

# University of Toledo Data Science Seminar

## Measuring Information Asymmetry in Event Time

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# Areas of Finance

## Asset Pricing

- Defining Investor Risk
- Investor Decisions
- Pricing Information
- Market Microstructure

## Corporate Finance

- Management Decisions:  
(Capital Structure, M&A, Dividends, Investment...)
- Banks and other Financial Intermediaries
- Corporate Governance

# Computational Tools

## Programming Tools

- R: doParallel, doRedis, data.table, foreach, ggplot2, RSQLite
- Python: pandas
- Stata
- Command Line: awk, sed, and rsync
- Control: ssh, mosh, and tmux

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## Hardware

- Rebuilt email servers
- HPC assets
- Windows Workstations

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## Storage

- Drobo file server (used hard drives)
- Google Drive (unlimited)
- BitTorrent Sync

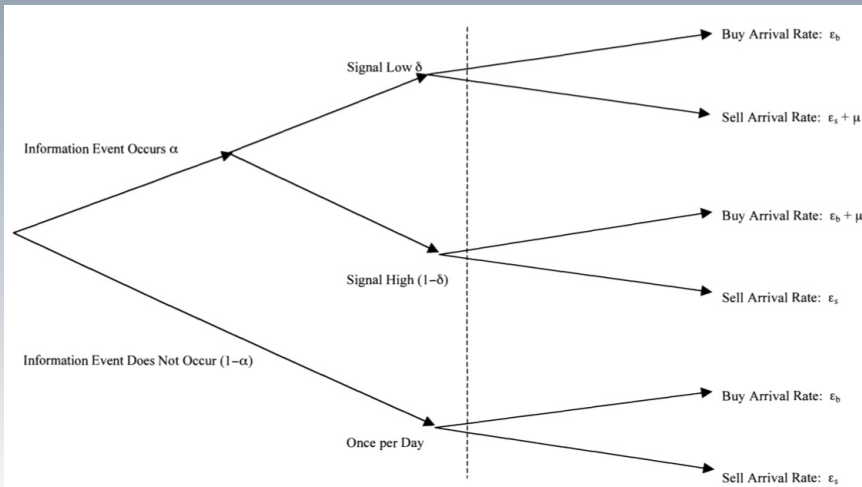
# The Big Picture

Adverse Selection Risk is part of the required return on equity

Market Microstructure affects pricing on longer horizons

Informed trading reduces abnormal returns

# Original Probability of Informed Trading (PIN)



# Volume Synchronized Probability of Informed Trading (VPIN)

## Stochastic Clock

- Mandelbrot (1963 and 1973), Clark (1973), Ane and Geman (2000)



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- VPIN (2011) Journal of Portfolio Management
- The CDF of VPIN predicts flash crash events (2012) RFS
- Bulk Volume Classification (2015) JFE

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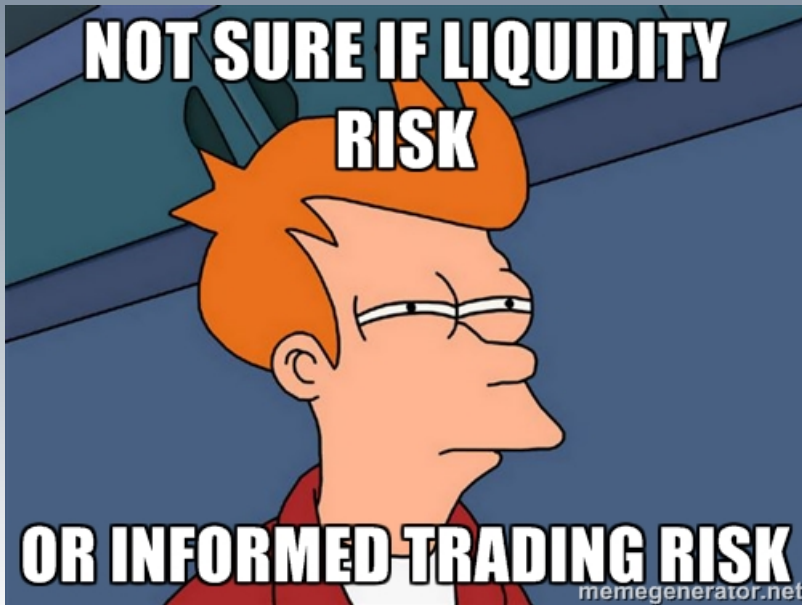
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- VPIN is correlated with volume and volatility
- VPIN does not predict volatility or flash crashes

## Duarte and Young (2009)

- Journal of Financial Economics
- PIN is priced because of liquidity



# Contribution

## The Takeaway

- First large sample test of the VPIN factor
- Signed VPIN is a priced risk

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## Overview

- Calculate VPIN for 20,399 stocks over 21 years
- Volatility Predictability
- Test decile portfolios and long/short portfolios
- Average annualized 5 factor abnormal return of 17.34%
- Annualized Information Ratio of 1.65

# Correlations with VPIN - Time Subsets

Average five-year correlations with VPIN are weighted by market value and statistical significance is tested in the cross section.

