Are Market Makers Incentivized to Provide Liquidity? Evidence from the Nasdaq

Version: May 28, 2017

Abstract

Abstract

1 Data

1.1 Measure of MPID Submission Intensity

As a measure of MPID submission intensity, we consider the number of orders submitted that are attributed to an MPID, divided by the total number of orders. Specifically, the MPID submission ratio $MPID_t^i$ is calculated for each stock i across the interval $[t-\tau, t]$, as:

$$MPID_t^i = \frac{\sum_{s=t-\tau}^{t} \mathbb{I}_s^{MPID.SUB,i}}{\sum_{s=t-\tau}^{t} \mathbb{I}_s^{SUB,i}},$$

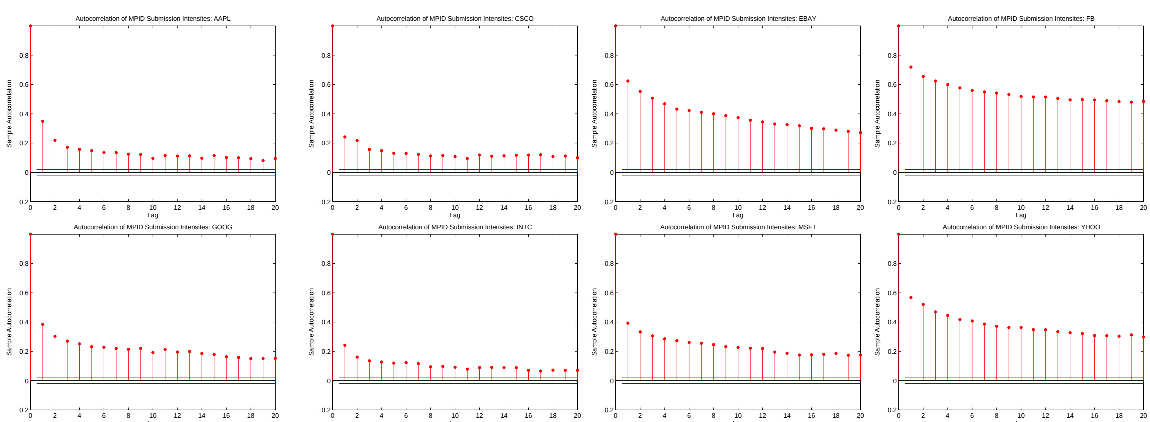
where $\mathbb{I}_t^{SUB,i}$ is a dummy variable equal to one if the order book message at time t describes the submission of a limit order, and $\mathbb{I}_t^{MPID.SUB,i}$ if the order book message at time t shows the submission of a limit order with an attributed MPID. Likewise, measures of buy-side and sell-side MPID submission intensities ($MPID_t^{i,BUY}$ and $MPID_t^{i,SELL}$) are calculated, respectively, as the ratio of buy- (sell-)side MPID-attributed submissions to the total number of buy- (sell-)side submissions. Note that using the ratio of MPID-attributed order submissions to total order submissions, rather than the absolute number of MPID-attributed order submissions, allows us to control for general trading strategies and order flow trends and better isolate marginal drivers of MPID submission strategies. For example, limit order submissions in general tend to be high early in the trading day; observing a high absolute number of MPID orders during this time may therefore reflect a general trend in order submission strategies. However, observing a higher *ratio* of MPID order submissions entails that there are additional incentives for traders to reveal their presence early in the trading day.

Table 1 shows summary statistics for the MPID submission ratios $MPID_t^i$, $MPID_t^{i,BUY}$ and $MPID_t^{i,SELL}$, for the individual stocks in our sample, along with on an aggregate level. As expected, MPID submission ratios are variables ranging from 0 to 1; the aggregate mean MPID submission ratio reflects a mean order submission ratio of about 0.03. FB has the highest MPID order submission ratios, with a mean of about 0.07, while all other firms have average MPID order submission ratios that range from 0.01 to 0.05. GOOG has the highest standard deviation in its MPID submission ratios; as it is the least liquid firm in our sample. Furthermore, MPID submission ratios tend to be right-skewed, reflecting the presence of occasional very high values. This is especially true for GOOG, who sees maximum MPID submission ratios equal to 1.

In terms of the time series properties of our measures, Column 7 of Table 1 shows that results from the KPSS tests for stationarity overwhelming reject the null of stationarity, in favor of the unit-root alternative. Autocorrellograms for $MPID_t^i$ for each firm are presented in Figure refratiostats, and show high persistence in MPID submission ratios, as autocorrelation remains highly significant even after 20 lags.

