the Nazi dictatorship, occupation of Rheinland, Olympic Games in Berlin, etc), war (invasion of the Benelux and France, U.S. declaraion of war, Battle of Stalingrad), and post-war (Yalta and Postdam conferences) periods.

Acemoglu, Johnson, Kermani, Kwak, and Mitton (2013) take the specific (and recent) event of the nomination of Tim Geithner as the U.S. Treasury Secretary on December 2009 and analyze the abnormal returns effect on firms to which Mr. Geithner had a connection (proxied by data on firms' executive meetings, common memberships of nonprofit boards, firm location being in NYC or not, etc). They find that for financial firms previously connected to Mr. Geithner cumulative abnormal returns are about 6% one trading day after the nomination and about 12% after ten business days.

Because of the relative fragility (sometimes lack) of democratic institutions, as well as political and economic instabilities, stock markets are highly sensitive to the political risks and external shocks on emerging markets in comparison to their peers in developed nations. For instance, Bailey and Chung (1995) show that equity market premiums of Mexican individual securities are exposed to political and exchange rate risks.

From a market microstructure standpoint, the concept of probability of informed trading (PIN) was firstly introduced by the seminal work of Easley, Kiefer, O'Hara, and Paperman (1996). The authors develop the theoretical framework for PIN as a mix-continous-discrete time information-tree model and empirically validate the measurements by computing the corresponding probabilities for NYSE stocks of different liquidity characteristics. By constructing different volume-decile clusters they show that PIN values are higher for low-volume stocks.

A vast literature has arisen from Easley, Kiefer, O'Hara, and Paperman (1996). Easley, Hvidkjaer, and O'Hara (2002) examine the link between informed trading activity and classical asset pricing theory, empirically showing that information-based trading levels can be considered a pricing factor, reflected by the equilibrium asset returns under the Fama and French (1992) asset pricing structure.

Easley and O'Hara (2004) create a theoretical model to show that cross-sectional differences of the components of both public and private information can be considered a priced factor to the cost of capital of different stocks. As the authors show, the higher the portion of private information (informed traders) the more disagvantaged will the uninformed inversions be, requirity therefore a higher cost of capital to hold such securities.

Duarte and Young (2009) divide the PIN component of different equities into two factors: one related to asymmetric information itself while the other is related to illiquidity. They find that the PIN component due to asymmetric information across traders is not priced while the illiquidity fraction actually is. Easley, Hvidkjaer, and O'Hara (2010) investigate a trading strategy that takes the probability of informed trading as a signal, by constructing a size-neutral portfolio with long positions in high PIN equities and short positions in low PIN stocks, following the intution that stocks with higher PIN values (higher inside trading levels) are underpriced because investors require additional cost of capital to hold them. Although the PIN factor itself (together with Fama and French (1992) and momentum factors) cannot explain the abnormal returns, the authors find a significant covariation among high-PIN and low-PIN stocks.

Despite the academic success of the PIN measure as a proxy for informed trading activity, the application of the PIN methodology itself became somewhat outdated as the relevance of high-frequency traders has increased substantially over the past 10 years, reaching more than 60% of the trading volume in US markets months before the appex of the 2008 Subprime Financial Crisis. The classical calibration of PIN takes into account the trade assignment (buys or sells) (see Lee and Ready (1991)), and based on the numbers of buy-initiated and sell-initiated trades, one performs a daily calibration of a likelihood function, yielding the best estimates of parameters defined by Easley, Kiefer, O'Hara, and Paperman (1996). Because of the nature of high-frequency traders acting as market makers, a time-volume measure is indeed more relevant than cronological time since higher trading volumes can be linked to higher information flows. This is the underlying intuition for the definition of the Volume-synchronized probability of inside trading (named VPIN) by Easley, de Prado, and O'Hara (2012).

Easley, de Prado, and O'Hara (2012) construct a methodology that only requires a sequence of time-stamps, trade execution prices and trading volumes. By pre-defining a constant volume bucket size they subdivide the sequence of trades placed into different points of time into different volume buckets. Minute-level price variations are computed and corresponding volumes of buy-initiated and sell-initiated orders are proxied by assuming that normalized price variations follow a normal distribution. VPIN is finally computed by smoothing the trade volume-disbalance (between buys and sells) with a moving window of a fixed number of past buckets (for a detailed description of the algorithm itself see the Appendix section of Easley, de Prado, and O'Hara (2012)).

In their original work, Easley, de Prado, and O'Hara (2012) use E-mini S&P 500 futures to estimate the flow toxicity (VPIN as a proxy to indicate toxicity induced volatility).Easley, De Prado, and O'Hara (2011) also demonstrate empirically that VPIN could be used to forecast the Flash Crash that happened on May, 6th, 2010. As described by Easley, de Prado, and O'Hara (2012), the authors also argue that the cumulative distribution function of VPIN (instead of VPIN itself) has a higher explanatory power to indicate ex-ante when the higher level of toxicity may lead to a market crash in a future time. Easley, De Prado, and O'Hara (2011) propose that VPIN can be used by market makers to anticipate unexpected rises in volatility, i.e., as a tool for risk management and control. Even for hedging purposes, the authors suggest that a derivative contract on VPIN can make market makers (expectedly liquidity providers) less likely to become liquidity takers.

The purpose of the present work is to investigate the effects on the usual levels of inside trading acticity for different equities in an emerging economy given a quasi-exogenous event. Inside trading is measured by VPIN, both for index level and individual equities over a period of approximately 3 months of data. We focus our study on the invasion of the Crimean region of Ukraine by the Russian Army. The event is not assumed to be 100% exogenous (see the timeline of E.U vs Russia Trade Agreement, Civilian unrests, etc at Section 2). However, tensions between both countries (Russia and Ukraine) and the geopolitical implications to Global

Powers (United States and the European Union) definitely affect capital markets. Hence, as the information flow of the prospects of a war propagates in an asymmetric pattern among different market participants we investigate how inside trading evolves with the sequence of relevant news.

As most of its peers from emerging economies, the Russian market itself is significantly sensitive to some political shocks, so similar event studies can also be found in the literature. Goriaev and Sonin (2005) explore Russian market reaction to the arrest and prosecution of Khodorkovsky, the leader of Russian oil company Yukos. This arrest demonstrated the fragile nature of Russian property rights and thus was an indicator of increased political risks. Goriaev and Sonin (2005) show other oil and non-oil company stock prices react negatively to the negative news about Yukos.

The paper is organized as follows. Section 2 presents the timeline of political events that followed from the refusal of the Ukraine-European Union trade agreement by former Ukrainian president Viktor Yanukovych to the invasion of the Crimean region by the Russian Army. Section 3 describes the empirical data used to evaluate microstructure variables for Russian equities. Section 4 comprises the main results of informed trading activities for index level and individual stocks, and Section 5 concludes the paper.

2 The Crimean Crisis: a Brief Background

Crimea was politically a territory of Russia since 1783 and remained Russian until 1954 when the Soviet leader Nikita Khrushchev decided to transfer Crimea region to the Ukrainian Repiblic within USSR. Consequently Crimea remained as part of Ukraine following the collapse of Soviet Union. Both Russian and Crimean population actually criticized Khrushchev's decision - according to 2001 census 58% of this region self-identify as Russian and 71% of its population have Russian as their native language. Additionally, Crimea has a significant military and recreational value for Russian Federation.

Ukrainian civilians started protests against their president Viktor Yanukovych in Kiev during the fall of 2013 when he decided to postpone the signing of Ukraine–European Union Association Agreement in favor of another trade agreement with the Russian Federation. In February 2014 Crimea region got involved in these pro-European protests. As a reaction to these civil unrests Russia decided to begin military involvement into Crimea.

The following Table 1 outlines the sequence of important events that led to Russia's action of military intervention, starting on February 23$^{\text{rd}}$, 2014.

Table 1: Timeline of important events of the Crimean Crisis

Date	Description
February 23rd	"Euromaidan" protests started in Simferopol, the administrative center of the Crimea region. At the same time pro-Russian protests also started in Crimea. These protests gained attention from both Russian and the new Ukrainian governments.
February 24th	Some media articles reported that Russian military ships with soldiers have arrived at the Crimean coast.
February 26th	Vladimir Putin put military forces in western Russia on alert. Despite the closeness of this region to the Ukrainian border, Russian Defense Minister Sergei Shoigu stated that this drill was not linked to Ukrainian events. However he also added a separate remark that Russia is "carefully watching what is happening in Crimea".
February 28th	The airport in Simferopol was controlled by unknown military troops. These troops were wearing Russian military uniform and speaking in Russian, producing reasons to believe that Russian government has sent these military troops. However, Vladimir Putin denied that those military troops were part of the Russian Army.
March 1st	Crimean leader Sergei Aksyonov appealed to Russian president Vladimir Putin asking Russia "to provide assistance in securing peace". At the same time, Vladimir Putin formally asked the Federation Council to permit to "use the armed forces of the Russian Federation on the territory of Ukraine until the normalization of the socio-political situation in the that country".The Federation Council granted this permission several hours afterwards.
March 2nd	Ukrainian military bases in Crimea were under control of the military troops which were seen in Crimea several days before. According to some rumors Russia has sent additional military units to Crimea.
March 4th	Putin gave a command to Russian troops to end the military exercises. Additionally he stated that he is not planning any military involvement in Crimea and denied that the military troops seen in Crimea were Russian.
March 12th	Crimean parliament decides to determine Crimean status by a referendum on March 16th.
March 16th	A referendum takes place in which people vote on whether Crimea should join Russian Federation as a federal subject. 95% of voters supported the annexation of Crimea by Russia.