Panel A uses the VPIN measure where all estimates are significant at the 1% level with the exception of Implied Volatility in 2003-2007 period. Panel B uses the signed VPIN measure where all estimates are significant at the 1% level.

Panel A

Metric	Entire Sample	Normal Period	Recession	1993-1997	1998-2002	2003-2007	2008-2012
Return	-0.0017	0.0561	-0.1724	0.0327	0.0171	0.0088	-0.0737
Volume	-0.1695	-0.1387	-0.2515	-0.1153	-0.1084	-0.1807	-0.1542
Amihud Illiquidity	-0.0010	-0.0123	0.1601	0.1204	0.0176	0.0453	-0.0102
Implied Volatility	-0.0812	-0.0386	-0.0884	0.1057	0.0323	<i>0.0012</i>	-0.1841
Historic Volatility	-0.0384	0.0264	-0.0884	0.1140	0.0352	-0.0195	-0.0975
Volatility Premium	-0.0311	-0.0965	0.0607	-0.0503	-0.0189	0.0192	-0.0612
OTM-ATM Volatility Spread	-0.0229	0.0089	-0.0899	-0.0237	-0.0119	0.0111	0.0164
Put-Call Parity Spread	-0.1609	-0.1552	-0.1982	-0.1404	-0.1100	-0.1479	-0.2367

Panel B

Metric	Entire Sample	Normal Period	Recession	1993-1997	1998-2002	2003-2007	2008-2012
Return	0.6140	0.6288	0.6588	0.6866	0.6607	0.6258	0.6272
Volume	-0.0567	-0.0850	-0.0733	0.0383	0.0252	-0.0545	-0.0264
Amihud Illiquidity	0.1087	0.1295	<i>-0.0064</i>	0.2579	0.0987	0.2379	0.0249
Implied Volatility	-0.0718	-0.0840	-0.3170	-0.0302	-0.0833	-0.0451	-0.1423
Historic Volatility	-0.0228	-0.0314	-0.2436	0.0405	-0.0268	0.0256	-0.0670
Volatility Premium	-0.0476	-0.0477	0.0378	-0.0714	-0.0273	-0.0748	-0.0543
OTM-ATM Volatility Spread	0.1027	0.0987	0.0500	0.1608	0.1133	0.1279	0.1118
Put-Call Parity Spread	-0.1609	-0.1552	-0.1982	-0.1404	-0.1100	-0.1479	-0.2367

# Characteristic Regression

We regress firm characteristics on the VPIN measure to look for contemporaneous joint relationships between VPIN and firm characteristics. Volume is scaled to billions of shares and Size is measured in millions of dollars.

Characteristic	VPIN (1)	VPIN (2)	Signed VPIN (1)	Signed VPIN (2)
CAPM Beta	0.0276***	0.0179***	-0.0003***	0.0003*
	141.7161	71.9802	-4.2735	2.2801
Size	0.0845***	0.0554***	0.0034***	0.0034***
	547.7554	219.9314	66.3472	28.1750
BTM	0.0000	-0.0000	-0.0000	-0.0000
	1.2196	-0.6589	-1.6094	-0.2494
MOM	-0.0098***	-0.0082***	0.0058***	0.0071***
	-55.4193	-37.7720	98.9195	66.9152
LIQ Gamma	1.3097	-5681.2845***	8.5075	1182.5707
	0.0199	-3.2284	0.3877	1.3905
Historic Vol.		0.0398***		-0.0160***
		48.5703		-40.3818
Vol. Premium		0.0284***		-0.0186***
		26.0020		-35.2945
Amihud Illiq.	-0.3578***	-26.5537***	0.0366***	3.1206***
	-26.0827	-89.4212	8.0203	21.7450
Volume	-4.5264***	-4.5042***	-0.8986***	-0.4313***
	-31.0767	-32.0251	-18.6014	-6.3455
Obs	574,599	262,325	574,455	262,325
Adj. R <sup>2</sup>	0.3664	0.2120	0.0270	0.0366



# Intraday Volatility Prediction

We test whether VPIN predicts intraday volatility. We use daily observations and all explanatory variables are lagged by one trading day. Firm size is measured as the log of market capitalization in millions of USD. Volume is measured as billions of shares.