-autocorrelation -min, max, skewness -average across trading day

Figure 1: Autocollerograms for MPID Submission Ratios



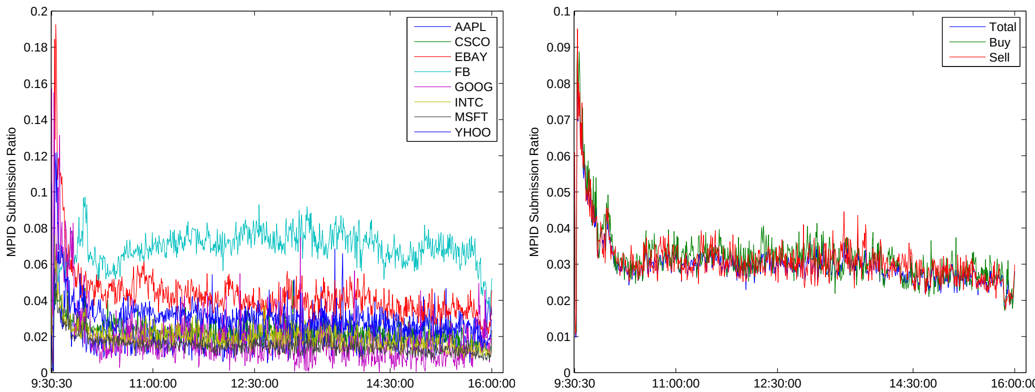
Caption

Table 1: Title

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(A.1) All MPID Submissions											
	Mean	Median	Std. Dev.	Min.	Max.	Skew	Lags	ADF	PP	KPSS1	KPSS2
AAPL	0.014	0.000	0.029	0.000	0.325	3.148	29	0.001	0.001	0.01	0.01
CSCO	0.013	0.011	0.013	0.000	0.261	2.540	17	0.001	0.001	0.01	0.01
EBAY	0.040	0.037	0.028	0.000	0.319	2.048	10	0.001	0.001	0.01	0.01
FB	0.051	0.051	0.020	0.000	0.174	0.213	17	0.005	0.001	0.01	0.01
GOOG	0.007	0.000	0.027	0.000	1.000	9.856	38	0.001	0.001	0.01	0.01
INTC	0.013	0.011	0.014	0.000	0.214	2.202	21	0.001	0.001	0.01	0.01
MSFT	0.013	0.012	0.010	0.000	0.118	2.023	12	0.001	0.001	0.01	0.01
YHOO	0.025	0.021	0.020	0.000	0.368	3.030	19	0.001	0.001	0.01	0.01
(A.2) Buy-Side MPID Submissions											
	Mean	Median	Std. Dev.	Min.	Max.	Skew	Lags	ADF	PP	KPSS1	KPSS2
AAPL	0.011	0.000	0.034	0.000	0.500	4.708	9	0.001	0.001	0.01	0.01
CSCO	0.014	0.009	0.019	0.000	0.273	3.081	8	0.001	0.001	0.01	0.01
EBAY	0.043	0.038	0.036	0.000	0.563	2.360	27	0.001	0.001	0.01	0.01
FB	0.053	0.051	0.026	0.000	0.375	0.936	18	0.001	0.001	0.01	0.01
GOOG	0.006	0.000	0.035	0.000	1.000	8.954	16	0.001	0.001	0.056	0.043
INTC	0.014	0.007	0.020	0.000	0.211	2.665	22	0.001	0.001	0.097	0.01
MSFT	0.014	0.012	0.014	0.000	0.200	2.753	20	0.001	0.001	0.01	0.01
YHOO	0.026	0.021	0.027	0.000	0.556	3.490	19	0.001	0.001	0.01	0.01
(A.3) Sell-Side MPID Submissions											
	Mean	Median	Std. Dev.	Min.	Max.	Skew	Lags	ADF	PP	KPSS1	KPSS2
AAPL	0.018	0.000	0.048	0.000	0.481	3.632	29	0.001	0.001	0.01	< 0.01
CSCO	0.014	0.008	0.019	0.000	0.250	2.849	22	0.001	0.001	0.1	< 0.01
EBAY	0.042	0.037	0.034	0.000	0.435	1.996	12	0.001	0.001	0.01	< 0.01
FB	0.052	0.051	0.025	0.000	0.364	0.816	19	0.001	0.001	0.01	< 0.01
GOOG	0.007	0.000	0.034	0.000	0.692	7.889	38	0.001	0.001	0.012	< 0.01
INTC	0.015	0.008	0.022	0.000	0.394	3.243	23	0.001	0.001	0.01	< 0.01
MSFT	0.014	0.012	0.014	0.000	0.200	2.602	12	0.001	0.001	0.01	< 0.01
YHOO	0.026	0.021	0.026	0.000	0.313	2.877	10	0.001	0.001	0.01	< 0.01
(A.4) All Firms											
	Mean	Median	Std. Dev.	Min.	Max.	Skew	Lags	ADF	PP	KPSS1	KPSS2
All MPID Submissions	0.022	0.015	0.026	0.000	1.000	2.856	45	0.001	0.001	0.01	0.01
Buy-Side MPID Submissions	0.023	0.012	0.032	0.000	1.000	3.469	47	0.001	0.001	0.01	0.01
Sell-Side MPID Submissions	0.023	0.013	0.033	0.000	0.692	3.290	45	0.001	0.001	0.01	0.01

Caption

Figure 2: Average Daily MPID Submission Ratios, by Firm



Caption

2 Empirical Results

2.1 Drivers of MPID Order Submissions

-results from panel regression

2.1.1 Robustness: Individual Market Maker

-results from TMBR Hill

2.1.2 Robustness: Firm-Level Regressions

In this estimation, we perform a linear regression of MPID-attributed submission intensity on various market conditions hypothesized to influence the decision to submit orders non-anonymously. Specifically, we estimate:

$$MPID_t^i = \alpha_0^i + \sum_{p=1}^{5} \alpha_p^i MPID_{t-p}^i + \alpha_6^i OPEN_t + (\beta^i)'\mathbf{x}_t^i + (\gamma^i)'\mathbf{z}_t^i + \varepsilon_{it}$$

where $MPID_t^i$ is a variable intended to capture the intensity of MPID-attributed submission volume over the interval $[t, t+1]$, $\mathbf{x}_t^i$ is a vector containing the average order characteristics of MPID-attributed orders submitted over the interval $[t, t+1]$, such as average order size, and $\mathbf{z}_t^i$ is a vector containing various market conditions averaged over the interval $[t-1, t]$ that are hypothesized to influence the decision to submit orders non-anonymously, such as volatility and the bid-ask spread. Lagged MPID-attributed submission intensity, $MPID_{t-1}^i$, is included as a regressor to account for the potential clustering of MPID-attributed orders. $OPEN_t$ is a dummy variable equal to one if the interval $[t, t+1]$ is within the first thirty minutes of the trading day.