3 Data Description

The data used for the present paper can be classified into two groups: intraday microstructure data (TAQ for different equities traded in Russia's main exchange MCX) and firm-specific characteristics (government ownership, market capitalization, industry, number of insiders owning stocks, etc). Both TAQ and company-specific data are provided by Bloomberg. We peform an initial screening on the stocks traded at MCX Exchange: we consider the daily average liquidity of the past 30 days and filter those equities whose average liquidity (measured as of June 12th

2014) is greater than the 1,000.00 RUB threshold, which yields 161 firms.

Although market cap and trading volume are usually related in the US markets, for some emerging economies (including Russia) one must account for the fact that government equity ownership is also common (state owned firms). For this reason, a company which has a very large market cap but has a substantial (say, 98%) fraction of its equity owned by the government must have lower trading volume (as only the remainder 2% of the firm's stocks are actually traded). Therefore we perform the initial (volume) filter by keeping track of the market cap order of each firm among their peers. Excluding the few firms for which microstructure data is either incomplete or not available [1] we obtain a sample of 161 Russian equities.

Industry classification is also considered (obtained firm-by-firm from Bloomberg and Yahoo Finance). Since most of the firms comprising the Russian stock market are either Energy or Commodities (Metals) firms we simply clusterize industry classification as three groups ("Energy", "Metals" and "Others").

As later described by subsection 4.4, we also collect intraday data for foreign Depositary Receipts (mainly in the European Union or London) to compare potential differences on the informed trading levels between two securities traded in different markets but claiming payment rights on the same firm.

In order to keep time consistency the time-stamps considered for the remainder of this paper will be the US Eastern Standard Time (EST) regardless of what market the security is actually traded. For example, during the period from January 6$^{\text{th}}$ (the first trading day in Russia after its national holidays), 2014 to April 4$^{\text{th}}$, 2014 the Russian market opens at 9:30AM (local time) with the first auctions and closes 7:00PM (also local time). Because of the daylight savings on March 9$^{\text{th}}$ inthe US[2] our time stamps seen in EST ranges from 00:30AM to 10:00AM from January 9$^{\text{th}}$ to March 7$^{\text{th}}$ and shifts from 01:30AM to 11:00AM starting on March 11$^{\text{th}}$

4 Results

We start our analysis by computing and populating VPIN time series for RTS index level (with index futures contracts) and for the individual stocks which were obtained by the screening process described by Section 3. The algorithm used to compute VPIN follows the exact procedure described by the supplementary section of Easley, de Prado, and O'Hara (2012), requiring as inputs just a sequence of tuples (time stamp, volume and price) associated to trades. In accordance with their original work, we also define the standard volume-bucket size for each underlying (index and individual stocks) as being one fifth of the average daily volume of the corresponding security.

Mid-quotes are also computed and considered as a proxy for the underlying price. As a proxy for liquidity we also compute time series of percent quoted spreads. The next subsections comprise the main results found for index and stock level data.

4.1 RTS Index Level VPIN

RTS index consist of 50 most liquid Russian stocks, its futures are the most traded securities on the Russian Exchange. These futures were 7th in the trading volume among most traded futures and options worldwide [3]. For our analysis we look at the behavior of future contract on RTS index for January 14$^{\text{th}}$ until March 15$^{\text{th}}$.

Figure 1 shows the dynamics of the RTS index futures price and its VPIN from the 1$^{\text{st}}$ of February 2014 until the 5$^{\text{th}}$ of March 2014. The average value of VPIN for this security

[1] Bloomberg usually stores intraday data for the past 240 trading days for international markets, but data availability may vary from country to country

[2] Russia has beenabolishing its Daylights Savings since 2011 in different locations and has it completely terminated in 2014

[3] http://www.futuresindustry.org/downloads/Volume-Mar_FI(R).pdf

is around 34% and it spikes up to 54% two trading days before the market crash. Figure **??** provides more detailed graph of futures price, VPIN and its CDF around the event. The CDF was estimated based on the empirical values of VPIN from the 1st of Februrary til the 15th of February, and the intuition behind this measure is a probability that VPIN level is lower than its current value. Easley, de Prado, and O'Hara (2012) argue that CDF values higher than 0.9 are a strong signal for suspicious market conditions. Figure 2 displays that CDF level was higher that 0.9 most part of two previous days.

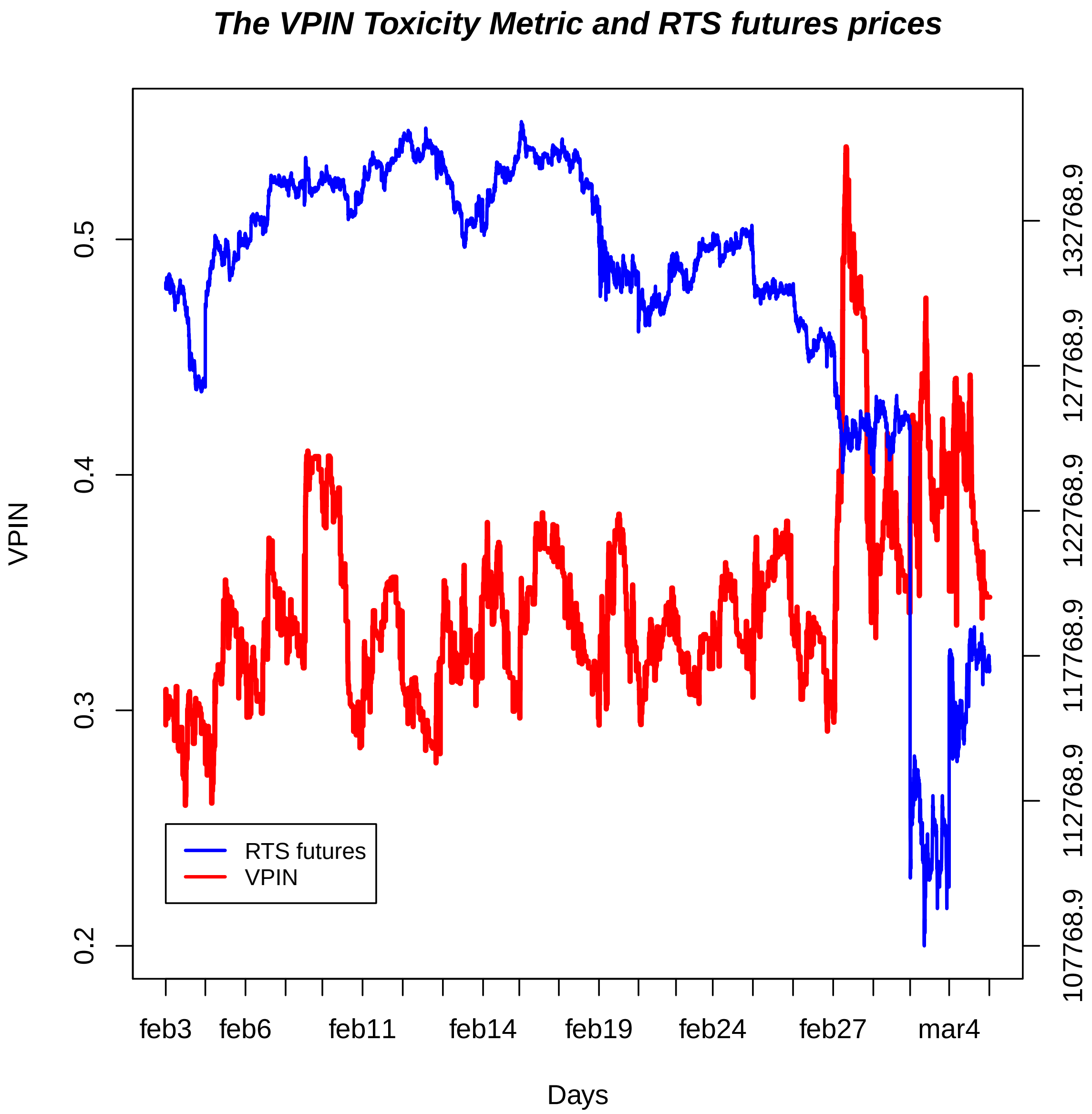

Figure 1: Informed Trading Measures for RTS futures between 02-01-2014 and 03-05-2014. The red line corresponds to VPIN values and blue line corresponds to the RTS futures prices