Variable	Intraday Volatility <sub>t+1</sub>			
Intraday Volatility	0.4617***	0.4801***	0.4617***	0.4803***
	1535.1584	2715.2458	1534.9396	2716.4530
VPIN	0.2968***	0.2942***		
	68.0633	124.2051		
VPIN CDF			0.0804***	0.0565***
			49.3573	65.0641
Historic Volatility	0.3328***		0.3433***	
	149.9271		155.1612	
Volatility Premium	0.2422***		0.2496***	
	92.2810		95.2144	
Size	-0.0200***	-0.0442***	-0.0037***	-0.0245***
	-26.3811	-124.6536	-5.2381	-78.7909
Volume	0.0466	1.5574***	0.0528	1.5361***
	0.6142	27.5668	0.6953	27.1704
Illiquidity	190.0629***	5.0753***	150.4778***	5.1293***
	5.3644	13.1932	4.2474	13.3303
Obs	8,715,068	24,358,080	8,715,068	24,358,080
Adj. R <sup>2</sup>	0.2202	0.2337	0.2200	0.2333



# Fama-Macbeth Regressions - Signed VPIN Factor

Factor	Full Sample	Normal	Recession	1998-2002	2003-2007	2008-2012
Alpha	0.0079	0.0442**	-0.2223***	0.0107	0.0124	-0.0046
	0.3267	1.9658	-2.2375	0.2193	0.3845	-0.0910
MRP	0.0331	0.0207	0.0795	0.0116	0.0152	0.0450
	1.1376	0.7521	0.6168	0.1877	0.5746	0.6973
SMB	0.0037	0.0089	-0.0410	-0.0527	0.0331*	0.0201
	0.2019	0.4353	-1.1868	-1.0083	1.7221	1.0811
HML	0.0839***	0.0760***	0.1482**	0.0892	0.1137***	0.0588**
	3.8050	3.2141	2.3957	1.3670	6.8423	2.5071
UMD	-0.0029	0.0050	-0.0217	0.0483	0.0101	-0.0651*
	-0.1726	0.3011	-0.3305	1.3249	0.5162	-1.8819
LIQ	0.0875***	0.0789***	0.1534***	0.0519**	0.1631***	0.0755
	6.6687	5.8704	3.4713	2.0356	11.5378	2.8327
SVPIN	0.0618***	0.0565***	0.0890*	0.0659*	0.0643***	0.0558**
	4.5372	4.0540	1.8006	1.8720	5.9901	2.3203