The vector of order characteristics, $\mathbf{x}_t^i$, contains two variables: the average aggressiveness of MPID-attributed orders over the interval $[t, t+1]$, $AGGR_t^i$ defined as the signed distance of a submitted order to the midquote, and the average order size (in dollar volume) of MPID-attributed submissions over the interval $[t, t+1]$, $ORSZ_t^i$. These variables are included to control for the potential that a higher intensity of MPID orders may be driven by, e.g., order-splitting strategies or by "hiding" attributed orders deep in the book.

The vector of market conditions, $\mathbf{z}_t^i$, contains [] variables: volatility,

Figure 3 below plots the coefficients on our main market condition variables, for each individual firm-level regression. Results largely confirm the main results from the panel regressions in Section [].

2.2 Impact of MPID Order Submissions

$$q_t^i = \alpha_0 + \sum_{p=1}^{5} \alpha_p q_{t-p}^i + \alpha_6 MPID_{t-1}^i + \alpha_7 SUB_{t-1}^i + \alpha_8 OPEN_t + \beta' \mathbf{x}_{t-1}^i + \gamma' \mathbf{z}_{t-1}^i + \mu' D_t + \varepsilon_{it}, \quad (1)$$

where q_t^i represents a measure of ex post market quality measured over the interval $[t+1, t]$, such as relative bid-ask spreads or volatility, $\mathbf{x}_{t-1}^i$ is a vector controlling for the average order characteristics of MPID-attributed orders submitted over the interval $[t-1, t]$, and $\mathbf{z}_{t-1}^i$ is a vector controlling for various market conditions averaged over the interval $[t-1, t]$. Since these measure of market quality tend to also exhibit high degrees of autocorrelation, the regression in (1) also includes $p = 5$ dependent variable lags.[1] The key coefficient of interest is the coefficient on lagged MPID order submission intensity, α_6, which should give the effect on market quality of an increase in MPID submission intensity. Note that (1) also controls for changes in the denominator of $MPID_t^i$, i.e., the total submission intensity $SUB.NUM_t^i$.

In a first step, the regression in (1) is run using the standard OLS, including firm fixed effects.

[1] Durbin-Watson tests statistics confirm a failure to reject a null hypothesis of no autocorrelation in the error terms (tested on a stock-by-stock basis) in the majority of specifications for q_t^i, for the majority of firms. Durbin-Watson statistics close to 2 are considered generally to confirm no autocorrelation in the errors (see, e.g., Gujarati, 2004); the average Durbin-Watson test statistic across specifications and stocks in our case is 1.98.

In this procedure, we implicity assume no endogeneity between MPID submission intensities and market characteristics. Given the results in [], this is a rather naive assumption, but the results are presented here for two reasons: first, Wu-Hausman tests for endogeneity (in which the null) show that OLS is more consistent than 2SLS for at least one of our model specifications. Secondly, as argued in [], OLS estimates

In a second step, to account for the endogeneity between MPID submission intensities and market characteristics, we instrument the submission intensity of MPID-attributed orders $MPID_t^i$ using the average submission intensities in the other stocks in our sample, $MPID_t^{-i}$. Note that this also requires instrumenting the denominator of $MPID_t^i$, $SUB.NUM_t^i$ with the average submission intensity of all other stocks, $SUB.NUM_t^{-i}$. The idea is that, while MPID-attributed orders submissions in other stocks are likely not driven by the market characteristics in the individual stock, MPID-attributed order submissions are correlated across stocks due to, e.g., trading capacities or constraints of each market makers.

Table 2 shows the Pearson correlation coefficient between the MPID submission ratios in each stock with that of the MPID submission ratios in the other sample stocks, as well as the correlation between each stocks' total submission intensities with the total submission intensities in all other stocks. The table shows a relatively high level of correlation between $SUB.NUM_t^{-i}$ and $SUB.NUM_t^i$, with correlation coefficients ranging from 0.19-0.55. Correlation coefficients between $MPID_t^i$ and $MPID_t^{-i}$ are also relatively high for six of the stocks, ranging from 0.13-0.447. However, there is nearly zero correlation for AAPL; FB also exhibits low correlation, particularly on the sell side of the book. Therefore, it is possible that $MPID_t^{-i}$ will serve as a weak instrument from these stocks.

In order to check this, explicit tests for instrument weakness, as well as tests for the endogeneity of $MPID_t^i$ and $SUB.NUM_t^i$, are conducted by running two-stage least squares (2SLS) regressions on a firm-by-firm basis. In the first stage, $MPID_t^i$ and $SUB.NUM_t^i$ are regressed on the instruments $MPID_t^{-i}$ and $SUB.NUM_t^{-i}$, along with the control variables, in order to obtain fitted values $M\hat{P}ID_t^i$ and $SUB.\hat{N}UM_t^i$. In the second stage, $M\hat{P}ID_t^i$ and $SUB.\hat{N}UM_t^i$ are used to substitute for $MPID_t^i$ and $SUB.NUM_t^i$ in the regression in (1), estimated on a firm-by-firm basis. A test for weakness of the instruments conducts an F-test on the first stage-regressions under the null hypothesis that the instruments is not significant for the first-stage regression. To test for endogeneity of $MPID_t^i$ and $SUB.NUM_t^i$, a Wu-Hausman test is conducted under the null hypothesis that OLS and 2SLS are equally consistent.