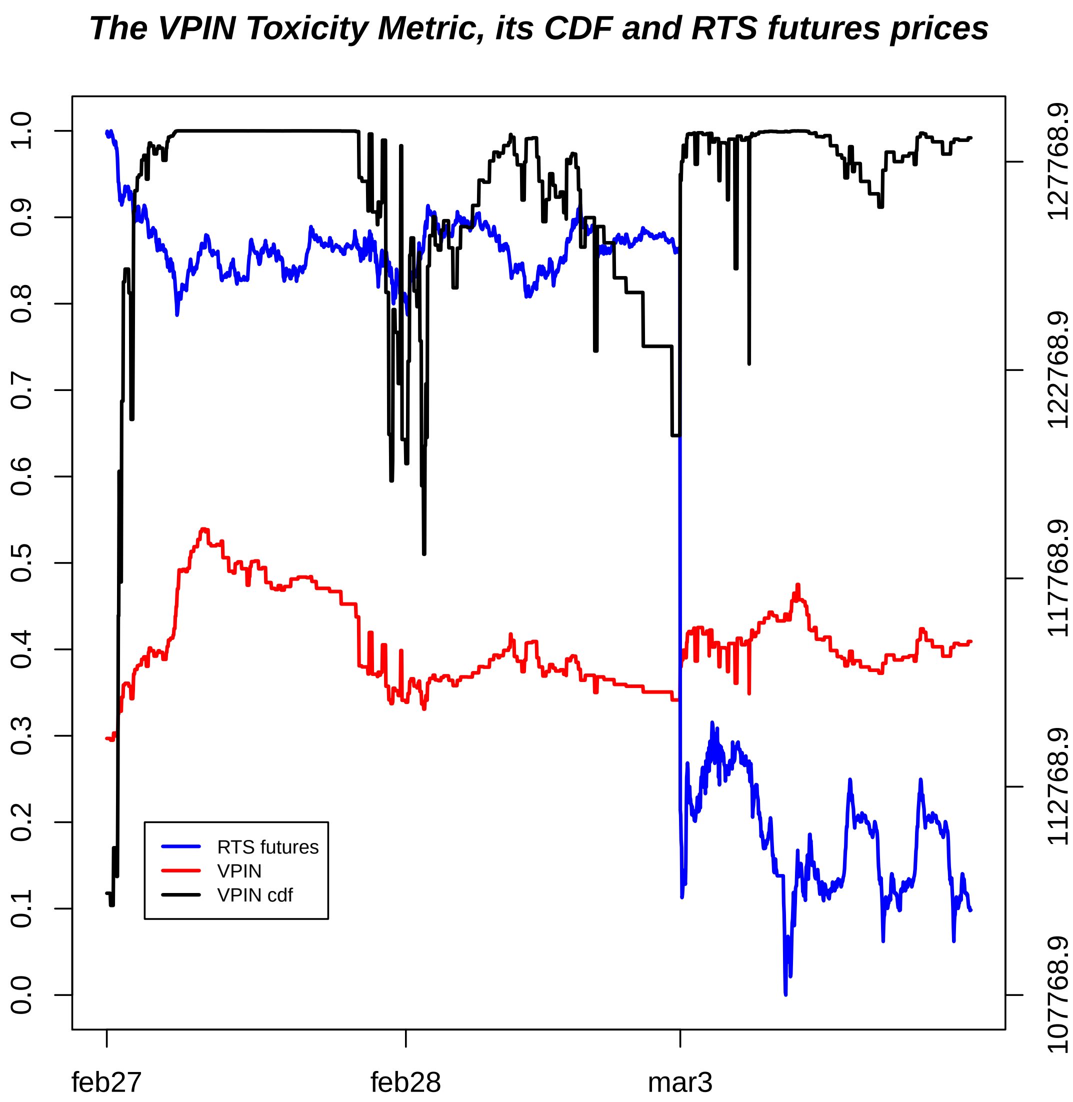

Figure 2: Informed Trading Measures for RTS futures between 02-01-2014 and 03-05-2014. The red line corresponds to VPIN values and blue line corresponds to the RTS futures prices. Black line shows the level of VPIN's CDF calculated based on the time interval from 02-01-2014 to 02-15-2014

4.2 Cross sectional VPIN

As shown in subsection 4.1, for index level data VPIN (and its CDF) can be used as a proxy of unusual informed trading activity and its jump anticipates the market effects of an extreme left-tail return by the market opening on March 3rd 2014, which is a direct effect of the Crimean invasion and the prospects of a war between two countries. The economic intuition of selling the Russian equity index by informed investors relies on the fact that a war would affect the whole economy of Russia (and other countries as well). Additionally, trading the index itself has advantages for informed traders since its liquidity is larger than trading volume of individual stocks.

However, results shown at Figures 1 and 2 raise the following question: can informed traders also use individual equities to trade on the (private) information of the (future) Crimean invasion? Moreover, are they able to select what stocks would be more affected (market value losses) by the outcomes of a war (costs, sanctions from Western powers, etc).? Indeed, Figures 3, 4, 5 and 6 illustrate similar patterns of VPIN peaks (and peaks of its CDF) few days before the market opens on March 3rd 2014 [4].

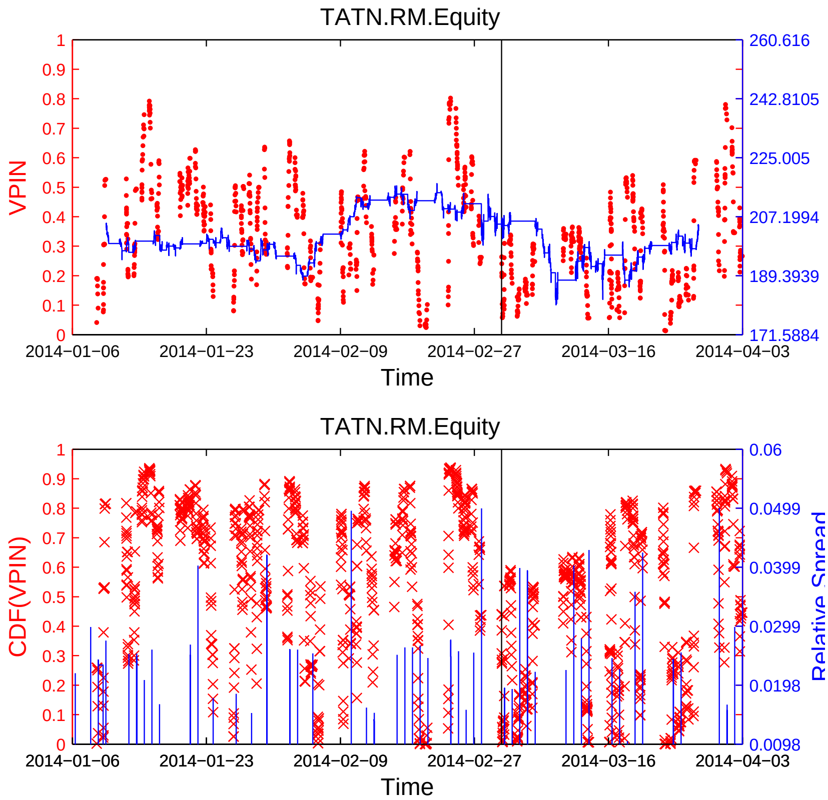

Figure 3: Informed Trading Measures for TATN between 01-06-2014 and 03-04-2014. The upper plot shows corresponding values of VPIN (red) and midquote prices (blue). The lower plot illustrates the evolution of relative (quoted) spreads (red) and the CDF of VPIN (blue).

In order to perform an experiment to potentially verify whether higher VPIN (or CDF(VPIN)) peaks are associated with worse (more negative) returns on March 3th we restrict our attention to the top 100 average trading volume firms. As liquidity is a factor that affects probability of informed trading (as shown by Duarte and Young (2009)), one must control for it in order to compare (mostly negative) market returns and prior VPIN levels. Table 3 shows a summary of the number of firms according to different characteristics. We consider four "clusters" of government ownership levels: low ($\leq 0.5\%$), moderate ($0.5\% - 50\%$), high ($50\% - 85\%$) and very high ($\geq 85\%$)

[4] Figures 3, 4, 5 and 6 are presented just as a sample of VPIN evolutions. Similar patterns are also found for other stocks. Usually the peaks of VPIN and CDF(VPIN) happen on Feb 27th, which is two trading days before Mar ^{3th}

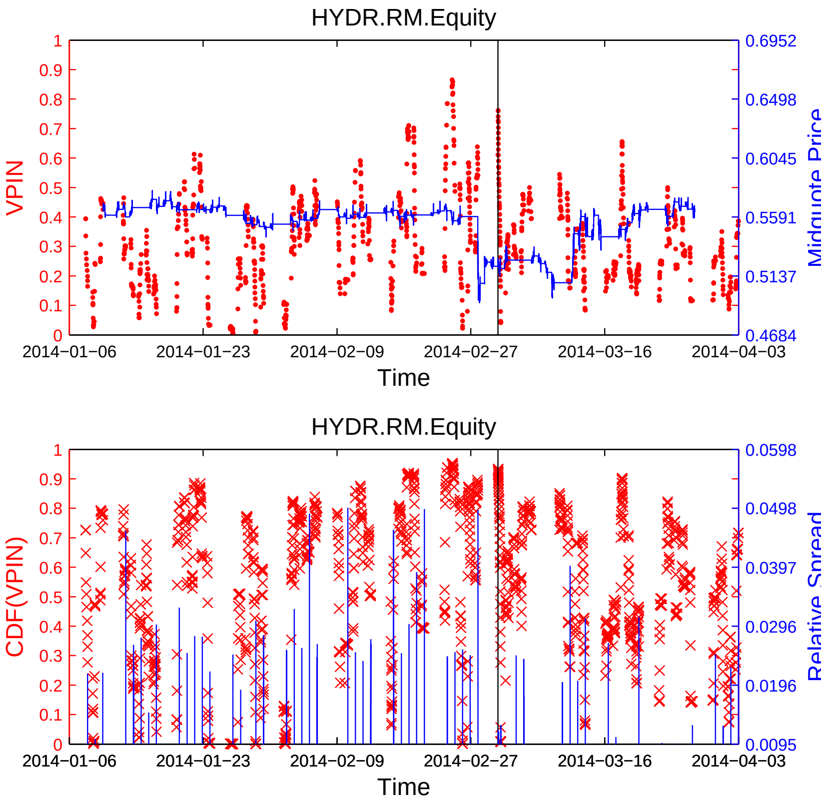

Figure 4: Informed Trading Measures for HYDR between 01-06-2014 and 03-04-2014. The upper plot shows corresponding values of VPIN (red) and midquote prices (blue). The lower plot illustrates the evolution of relative (quoted) spreads (red) and the CDF of VPIN (blue).