# Monthly VPIN Deciles

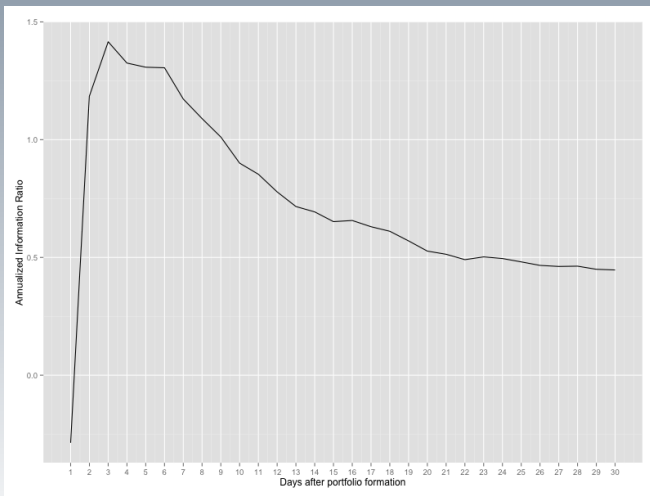
VPIN Value-weighted Monthly Deciles

Factor	Decile 1	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10
Alpha	0.0020**	0.0026**	0.0026***	0.0013	0.0023*	0.0008	0.0008	-0.0004	-0.0003	0.0001
	2.1991	2.4961	2.8467	0.9282	1.7855	0.7491	0.8673	-0.4086	-0.3458	0.2059
MRP	0.3486***	0.4908***	0.5764***	0.7816***	0.7589***	0.8214***	0.8870***	0.9678***	0.9847***	1.0448***
	15.5676	20.6046	25.9482	25.1322	25.2913	33.3847	40.3543	45.8526	55.0188	66.2287
SMB	0.2066***	0.2995***	0.3041***	0.2780***	0.2328***	0.2455***	0.2310***	0.1906***	0.1237***	-0.1006***
	7.8120	9.7939	10.7497	7.0960	6.0693	7.5451	8.1675	7.0088	4.9963	-5.0829
HML	0.2344***	0.3245***	0.3127***	0.4492***	0.3412***	0.3295***	0.2768***	0.1554***	-0.0358	0.0200
	8.0372	10.3181	10.5092	10.8357	8.4683	10.0185	9.2726	5.2087	-1.4271	0.9466
UMD	-0.0001	-0.0365*	-0.0128	-0.0197	-0.0090	0.0173	-0.0067	-0.0323*	-0.0902***	0.0443***
	-0.0053	-1.9188	-0.7154	-0.7957	-0.3745	0.8774	-0.3678	-1.8911	-5.7171	3.2652
LIQ	0.0299	0.0502**	0.0296	0.0142	0.0539*	0.0816***	0.0762***	0.0880***	0.0674***	0.0448***
	1.2859	2.0736	1.2662	0.4495	1.7656	3.2784	3.3995	4.0675	3.6701	2.7391

Signed VPIN Value-weighted Monthly Deciles

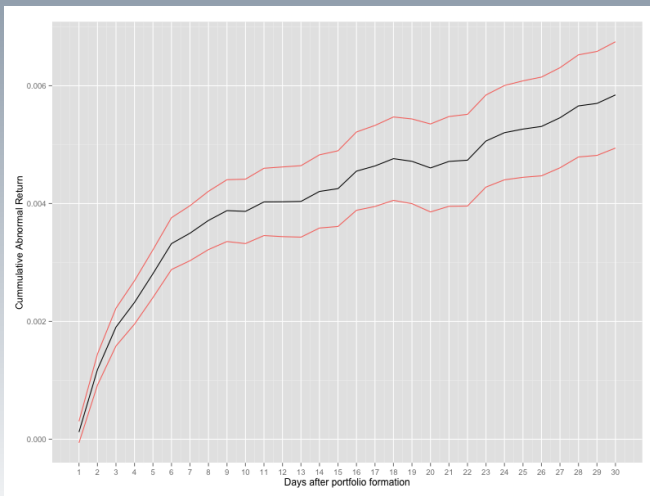
Factor	Decile 1	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10
Alpha	0.0029**	0.0011	0.0017	-0.0002	-0.0009	0.0010	-0.0003	-0.0009	-0.0018*	-0.0000
	2.0996	1.0865	1.4387	-0.1873	-0.6909	0.8498	-0.2767	-0.9717	-1.7366	-0.0168
MRP	1.0694***	1.0727***	0.9547***	0.9460***	0.8904***	0.9295***	0.8775***	0.9714***	0.9305***	0.9420***
	33.6807	44.3748	34.6873	35.1526	28.4538	32.3190	33.8514	43.1717	38.8077	40.7154
SMB	-0.00539	0.1183***	0.0601*	0.1597***	0.1148***	0.0810**	0.2055***	0.0555*	0.1105***	-0.0722**
	-1.3024	3.7172	1.6963	4.7402	2.8022	2.1844	6.2430	1.8432	3.4605	-2.2973
HML	-0.1615***	0.0448	0.0201	0.2128***	0.1229***	0.0769**	0.1933***	0.0896***	0.1170***	0.0524
	-3.5227	1.3801	0.5129	5.7207	2.9255	1.9990	5.4449	2.9837	3.4368	1.6111
UMD	-0.1012***	-0.0468**	-0.0763***	0.0337	0.0131	0.0092	-0.0165	-0.0095	0.0155	0.0834***
	-3.6000	-2.3761	-3.3407	1.4095	0.5099	0.3976	-0.7747	-0.5308	0.7582	4.3214
LIQ	0.1027***	0.0013	0.0361	0.0475*	0.0308	0.1035***	0.0322	0.0415*	0.0286	0.0064
	3.1304	0.0521	1.2443	1.7281	0.9389	3.5324	1.2065	1.8248	1.1695	0.2702

# Daily Information Ratio





# Daily SVPIN Trading Rule



# Thank You

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Twitter: @Phreakonomist

Slides: <https://www.stephenrush.org/talk/>