Results for the F-tests and Wu-Hausman tests for each stock are presented in Table [], substituting our main market quality measures of interest for q_t^i for the dependent variable in regression (1): relative bid-ask spreads ($RELSPR_t^i$), volatility (VOL_t^i), submission volume ($SUB.DVOL_t^i$), execution volume ($EXE.DVOL_t^i$), and depth ($DEPTH_t^i$). These results confirm the weakness of $MPID_t^{-i}$ as an instrument for AAPL: the F-test fails to reject that $MPID_t^{-i}$ does not enter the first-stage regression at a $\alpha = 10\%$ level for two regressions (relative bid-ask spreads and submission volumes), at a $\alpha = 1\%$ for all regressions. Therefore, the proceeding panel regression in which instrumental variable estimation is implemented excludes AAPL from the panel. Interestingly, Panel (E) shows that the Wu-Hausman test fails to reject ($\alpha = 5\%$) that OLS is more consistent for 4 out of the eight firms, when depth ($DEPTH_t^i$) enters as the dependent variable in (1). This confirms our presentation of the OLS results, in addition to the 2SLS results.

To estimate the instrumental panel regression, the Balestra and Varadharajan-Krishnakumar (1987) generalized two-stage least squares (G2SLS) estimator is implemented in order to to estimate the instrumental variable panel regression with fixed effects. This procedure begins with a structural equation of the following form:

$$y_t^i = \alpha^i + \beta' \mathbf{x}_t^i + \varepsilon_t^i,$$

where $\mathbf{x}_t^i = [\mathbf{u}_t^i, \mathbf{v}_t^i]$, and $\mathbf{v}_t^i$ is the set of endogenous variables. As is standard in fixed effects, these variables are transformed by subtracting the sample mean, as: $\bar{y}_t^i = y_t^i - \frac{1}{T}\sum_{t=1}^{T} y_t^i$, $\bar{x}_t^i = x_t^i - \frac{1}{T}\sum_{t=1}^{T} x_t^i$, and $\bar{\varepsilon}_t^i = \varepsilon_t^i - \frac{1}{T}\sum_{t=1}^{T} \varepsilon_t^i$.

The Balestra and Varadharajan-Krishnakumar (1987) begins by premultiply

Given a set of instruments

As in standard

In a first step, the instruments are checked whether they are weak and whether their is an endogeneity problem.

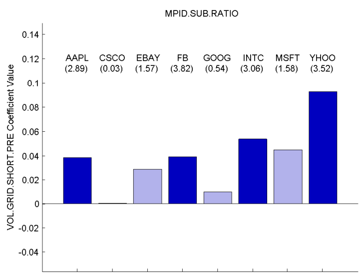
"for very large T , they argue that individual unit root time series tests" https://fvela.files.wordpress.com/2011/10/baltagi-2005-econometric-analysis-of-panel-data-3e.pdf

Table 2: Instrumental Variables: Pearson Correlation Coefficients

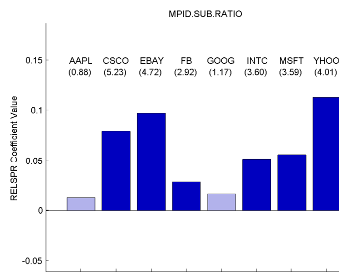
	AAPL	CSCO	EBAY	FB	GOOG	INTC	MSFT	YHOO
MPID Submissions (All)	0.018	0.206	0.447	0.113	0.211	0.229	0.392	0.421
MPID Submissions (Buy)	0.053	0.125	0.366	0.158	0.154	0.139	0.291	0.356
MPID Submissions (Sell)	0.006	0.167	0.313	0.073	0.145	0.180	0.280	0.288
Total Submissions (All)	0.446	0.367	0.399	0.437	0.296	0.423	0.546	0.456
Total Submissions (Buy)	0.325	0.389	0.268	0.357	0.193	0.375	0.460	0.301
Total Submissions (Sell)	0.434	0.335	0.377	0.421	0.266	0.384	0.509	0.450