Table 2: Firm characteristics of the top 100 trading volume equities

Government ownership	Low ($\leq 0.5\%$)	Moderate ($0.5{-}50\%$)	High ($50-85\%$)	Very High ($\geq 85\%$)
	54	14	20	12
Industry classification		Energy	Metals	Other
		48	13	39
Insiders owning stocks			No	yes
			35	65

The economic intuition suggests that firms with more government ownership are more subject to corruption and, therefore, informed trading activities expectedly would be higher [5]. For similar reasons the report of insiders to the firm (managers) owning stocks may yield higher informed trading levels [6].

By using the computed time series of VPIN (and their cumulative distribution) for the

[5] According to Transparency International Russia scored 28 out of 100 on its 2013 Corruption Perceptions Index (lower values means higher corruption perception), which corresponds to a rank of 127 out of 177 countries (rank 1 being the less corrupt).

[6] Although the actual number of insiders owning stocks is provided by Bloomberg we simply create clusters based on the binary observation of a firm having or not insiders owning stocks.

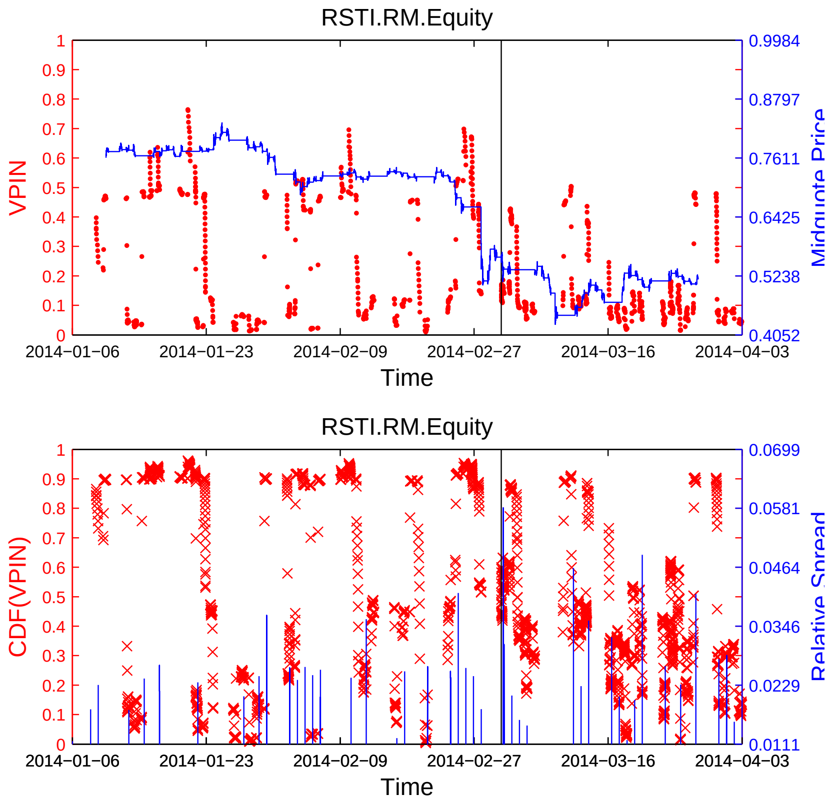

Figure 5: Informed Trading Measures for RSTI between 01-06-2014 and 03-04-2014. The upper plot shows corresponding values of VPIN (red) and midquote prices (blue). The lower plot illustrates the evolution of relative (quoted) spreads (red) and the CDF of VPIN (blue).

subset of 100 firms it is possible to compare how their peaks (measured for the interval of 10 trading days before the opening time of March 3rd) are distributed within different groups. Figures 7, 8 and 9 respectively illustrate the distributions of informed trading peaks for different categories of government ownership, different industries and the presence (or not) of insiders owning stocks.

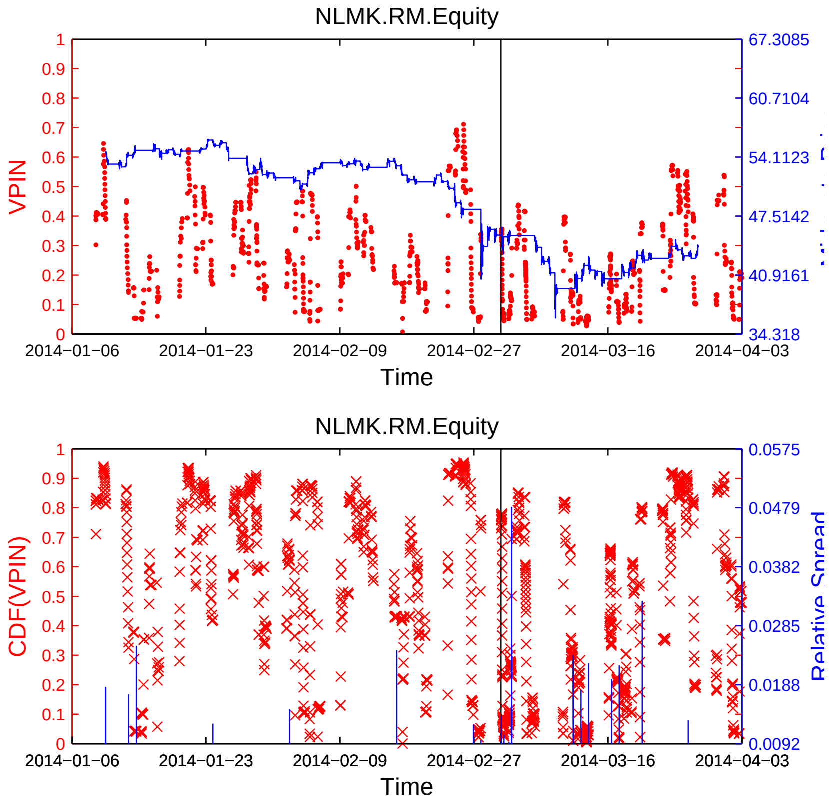

Figure 6: Informed Trading Measures for NLMK between 01-06-2014 and 03-04-2014. The upper plot shows corresponding values of VPIN (red) and midquote prices (blue). The lower plot illustrates the evolution of relative (quoted) spreads (red) and the CDF of VPIN (blue).

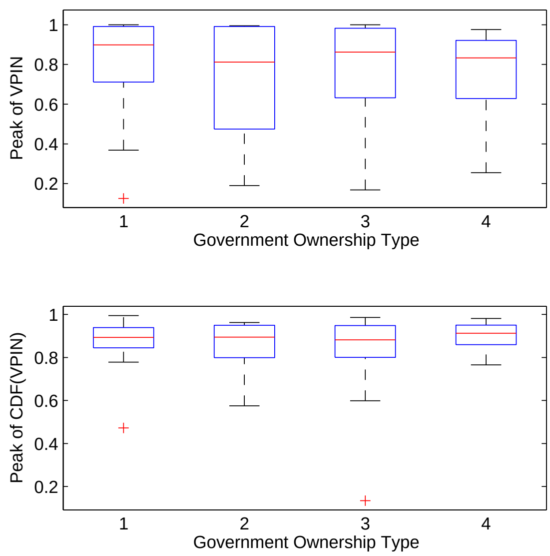

Figure 7: Box-plot of VPIN (upper plot) and CDF(VPIN) (lower plot) for different categories of Government ownership: 1-low ($\leq 0.5\%$); 2-moderate ($0.5\% - 50\%$); 3- high ($50\% - 85\%$) and 4-very high ($\geq 85\%$).

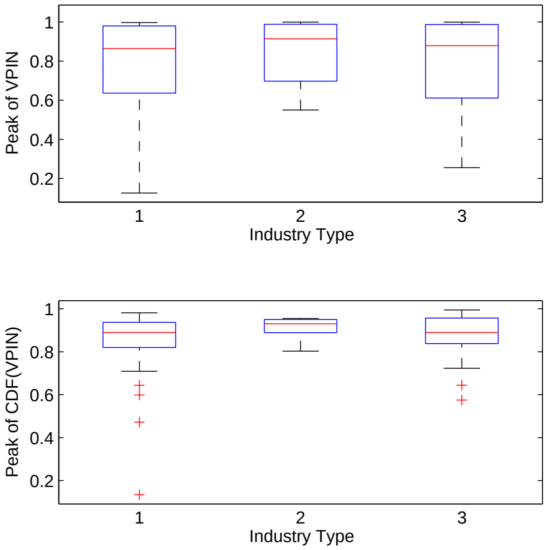

Figure 8: Box-plot of VPIN (upper plot) and CDF(VPIN) (lower plot) for different industry categories: 1-Energy; 2-Metals; 3-Other.