(A) RELSPR								
	AAPL	CSCO	EBAY	FB	GOOG	INTC	MSFT	YHOO
L1.MPID	1.3463	149.1246	600.1261	162.8775	40.9303	146.4179	668.9549	650.4820
p-value	[0.26]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
L1.SUB.NUM	37.6359	49.7654	19.1601	98.7247	27.2530	233.0876	204.4232	90.2690
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Wu-Hausman	20.9295	23.8116	44.0817	9.8165	6.2894	9.9995	20.6472	49.3961
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
(B) VOL								
	AAPL	CSCO	EBAY	FB	GOOG	INTC	MSFT	YHOO
L1.MPID	3.3525	139.4275	671.2843	174.2196	39.7615	129.3896	621.7281	635.9997
p-value	[0.04]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
L1.SUB.NUM	36.8763	31.3482	17.1792	65.7633	27.6174	224.8208	147.6018	69.5554
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Wu-Hausman	25.5240	11.0042	10.7909	41.2444	29.5139	10.4909	24.6375	40.7745
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
(C) SUB								
	AAPL	CSCO	EBAY	FB	GOOG	INTC	MSFT	YHOO
L1.MPID	1.1042	146.8666	686.2759	167.0239	36.5413	138.0851	700.1361	793.9297
p-value	[0.33]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
L1.SUB.NUM	33.5852	22.7802	7.9488	20.9358	27.8313	194.1566	147.4769	52.2922
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Wu-Hausman	54.6874	47.4022	39.5764	41.9758	64.9352	32.6131	18.8722	23.8363
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
(D) EXE								
	AAPL	CSCO	EBAY	FB	GOOG	INTC	MSFT	YHOO
L1.MPID	3.8857	147.6724	703.1845	163.3928	41.0730	138.8149	692.5449	784.6604
p-value	[0.02]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
L1.SUB.NUM	38.5449	36.4058	15.9906	59.9954	31.2399	226.7980	172.1684	67.7944
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Wu-Hausman	41.6753	14.0255	32.9097	48.6890	85.4116	12.4984	21.5540	45.8788
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
(E) DEPTH								
	AAPL	CSCO	EBAY	FB	GOOG	INTC	MSFT	YHOO
L1.MPID	3.8857	147.6724	703.1845	163.3928	41.0730	138.8149	692.5449	784.6604
p-value	[0.02]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
L1.SUB.NUM	38.5449	36.4058	15.9906	59.9954	31.2399	226.7980	172.1684	67.7944
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Wu-Hausman	2.5025	6.0314	12.9104	1.0058	0.5394	7.5641	1.4186	0.7116
p-value	[0.08]	[0.00]	[0.00]	[0.37]	[0.58]	[0.00]	[0.24]	[0.49]

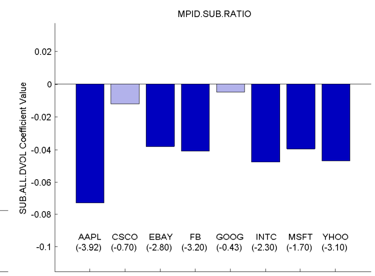
Figure 3: Coefficients from Firm-Level Regressions



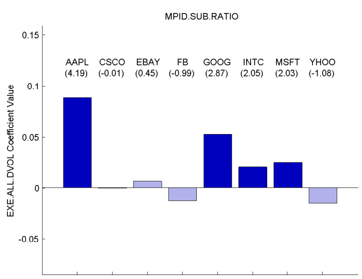
(a) Caption



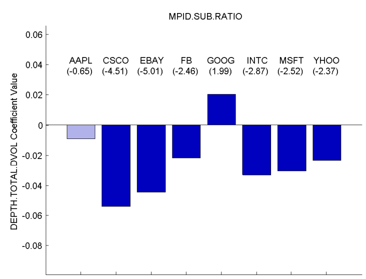
(b) Caption



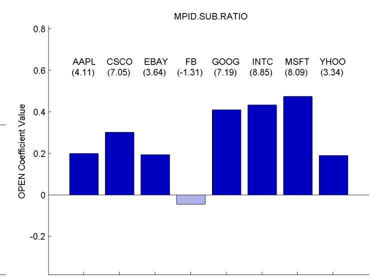
(c) Caption



(d) Caption



(e) Caption



(f) Caption

The bar graphs in the figure above correspond to key coefficients from a regression of measures capturing various dimensions of market quality, on a dummy variable equal to one if a submitted order is attributed to an MPID, and zero otherwise. The dependent variables are calculated during the interval $[t, t+\Delta t]$, where Δt is the time it takes to observe $N = 20$ consecutive submissions, proceeding the submitted order. Results are presented separately for buy- and sell-side MPID-attributed orders, and separately for each firm in the sample, ordered according to the stock's mean stock price during the sample time period, 4-22 November, from highest to lowest. t-statistics are presented in parenthesis above the bar. Dark blue and red bars correspond to coefficients that are significant at a significance level of $\alpha = 5\%$. Light blue and red bars correspond to coefficients that are insignificant at this level.

Table 3: Panel Regression Results

	Dependent variable:						
	MPID.SUB.RATIO			MPID.SUB.BUY.RATIO		MPID.SUB.SELL.RATIO	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
L1.MPID.SUB	0.276***	0.274***	0.272***				
	(0.028)	(0.029)	(0.028)				
L2.MPID.SUB	0.134***	0.130***	0.128***				
	(0.014)	(0.015)	(0.014)				
L3.MPID.SUB	0.084***	0.081***	0.079***				
	(0.009)	(0.010)	(0.008)				
L4.MPID.SUB	0.077***	0.074***	0.071***				
	(0.006)	(0.007)	(0.006)				
L5.MPID.SUB	0.074***	0.070***	0.067***				
	(0.006)	(0.007)	(0.007)				
L1.MPID.SUB.BUY				0.239***	0.240***		
				(0.024)	(0.024)		
L2.MPID.SUB.BUY				0.117***	0.117***		
				(0.012)	(0.012)		
L3.MPID.SUB.BUY				0.073***	0.073***		
				(0.008)	(0.008)		
L4.MPID.SUB.BUY				0.071***	0.071***		
				(0.005)	(0.005)		
L5.MPID.SUB.BUY				0.066***	0.066***		
				(0.007)	(0.007)		
L1.MPID.SUB.SELL						0.243***	0.244***
						(0.026)	(0.026)
L2.MPID.SUB.SELL						0.121***	0.121***
						(0.012)	(0.012)
L3.MPID.SUB.SELL						0.071***	0.071***
						(0.010)	(0.010)
L4.MPID.SUB.SELL						0.069***	0.068***
						(0.008)	(0.008)
L5.MPID.SUB.SELL						0.065***	0.064***
						(0.008)	(0.008)
AGGR.MPID	−0.149***	−0.143***	−0.140***	−0.120***	−0.120***	−0.111***	−0.111***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
ORSZ.MPID	0.063**	0.056**	0.057**	0.037*	0.037*	0.043**	0.044**
	(0.025)	(0.026)	(0.026)	(0.020)	(0.020)	(0.021)	(0.021)
L1.AGGR.TOTAL	0.002	0.013	0.017**	0.006	0.004	0.008	0.010
	(0.008)	(0.008)	(0.009)	(0.008)	(0.009)	(0.008)	(0.007)
L1.ORSZ.TOTAL	0.020***	0.003	0.005	−0.005	−0.007	−0.008	−0.002
	(0.005)	(0.009)	(0.008)	(0.007)	(0.009)	(0.008)	(0.009)
L1.VOL	0.030**	0.032***	0.029***	0.029***	0.028***	0.019*	0.018*
	(0.013)	(0.011)	(0.011)	(0.008)	(0.009)	(0.010)	(0.010)
L1.RELSPR	0.030***	0.032*	0.033*	0.029*	0.028	0.014	0.015
	(0.005)	(0.018)	(0.020)	(0.017)	(0.017)	(0.015)	(0.015)
L1.SUB.ALL	−0.054***	−0.053***	−0.050***				
	(0.011)	(0.012)	(0.011)				
L1.SUB.BUY				−0.032***			−0.028***
				(0.003)			(0.006)
L1.SUB.SELL					−0.032***	−0.025**	
					(0.008)	(0.011)	
L1.EXE.ALL	0.027*	0.023*	0.020				
	(0.015)	(0.013)	(0.014)				
L1.EXE.BUY				−0.004			0.013
				(0.008)			(0.012)
L1.EXE.SELL					0.004	0.009	
					(0.008)	(0.010)	
L1.DEPTH.ALL	−0.033***	−0.025***	−0.026***				
	(0.007)	(0.007)	(0.005)				
L1.DEPTH.BUY				−0.013*			−0.026***
				(0.007)			(0.004)
L1.DEPTH.SELL					−0.013***	−0.009	
					(0.003)	(0.005)	
L1.RELDPR	−0.026***	−0.030***	−0.032***	−0.027**	−0.039***	−0.046***	−0.032***
	(0.007)	(0.008)	(0.009)	(0.013)	(0.012)	(0.009)	(0.007)
L1.NEG.DUMMY	0.038***	0.020**	0.019**	0.015	0.020	0.009	0.001
	(0.011)	(0.008)	(0.009)	(0.013)	(0.013)	(0.015)	(0.017)
OPEN	0.150**	0.168**	0.182**	0.171***	0.169***	0.186***	0.180***
	(0.065)	(0.073)	(0.072)	(0.060)	(0.061)	(0.068)	(0.067)
L1.RELDPR*L1.NEG.DUMMY	−0.019	−0.009	−0.008	−0.007	0.011	0.007	−0.018
	(0.013)	(0.014)	(0.015)	(0.015)	(0.014)	(0.013)	(0.015)
Intercept	0.047						
	(0.039)						
Firm Fixed Effects	NO	YES	YES	YES	YES	YES	YES
Time Fixed Effects	NO	NO	YES	YES	YES	YES	YES
Observations	87,320	87,320	87,320	87,320	87,320	87,320	87,320
R^2	0.441	0.293	0.295	0.221	0.221	0.207	0.208
Adjusted R^2	0.441	0.293	0.295	0.221	0.221	0.207	0.207
Durbin-Watson	1.9935	1.9916	1.9905	1.9994	1.9990	1.9971	1.9974
p-value	0.33	0.21	0.14	0.89	0.84	0.63	0.66

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 4: Panel Regression Results: Timber Hill, Inc.