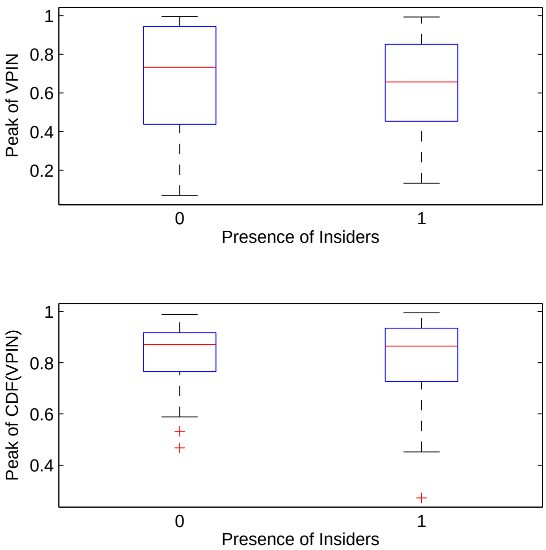

Figure 9: Box-plot of VPIN (upper plot) and CDF(VPIN) (lower plot) for: 1-With insiders owning stocks; 2-Without insiders owning stocks.

Although individually studying each variable doesn't provide any supporting evidence of the hypothesis of higher VPINs being associated with presence of insiders and higher government ownership, such results are consistent with the specific type of geopolitical event we analyze. A possible war between Russia and Ukraine would likely affect the whole economy of both countries as opposed to only specific firms. Additionally, presence of insiders (e.g. executives) owning stocks can imply higher VPINs only for firm-idiosyncratic events (e.g. earnings announcements, frauds, results of government auctions, lawsuit settlements, etc), not for a market-wise "exogenous" shock. Finally but not less importantly, government ownership may imply higher market losses as a second degree effect from the possible sanctions imposed on Russian government officials or financial constraints due to war costs. However, there is no economic reasoning for why these effects could significantly influence market cap losses as the invasion takes place.

These preliminary observation supports the hypothesis that informed investors may specifically evaluate which individual equities (based on the idiosyncratic characteristics of firms) are more likely to be negatively affected by the possibility of a war when they decide to select the firms to trade. As informed traders use their information advantage to benefit from the invasion, liquidity is definitely an important variable to be taken into account. Therefore we control for liquidity by using the average relative (quoted) spreads of each of the 100 stocks and constructing deciles of liquidity, with "1" representing the decile of the more liquid (lowest spread) firms.

Table 3: Firm characteristics of the top 100 trading volume equities

	Deciles									
	1	2	3	4	5	6	7	8	9	10
Number of firms	10	10	10	10	10	10	10	10	10	10
Number of energy firms	5	3	5	3	6	1	6	8	3	8
Number of metal firms	1	5	1	1	0	2	1	1	0	1
Average spread (%)	0.062	0.099	0.216	0.520	0.966	1.310	1.686	3.198	5.815	13.99
% Government ownership	34.00	30.90	45.84	10.35	60.98	26.50	12.58	17.03	9.224	15.04
Number of firms with insiders	10	10	10	6	5	5	7	7	3	3

Figure 10 shows how the (mostly negative) market returns are distributed for different spread deciles. The relative variety of returns within each decile and a non-monotonic pattern of average intra-decile return and deciles from 1 to 10 indicate that liquidity itself doesn't seem to be the determinant factor to explain cross-sectional differences on market returns on the day of the event.

We also verify how the peaks of VPIN and its CDF vary among different spread buckets as illustrated by Figure 11. Lower values of VPINs for higher liquidity (smaller spreads) buckets are consistent with the empirical results found for other equity markets. For the less liquid stocks, trading volume is irrelevant in a way that the VPIN measures themselves become statistically meaningless.

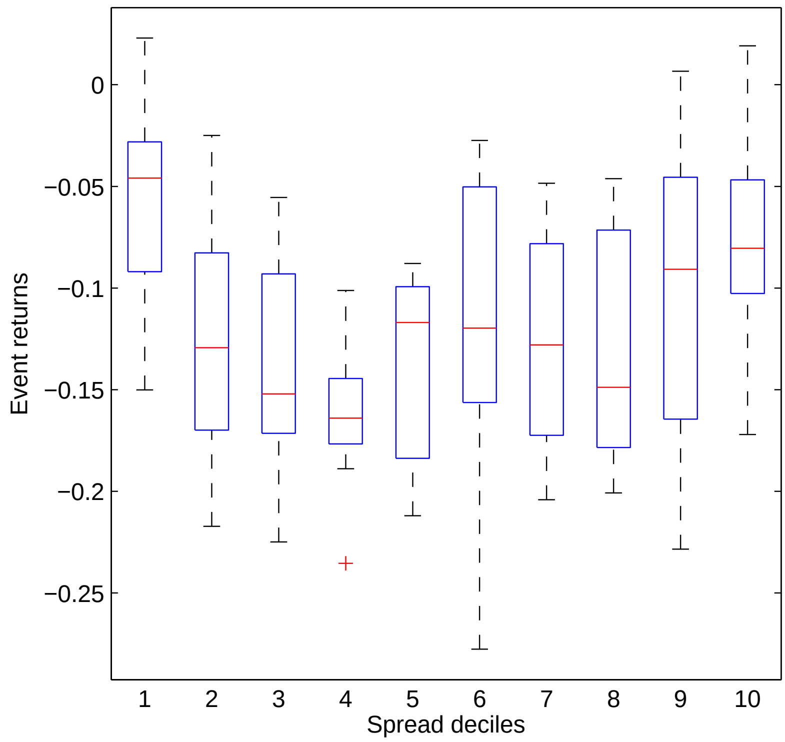

Figure 10: Box-plot of event returns (measured as the market return of the stock price between the closing time of Feb 28$^{\text{th}}$ and the closing time of Mar 3$^{\text{rd}}$) for different liquidity (spread) deciles.

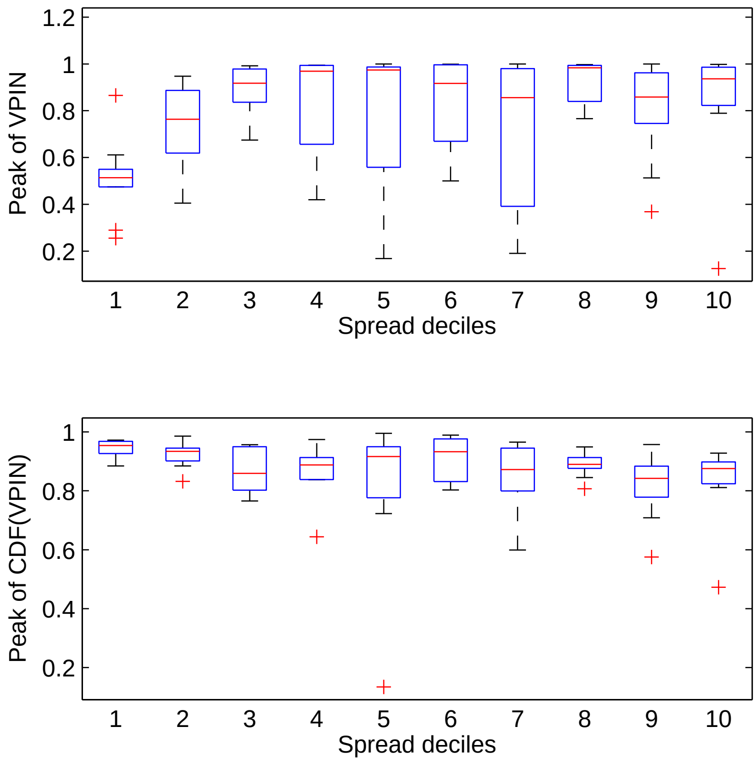

Figure 11: Box-plot of peaks of VPIN and its CDF (measured within a time window of 4 trading days prior to the event) for different liquidity (spread) deciles.

Preliminary observations of the cross-sectional characteristics of the firms within spread deciles therefore show that higher VPIN forecasts lower returns, support the proposed experiment to verify whether informed traders can indeed forecast which firms would loose more market value as the market crashes. For each of the 10 deciles we sort the ten firms contained on each bucket by their market returns between February 28$^{\text{th}}$ and March 3$^{\text{rd}}$. We then select (for each decile) the top three firms with the best returns (usually this means firms with smallest losses) and the bottom three firms with the worst returns. We construct for each of threse six firms time series with the daily maximum values of VPIN[7] and take, for each day, a cross-sectional average among the top three and among the bottom three, creating a time series for the best-returning and the worst-returning firms. Figures 12, 13 and 14 illustrate these patterns for deciles 1 to 9.