	Dependent variable:						
	MPID.SUB.RATIO			MPID.SUB.BUY.RATIO		MPID.SUB.SELL.RATIO	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
L1.MPID.SUB	0.314***	0.298***	0.295***				
	(0.026)	(0.026)	(0.026)				
L2.MPID.SUB	0.131***	0.116***	0.114***				
	(0.015)	(0.017)	(0.015)				
L3.MPID.SUB	0.094***	0.080***	0.077***				
	(0.008)	(0.008)	(0.008)				
L4.MPID.SUB	0.080***	0.065***	0.063***				
	(0.006)	(0.006)	(0.005)				
L5.MPID.SUB	0.081***	0.062***	0.058***				
	(0.005)	(0.006)	(0.006)				
L1.MPID.SUB.BUY				0.255***	0.256***		
				(0.027)	(0.026)		
L2.MPID.SUB.BUY				0.108***	0.107***		
				(0.014)	(0.014)		
L3.MPID.SUB.BUY				0.063***	0.062***		
				(0.008)	(0.008)		
L4.MPID.SUB.BUY				0.064***	0.064***		
				(0.006)	(0.006)		
L5.MPID.SUB.BUY				0.057***	0.057***		
				(0.006)	(0.006)		
L1.MPID.SUB.SELL						0.266***	0.266***
						(0.026)	(0.025)
L2.MPID.SUB.SELL						0.106***	0.105***
						(0.013)	(0.013)
L3.MPID.SUB.SELL						0.064***	0.064***
						(0.007)	(0.007)
L4.MPID.SUB.SELL						0.054***	0.053***
						(0.009)	(0.009)
L5.MPID.SUB.SELL						0.057***	0.056***
						(0.004)	(0.004)
AGGR.MPID	−0.041*	−0.017	−0.016	−0.017	−0.017	−0.016	−0.016
	(0.023)	(0.022)	(0.022)	(0.018)	(0.019)	(0.019)	(0.019)
ORSZ.MPID	0.017	−0.001	−0.001	−0.005	−0.006	−0.002	−0.002
	(0.019)	(0.019)	(0.019)	(0.015)	(0.015)	(0.017)	(0.017)
L1.AGGR.TOTAL	−0.010	0.023***	0.029***	0.016**	0.015**	0.019**	0.020**
	(0.013)	(0.008)	(0.008)	(0.007)	(0.007)	(0.009)	(0.008)
L1.ORSZ.TOTAL	0.057***	0.004	0.006	−0.004	−0.004	−0.008	−0.004
	(0.008)	(0.008)	(0.007)	(0.005)	(0.007)	(0.007)	(0.009)
L1.VOL	0.041***	0.045***	0.044***	0.040***	0.039***	0.028***	0.027***
	(0.014)	(0.011)	(0.010)	(0.009)	(0.010)	(0.010)	(0.010)
L1.RELSPR	0.049***	0.050***	0.049***	0.036**	0.036**	0.032**	0.033**
	(0.012)	(0.018)	(0.019)	(0.016)	(0.016)	(0.014)	(0.015)
L1.SUB.ALL	−0.056***	−0.051***	−0.055***				
	(0.009)	(0.010)	(0.009)				
L1.EXE.ALL	0.006	−0.006	−0.006				
	(0.009)	(0.006)	(0.007)				
L1.DEPTH.ALL	−0.047***	−0.028***	−0.026***				
	(0.007)	(0.008)	(0.007)				
L1.SUB.BUY				−0.035***			−0.036***
				(0.008)			(0.007)
L1.EXE.BUY				−0.016***			−0.005
				(0.004)			(0.007)
L1.DEPTH.BUY				−0.014*			−0.024***
				(0.007)			(0.004)
L1.SUB.SELL					−0.040***	−0.033***	
					(0.009)	(0.008)	
L1.EXE.SELL					−0.009**	−0.011**	
					(0.004)	(0.005)	
L1.DEPTH.SELL					−0.012***	−0.010	
					(0.004)	(0.007)	
L1.RELDPR	−0.002	−0.011*	−0.014**	−0.034***	−0.041***	−0.012*	−0.005
	(0.008)	(0.006)	(0.007)	(0.011)	(0.013)	(0.007)	(0.006)
L1.NEG.DUMMY	0.076***	0.025***	0.023***	0.027**	0.033**	0.005	−0.002
	(0.025)	(0.007)	(0.007)	(0.012)	(0.013)	(0.013)	(0.015)
OPEN	0.143**	0.230***	0.252***	0.255***	0.254***	0.235***	0.229***
	(0.058)	(0.062)	(0.060)	(0.043)	(0.044)	(0.053)	(0.053)
L1.RELDPR*L1.NEG.DUMMY	−0.040*	−0.011	−0.011	0.015*	0.023**	−0.021	−0.032**
	(0.021)	(0.013)	(0.014)	(0.008)	(0.012)	(0.016)	(0.014)
Intercept	−0.110						
	(0.073)						
Observations	87,320	87,320	87,320	87,320	87,320	87,320	87,320
R^2	0.478	0.259	0.261	0.193	0.193	0.183	0.184
Adjusted R^2	0.478	0.258	0.261	0.193	0.193	0.183	0.183
Durbin-Watson	2.0219	2.0156	2.0150	2.0113	2.0108	2.0109	2.0107
p-value	0.00	0.02	0.03	0.11	0.12	0.12	0.13

Note: *p<0.1; **p<0.05; ***p<0.01

Table 5: Post Panel Regression Results: Bid-Ask Spreads

	Dependent variable:					
	RELSPR					
	(1)	(2)	(3)	(4)	(5)	(6)
lag(MPID.SUB.RATIO, k = c(1:mpidlags))	−0.002					
	(0.010)					
lag(MPID.SUB.HAT, k = c(1:mpidlags))		−0.081***	−0.061	−0.113***	−0.011	−0.002***
		(0.031)	(0.038)	(0.038)	(0.038)	(0.038)
lag(AGGR.REL.TOTAL, k = 1)	−0.104***	−0.097***	−0.096***	−0.107***	−0.095***	−0.076***
	(0.017)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)
lag(ORSZ.DVOL.TOTAL, k = 1)	0.080***	0.022***	0.021***	0.021***	0.013***	0.028***
	(0.026)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
lag(AGGR.REL.MPID, k = 1)	0.006	0.007	0.008	0.003	0.011	0.008
	(0.007)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)
lag(ORSZ.DVOL.MPID, k = 1)	0.010**	−0.001	−0.002	−0.001	−0.001	−0.002
	(0.004)	(0.010)	(0.011)	(0.011)	(0.011)	(0.011)
lag(VOL.GRID.SHORT.PRE, k = 1)	−0.003	−0.033**	−0.033***	−0.028**	−0.030***	−0.034**
	(0.011)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
lag(RELSPR, k = 1:depvarlags)1	0.330***	0.383***	0.382***	0.383***	0.379***	0.390***
	(0.024)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
lag(RELSPR, k = 1:depvarlags)2	0.103***	0.184***	0.184***	0.183***	0.184***	0.183***
	(0.010)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
lag(RELSPR, k = 1:depvarlags)3	0.067***	0.132***	0.132***	0.131***	0.132***	0.131***
	(0.005)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
lag(RELSPR, k = 1:depvarlags)4	0.053***	0.123***	0.123***	0.124***	0.121***	0.120***
	(0.008)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
lag(RELSPR, k = 1:depvarlags)5	0.049***	0.130***	0.128***	0.130***	0.126***	0.127***
	(0.008)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
lag(SUB.ALL.DVOL, k = 1)	−0.156***	−0.028***	−0.029***			−0.053
	(0.047)	(0.007)	(0.007)			
lag(EXE.ALL.DVOL, k = 1)	0.088***	0.110***	0.111***			0.118
	(0.018)	(0.015)	(0.015)			
lag(DEPTH.TOTAL.DVOL, k = 1)	−0.036***	−0.021*	−0.018			−0.009
	(0.009)	(0.012)	(0.011)			
lag(SUB.BUY.DVOL, k = 1)				−0.005		
lag(EXE.BUY.DVOL, k = 1)				0.073		
lag(DEPTH.BUY.DVOL, k = 1)				−0.002		
lag(SUB.SELL.DVOL, k = 1)					0.005	
lag(EXE.SELL.DVOL, k = 1)					0.083	
lag(DEPTH.SELL.DVOL, k = 1)					−0.008	
OPEN	0.309***	0.170***	0.165***	0.184***	0.144***	0.088***
	(0.031)	(0.038)	(0.043)	(0.043)	(0.043)	(0.043)
lag(abs(RELDPR.MID), k = 1)	−0.008	−0.040**	−0.041**	−0.013	−0.055**	−0.029
	(0.020)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
lag(NEG.DUMMY, k = 1)	−0.084***	−0.184***	−0.186***	−0.186***	−0.184***	−0.177***
	(0.018)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
SUB.ALL.NUM	0.342***					
	(0.082)					
DUMMIESday.f5	−0.022		0.008	0.005	−0.0004	−0.009
	(0.019)		(0.014)	(0.014)	(0.014)	(0.014)
DUMMIESday.f6	−0.031		0.043***	0.052***	0.035***	0.021***
	(0.045)		(0.015)	(0.015)	(0.015)	(0.015)
DUMMIESday.f7	−0.027		0.048**	0.052**	0.037**	0.022**
	(0.047)		(0.024)	(0.024)	(0.024)	(0.024)
DUMMIESday.f8	−0.063		0.024	0.013	0.021	0.013
	(0.044)		(0.018)	(0.018)	(0.018)	(0.018)
DUMMIESday.f12	−0.027		0.037*	0.030	0.032*	0.013
	(0.032)		(0.021)	(0.021)	(0.021)	(0.021)
DUMMIESday.f13	−0.064***		0.035	0.034	0.029	0.012
	(0.022)		(0.022)	(0.022)	(0.022)	(0.022)
DUMMIESday.f14	−0.118**		0.034**	0.031**	0.034**	0.013**
	(0.050)		(0.015)	(0.015)	(0.015)	(0.015)
DUMMIESday.f15	−0.030		0.020	0.008	0.030	0.018
	(0.047)		(0.021)	(0.021)	(0.021)	(0.021)
DUMMIESday.f18	0.051		0.047*	0.029	0.060*	0.039
	(0.053)		(0.027)	(0.027)	(0.027)	(0.027)
DUMMIESday.f19	0.022		0.045*	0.030	0.052*	0.039
	(0.051)		(0.025)	(0.025)	(0.025)	(0.025)
DUMMIESday.f20	0.044		0.068***	0.059**	0.074***	0.051**
	(0.060)		(0.026)	(0.026)	(0.026)	(0.026)
DUMMIESday.f21	0.009		0.036	0.014	0.049	0.031
	(0.062)		(0.022)	(0.022)	(0.022)	(0.022)
DUMMIESday.f22	0.005		0.020	0.011	0.036	0.021
	(0.066)		(0.015)	(0.015)	(0.015)	(0.015)
lag(SUB.NUM.HAT, k = 1:mpidlags)		−0.019	−0.025*	−0.010	−0.023*	
		(0.012)	(0.013)	(0.013)	(0.013)	
lag(abs(RELDPR.MID), k = 1):lag(NEG.DUMMY, k = 1)	0.059***	0.119***	0.120***	0.075***	0.156***	0.113***
	(0.014)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Constant		0.078	0.044	−0.002	0.020	−0.026
		(0.091)	(0.089)	(0.089)	(0.089)	(0.089)
Observations	87,320	76,398	76,398	76,398	76,398	87,312
R^2	0.456	0.881	0.881	0.880	0.880	0.896
Adjusted R^2	0.455	0.880	0.880	0.880	0.880	0.896
F Statistic	2,282.843*** (df = 32; 87280)	29,622.040*** (df = 19; 76378)	17,589.190*** (df = 32; 76365)	17,517.540*** (df = 32; 76365)	17,537.750*** (df = 32; 76365)	24,346.960*** (df = 31; 87280)

Note: *p<0.1; **p<0.05; ***p<0.01

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