We focus our attention to the lower-spread deciles, since they provide more reliable PIN measures. Plots for deciles 1, 2, 4 and 5 clearly indicate that informed trading intensities were higher for the three worst performing firms as opposed to the top performing ones.

[7]This is done by taking for each firm and each trading day the corresponding peak of VPIN within that day

Figure 12: Average daily VPIN evolution of the three best-return (blue) and the three worst-return (red) equities within each of deciles 1, 2 and 3.

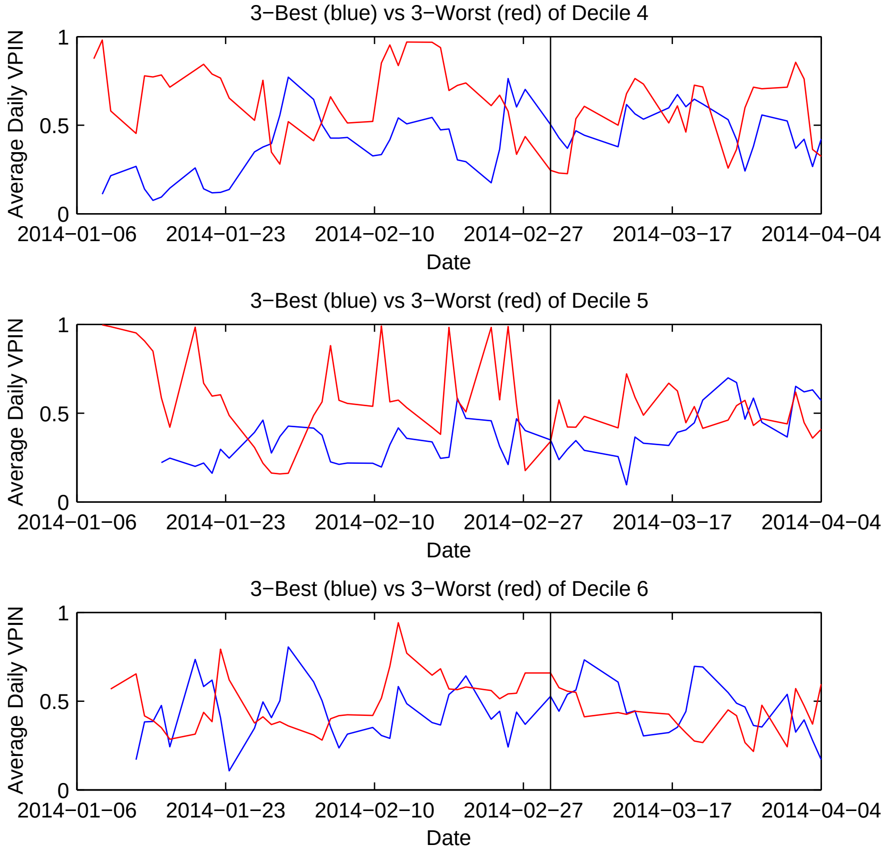

Figure 13: Average daily VPIN evolution of the three best-return (blue) and the three worst-return (red) equities within each of deciles 4, 5 and 6.

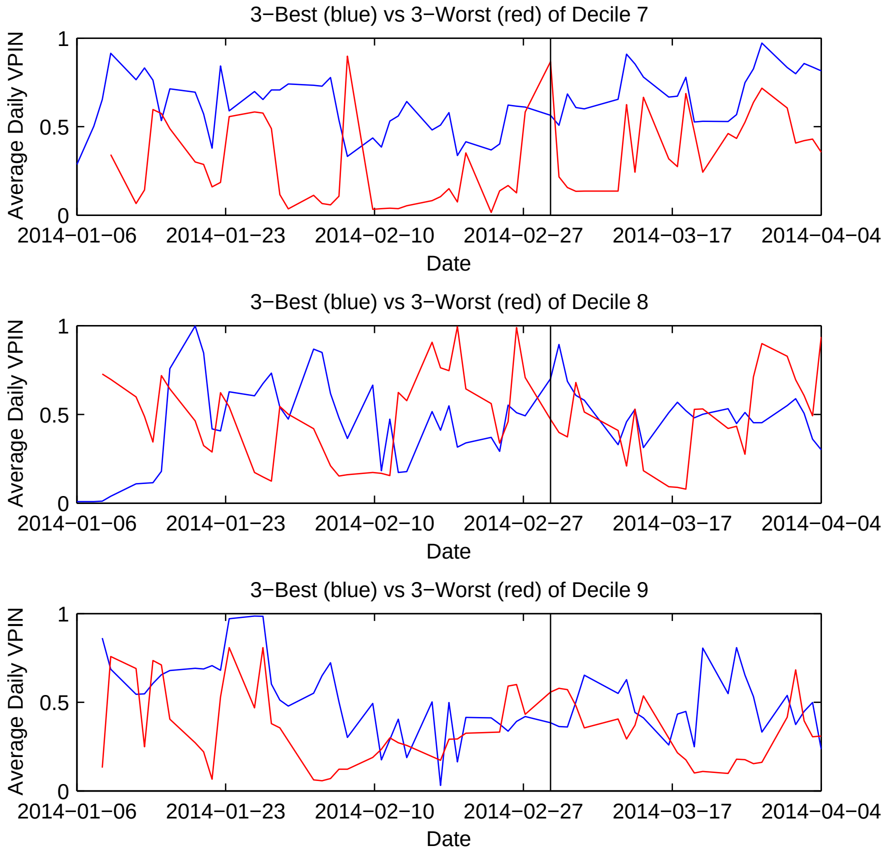

Figure 14: Average daily VPIN evolution of the three best-return (blue) and the three worst-return (red) equities within each of deciles 7, 8 and 9.

4.3 Predictive Power of VPIN Series

Previously we have shown that VPIN is able to indicate rare stock market drop for both index futures and common stocks. In this section we show that VPIN and its CDF can not only help to indentify extraordinary market conditions but they also have a predicitve power with respect to stock market returns during the whole time interval.

For this section we only pick stock for which VPIN is updated at least daily. Thus we get rid of the stock for which there was at least one day when the whole day volume does not exceed the bucket size which was used for VPIN estimation. After this filter we have a final sample of 143 stocks.

We investigated return predictability for these stocks during time interval from 1$^{\text{st}}$ of February 2014 till 1$^{\text{st}}$of April 2014. We used the following model to forecast stock returns:

$$ret_{i,t} = \alpha + \beta \cdot cdf_{i,t-1} + controls + \epsilon_{i,t} \quad (1)$$

Where $ret_{i,t}$ is a return of stock i during day t, $cdf_{i,t}$ is the maximum CDF value of stock's i VPIN duing the day t. Table 4 shows the results of such regressions. Model (1) illustrates that lad of maximum of VPIN's CDF is significantly negativelly correlated with stock returns. Model (2) controls for average value of stocks' spread during two week period before the start of our time interval which is used as a proxy of stock liquidity.

Short selling is permitted on the Russian stock market only for a subset of stocks defined by the local securities authority. At the begging of each quater Federal Financial Markets Service (FFMS) publishes a list of stocks and bonds for which short sell in allowed. Usually FFMS chooses among the most liquid traded assets for that list. Out of 143 firms in our sample 31 were cleared for short selling in the quater from January 14^{th} till March 27^{th}. For all other stocks we created no_short_i dummy and included interaction of this dummy and the one day lag of cdf into Model (3). We expected CDF to have higher predictive power for the stock with short selling option because informed traders would be able to gain on both positive and negative information assosiated with these stocks, whereas for the stocks without short sell would be possible only gain so from information about future positive news.

Model (4) controls for firm-specific fixed effects. This model shows that CDF has even more pronounced predictive power when we control for firm-specific features.

In all the models in Table 4 higher values of VPIN's CDF during the previous day indicate lower returns in the future. This corresponds with the intuition that high concentration of informed traders is negatively related to the stock market returns.

Table 4: Predictive Power of VPIN in Panel Level. This model show that maximum value of stocks VPIN's CDF during the previous day ($cdf_{i,t-1}$) has a significant forecasting power towards stocks' returns $ret_{i,t}$. This results are estimated for 143 most liquid firm which are traded on MICEX, Russian Stock Exchange during the interval from 1st of February 2014 till 1st of April 2014. Model (2) controls for the average value of relative spread during previous two weeks. In Model (3) we separate prediction for the stock which can not be short sold. In Model (4) we control for firm fixed effects

	Dependent variable:			
	$ret_{i,t}$ - Return in %			
	(1)	(2)	(3)	(4)
$cdf_{i,t-1}$	-0.369^{*}	-0.389^{*}	-0.559^{*}	-0.644^{**}
	(0.219)	(0.220)	(0.291)	(0.267)
$cdf_{i,t-1} \cdot no\_short_i$			0.212	
			(0.237)	
$spread_i$		-1.214	-1.543	
		(1.322)	(1.372)	
Fixed Effects	—	—	—	+
Constant	0.056	0.105	0.117	0.158
	(0.146)	(0.156)	(0.156)	(0.725)
Observations	5,033	5,033	5,033	5,033
R^2	0.001	0.001	0.001	0.018
Adjusted R^2	0.0004	0.0003	0.0003	-0.011
Note:		*p<0.1; **p<0.05; ***p<0.01		

Table 5 shows how forecasting power of VPIN and its CDF changes with the level of the goverment ownership. $NoGov_i$is a dummy variable for the companies whose stocks are not held by the government. $HighGov_i$ is a dummy for the companies in which goverment owns more than 90% of stocks. Models (1) to (4) in Table 5 indicate that companies with moderate amount of government ownership are more sensitive to the informed trader's activity, and so their VPIN's cdf has a stronger predicitive power. This is consistent with the intuition that independent companies without any governmet ownership have their managment more aligned with the best interests of their common shareholders. On the other hand, companies with high goverment ownership are expected to be financially backed up by the government and are therefore less prone to be affected by any adverse shock in the first place. During the bad times these companies have access to additional benefits: tax benefit, subsidized loans, ect. owing to their political connections. For instance, Igor Sechin, the chairman of Rosneft, the largest publicly traded oil company in the world, directly asked Russian government to cover their $42 billion debt[8].

Table 5: VPIN's Predictive Power and Government Ownership. This model shows that maximum value of stocks VPIN's CDF during the previous day ($cdf_{i,t-1}$) has a significant forecasting power for stocks' returns $ret_{i,t}$. These results are estimated for 143 most liquid firms which are traded on MICEX, Russian Stock Exchange during the interval from 1st of February 2014 till 1st of April 2014. $NoGov_i$ is a dummy for companies in which government does not own any shares, $HighGov_i$ is a dummy for companies where government owns more than 90% of stocks.

	Dependent variable:			
	$ret_{i,t}$ - Return in %			
	(1)	(2)	(3)	(4)
$cdf_{i,t-1}$	-0.502^{**}	-0.398^{*}	-0.551^{**}	-0.551^{**}
	(0.240)	(0.223)	(0.251)	(0.251)
$cdf_{i,t-1} \cdot NoGov_i$	0.228		0.274	0.274
	(0.193)		(0.205)	(0.205)
$cdf_{i,t-1} \cdot HighGov_i$		0.077	0.219	0.219
		(0.301)	(0.319)	(0.319)
$spread_i$	-1.647	-1.192	-1.675	-1.675
	(1.372)	(1.325)	(1.373)	(1.373)
Constant	0.119	0.105	0.122	0.122
	(0.156)	(0.156)	(0.156)	(0.156)
Observations	5,033	5,033	5,033	5,033
R^2	0.001	0.001	0.001	0.001
Adjusted R^2	0.0004	0.0001	0.0003	0.0003
Note:	*p<0.1; **p<0.05; ***p<0.01			

4.4 Informed Trading on Foreign Depositary Receipts

Although our study focuses on the cross-sectional differences within the set of Russian equities whose daily trading volume ranges from 22 billion RUB - case of Inter RAO EES (ticker IRAO) to illiquid stocks, some of the high trading volume equities in Russia also have their correspond-

[8] http://www.dw.de/russias-rosneft-pleads-for-debt-relief-amid-western-sanctions/a-17854908

ing Depositary Receipts (mainly in London or EU). As Depositary Receipts are by construction cash flow claims backed by the same firm, it raises the issue of how informed trading activities may differ between the local securities traded in Russia and its DR traded in other market.

The hypothesis that Russian domestic securities and their corresponding Global Depositary Receipts have different investor's clientele is largely suppored by the literature. Boubakri, Hamza, and Kooli (2011) show that, in general, institutional investors hold higher stakes in foreign firms that are larger, privatized, more liquid, and more transparent. They also show that mutual investors also prefer firms from countries with weaker institutional environments and a civil law legal tradition.

Zhu (2010) investigate whether regulatory and environmental charactertistics of the home country capital market (e.g. information disclosure and investor rights protection) affect ADRs cross-listed in the U.S. market. The authors find that, especially for emerging economies, less transparent disclosure, poorer investor rights' protection, and weaker legal institutions are associated with higher levels of information asymmetry (proxied by bid-ask spreads and other microstructure measures). They also use an alternative measure of informed trading intensity developed by Llorente, Michaely, Saar, and Wang (2002) to assess information asymmetry.

We create pairs of equity securities for Russian firms in our sample traded at the local exchange and their corresponding Depositary(ies) Receipt(s). For each pair we analyze how patterns of VPIN and its CDF evolve as we get close to the event date. Table 6 depicts the list of RD-Local pairs considered for the present work.

Table 6: List of Russian-Depositary Receipt pairs

Firm Name	Ticker (local)	DR Location	DR Ticker
Sberbank Rossii OAO	SBER	London	SBER
Sberbank Rossii OAO	SBER	Europe	SBER
Gazprom OAO	GAZP	London	OGZD
Gazprom OAO	GAZP	Europe	OGZD
Rosneft' NK OAO	ROSN	London	ROSN
Rosneft' NK OAO	ROSN	Europe	ROSN
Uralkaliy OAO	URKA	London	URKA
Uralkaliy OAO	URKA	Europe	URKA
Novatek OAO	NVTK	London	NVKT
Novatek OAO	NVTK	Europe	NVKT
Magnit OAO	MGNT	London	MGNT
Magnit OAO	MGNT	Europe	MGNT
RusHydro OAO	HYDR	London	HYDR
Severstal' OAO	CHMF	London	SVST
AFK Sistema OAO	AFKS	London	SSA
Novolipetskiy metallurg. komb. OAO	NLMK	London	NLMK
PhosAgro OAO	PHOR	London	PHOR
Gruppa LSR OAO	LSRG	London	LSRG

Figures 15, 16 and 17 depict how VPIN series behave respectively for Magnit, Sberbank Rossi, and Rosneft' NK. Althougth the Depositary security can show even higher peaks of probability of informed trading when compared to their Russian stocks, the points at which the peaks occur seem to be consistently (across different pairs) later than what is observed for the local market.

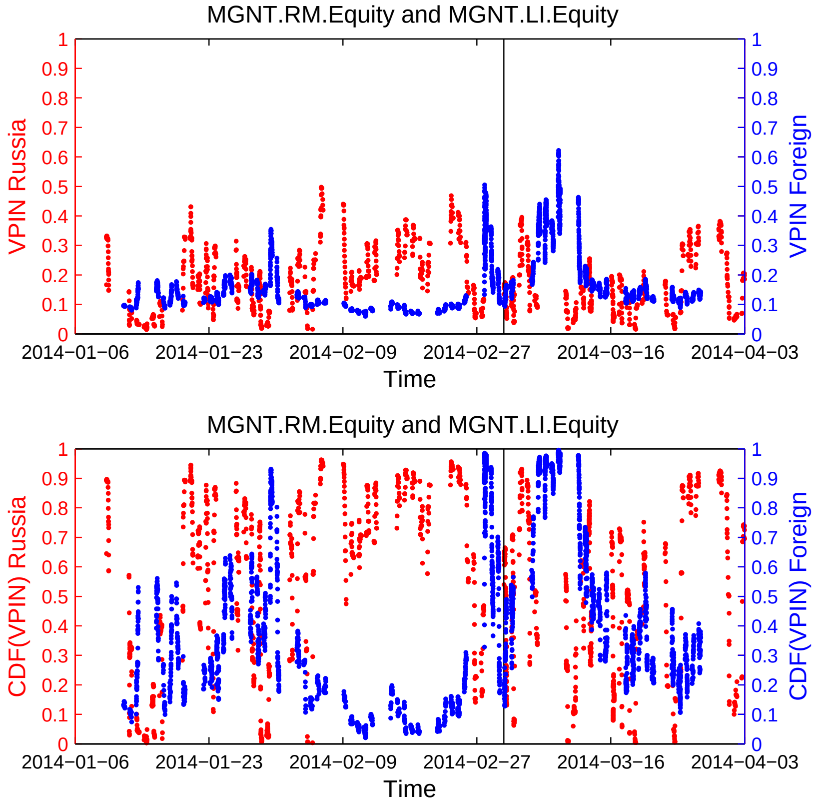

Figure 15: Plots of VPIN (top) and CDF(VPIN) (bottom) for MGNT considering the local security (red) and the corresponding receipt in London (blue).

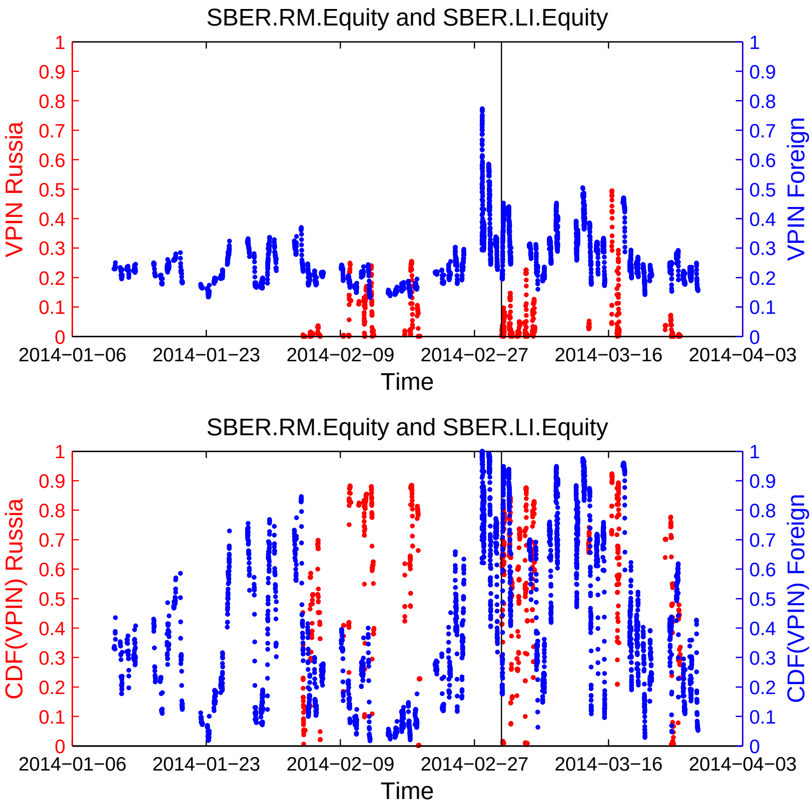

Figure 16: Plots of VPIN (top) and CDF(VPIN) (bottom) for SBER considering the local security (red) and the corresponding receipt in London (blue).

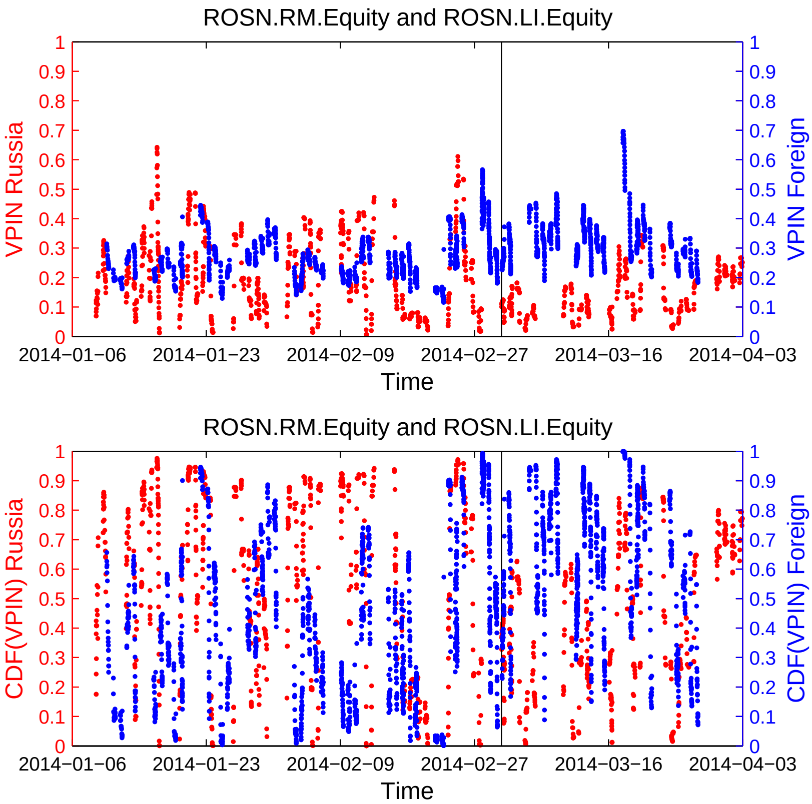

Figure 17: Plots of VPIN (top) and CDF(VPIN) (bottom) for ROSN considering the local security (red) and the corresponding receipt in London (blue).

Such patterns shed light on an interesting fact. Peaks of VPIN for the Depositary Receipt may be higher or lower than the peaks for the local securities. However, out of 18 Local-DR pairs we find that 14 of them have the corresponding VPIN peak happening earleir for the local securities than it does for the foreign market. The "time stamp" of the maximum VPIN (considering a period of 5 trading days before the event) for the foreign market happens on average 127 minutes after it spikes for the Russian market (the distribution median of the time difference is 169 minutes).

A possible explanation for such patterns is the following. Investor's clientele of foreign Depositary Receipts of Russian firms could be mainly ETFs or fund of funds that necessarily need to have a given exposure to the Russian main equities because of their portfolios' policies. On the other hand, informed investors possibly linked to Russian top government officials hold portfolios in local markets due to (lack of) transparency and regulation.

5 Conclusion

Thia paper studies the event of the Crimean-Russian crisis as a quasi-exogenous shock to provide supporting evidence that Volume-synchronized Probability of Informed Trading (VPIN) has predictive power in forecasting collapses on equity markets due to geopolitical events.

For index level data we conclude that VPIN (and its CDF) does indeed spike around two trading days before the first opening of the market after the apex of the tensions between Ukraine and Russia. This indicates that intraday data illustrates the disbalances between buys and sells due to the unusually high activity of informed traders who would profit (or avoid losses) from the event. Results for individual equities also depict similar patterns of VPIN jumps, with results being higher (although not significantly) for those stocks that had the worst losses on the event day.

We also analyze the overall forecasting power of a one-day lagged CDF(VPIN) peak and the subsequent return of the corresponding stock in a panel data model demonstrating that higher values of daily CDF(VPIN) peaks have predictive power associated to negative returns. Such observation is more significant for firms with no government ownership as well as those for which short selling is allowed.

Finally we compare how informed trading activity may vary fortwo different securities (local stock and Depositary Receipt) of same companies, showing that VPIN usually reaches its event-related maximum for the Russian-traded security before it does for the Foreign receipt.

Since VPIN itself can be considered as a measure of flow toxicity, Easley, De Prado, and O'Hara (2011) propose the creation of a "VPIN" contract to allow for market participants to monitor, hedge (or even speculate) on the level of informational asymmetry. Results of our paper collaborate with their views since the "creation" of Russian VPIN contracts (as for other markets as well) would allow investors to hedge againts informed traders, which could potentially increase the size of capital markets in Russia and enhance the level of international diversification of global funds.

If adopted for US markets (example of the Flash Crash studied by Easley, De Prado, and O'Hara (2011)) could be used by Exchanges and Government Agencies to montor the risks of a Flash Crash among other undesirable events associated to increasing toxicity on the order flow. Given the different nature of the event study we focus our analysis, an analog "Russian VPIN contract" could be seen as a monitoring tool for global leaders (governments, the UN, Treaty Organizations, etc) to forecast when unexpected geopolitical problems are likely to occur.

References

Daron Acemoglu, Simon Johnson, Amir Kermani, James Kwak, and Todd Mitton. The value of connections in turbulent times: evidence from the united states. Technical report, National Bureau of Economic Research, 2013.

Yakov Amihud and Avi Wohl. Political news and stock prices: The case of saddam hussein contracts. *Journal of banking & Finance*, 28(5):1185–1200, 2004.

Warren Bailey and Y Peter Chung. Exchange rate fluctuations, political risk, and stock returns: some evidence from an emerging market. *Journal of Financial and Quantitative Analysis*, 30 (04):541–561, 1995.

Narjess Boubakri, Olfa Hamza, and Maher Kooli. Institutional investors' participation in foreign firms: Evidence from adrs. *International Finance Review*, 12:145–168, 2011.

Jefferson Duarte and Lance Young. Why is pin priced? *Journal of Financial Economics*, 91 (2):119–138, 2009.

David Easley and Maureen O'Hara. Information and the cost of capital. *The journal of finance*, 59(4):1553–1583, 2004.

David Easley, Nicholas M Kiefer, Maureen O'Hara, and Joseph B Paperman. Liquidity, information, and infrequently traded stocks. *The Journal of Finance*, 51(4):1405–1436, 1996.

David Easley, Soeren Hvidkjaer, and Maureen O'Hara. Is information risk a determinant of asset returns? *The journal of finance*, 57(5):2185–2221, 2002.

David Easley, Soeren Hvidkjaer, and Maureen O'Hara. Factoring information into returns. 2010.

David Easley, MM Lopez De Prado, and Maureen O'Hara. The microstructure of the flash crash: Flow toxicity, liquidity crashes and the probability of informed trading. *Journal of Portfolio Management*, 37(2):118–128, 2011.

David Easley, Marcos M López de Prado, and Maureen O'Hara. Flow toxicity and liquidity in a high-frequency world. *Review of Financial Studies*, page hhs053, 2012.

Eugene F Fama and Kenneth R French. The cross-section of expected stock returns. *the Journal of Finance*, 47(2):427–465, 1992.

Bruno S Frey and Marcel Kucher. History as reflected in capital markets: the case of world war ii. *The Journal of Economic History*, 60(02):468–496, 2000.

Alexei Goriaev and Konstantin Sonin. Is political risk company-specific? the market side of the yukos affair. 2005.

Charles Lee and Mark J Ready. Inferring trade direction from intraday data. *The Journal of Finance*, 46(2):733–746, 1991.

Andrew Leigh, Justin Wolfers, and Eric Zitzewitz. What do financial markets think of war in iraq? Technical report, National Bureau of Economic Research, 2003.

Guillermo Llorente, Roni Michaely, Gideon Saar, and Jiang Wang. Dynamic volume-return relation of individual stocks. *Review of Financial studies*, 15(4):1005–1047, 2002.

Qiaoqiao Zhu. The home stigma: Adverse selection in adrs and the home capital market environment. In *2012 Financial Markets & Corporate Governance Conference*, 2010.