

# Online Appendix to “Click first or last? Strategic order placement during the Euronext preopening session”

Laurence Daures\*      Sophie Moinas†      Selma Boussetta‡

*Management Science Forthcoming*

The aim of this Online Appendix is to present a number of additional results, the description of the variables used in the regressions, and robustness tests.

## Contents

<b>A.1 Understanding the preopening behavior of Slow Clients using 2007 Euronext data</b>	<b>3</b>
<b>A.2 Order imbalances: two alternative measures</b>	<b>11</b>
<b>A.3 Supplementary tables and figures</b>	<b>13</b>

## List of Tables

A.1 Descriptive statistics on 2007 members’ groups . . . . .	5
A.2 Price discovery and preopening activity of members in 2007 . . . . .	7
A.3 Price discovery and preopening members’ activity: Alternative standardization schemes for order imbalances . . . . .	12
A.4 Variables description . . . . .	13
A.5 Summary statistics by member-type . . . . .	14
A.6 Breakdown of trading volume by member category . . . . .	15
A.7 Descriptive statistics on order imbalances . . . . .	16
A.8 Determinants for trading on Chi-X before Euronext open: Selection equation . .	17
A.9 Daily price discovery on days with delayed openings . . . . .	18
A.10 Descriptive statistics about delayed openings (excluding the glitch) . . . . .	19
A.11 Price discovery measures and late preopening activity of member categories, decomposing SP traders by speed and account . . . . .	20

---

\*ESSEC Business School, 3 avenue Bernard Hirsch, 95021 Cergy-Pontoise, France. [daures@essec.edu](mailto:daures@essec.edu).

†Toulouse Capitole University (Toulouse School of Economics, TSM-R), 1 esplanade de l’Université, 31000 Toulouse, France. [sophie.moinas@tse-fr.eu](mailto:sophie.moinas@tse-fr.eu).

‡Bordeaux School of economics, Bordeaux University, Avenue Leon Duguit, 33608 Pessac, France. [selma.boussetta@u-bordeaux.fr](mailto:selma.boussetta@u-bordeaux.fr).

## List of Figures

A.1	Preopening messages for each phase (early, middle, and late) by member category	6
A.2	Preopening messages for each phase (early, middle, and late) by member category	9
A.3	Preopening messages for each 15-min interval on normal days and on days with informational or liquidity shocks . . . . .	21

## A.1 Understanding the preopening behavior of Slow Clients using 2007 Euronext data

The classification of Euronext members in our 2012-13 dataset is based on two flags that are central for the analysis, the account flag (CLIENT/PROP/LP/RT/RL) and the speed flag (HFT/MX/NHFT). The latter is provided by the AMF, the French financial markets authority. The AMF reports that there are 10 to 20 pure HFT members, 10 to 20 MX members, and more than 150 NHFT members on Euronext. The Slow Clients (SC) category, made mainly of NHFT-CLIENT, might be highly heterogeneous and formed of noisily informed traders. This could explain why the SC category, while apparently less skilled than the other two categories, contributes positively and significantly to the daily price discovery.

To better understand this group, we use Euronext data from 2007, which includes non-anonimized member IDs and the account flag (CLIENT/PROP/LP/RL), beyond other standard variables (message IDs, time-stamps, validity, etc.).<sup>1</sup> This dataset is also utilized in Daures-Lescouret and Moinas (2023). Our sample consists of 29 multi-listed stocks trading continuously in euros (among which Air France, L’Oreal, Carrefour, Total, etc.), spanning 79 trading days from January 2, 2007 to April 30, 2007. There is a 35% overlap in stocks with the sample of the 2012-2013 Eurofidai-Bedofih dataset. The IDs of members allow us to decompose the Slow Clients category into sub-categories to better understand its heterogeneity.

### A Classification of the 2007 members

To categorize our 2007 members, we implement a three-step approach.

- Because the 2007 data precedes the introduction of the AMF flag included in our Eurofidai-Bedofih data, in the first step, we create a “pre-speed” flag based on triangulating (i) the 2012 AMF reported number of members in each category, (ii) snapshots of the European Principal Trader Information; and (iii) the order-to-trade ratio, the number of messages, and the number of transactions. We understand that the 2007 context differs from the 2012 environment (pre-Great Financial Crisis, pre-low latency infrastructure); the classification of members in HFT/MX/NHFT participants is, however, extremely persistent across years, according to the AMF. We identify 14 members that we flag as HFT, which are Proprietary Trading Firms such as Citadel, Optiver, or Susquehanna. We flag 19 members as MX (the AMF targeting full-service investment banks with this flag). Members flagged MX are the largest international European and U.S. commercial banks such as BNP Paribas, UBS, Deutsche Bank, Goldman Sachs, JP Morgan, or Morgan Stanley. The remaining members are all categorized as NHFT.
- Second, we combine the “pre-speed” flag and the account flag to replicate the SP (Sophisticated Prop), SC (Slow Clients), and OA (Other Agency) categories defined in Table 2. We recall that the speed flag is immutable for a member, but the same member can use the 4 possible accounts to send orders. For instance, the same member can be in the SP group (as a proprietary trader) and the OA group (trading on agency) or the SC group (trading on behalf of clients).

---

<sup>1</sup>The RT value of the “account” flag was not yet created.

- Third, using Capital IQ (industry description and firm tear sheet) and Factiva, we manually sub-categorize the Slow Clients category into 6 sub-categories. Remind that this category is made of NHFT members trading on behalf of retail or institutional clients:
  1. Asset Managers (AM) focusing on portfolio management, institutional investments, and asset advisory (such as Eureffect Asset Management B.V, or Foyer Asset Management);
  2. Retail brokers (R\_BROKER), serving individual clients only, such as Cortal Consors, Dubus S.A., or SeBroker;
  3. Full-line brokers (INST\_BROKER) handling multiple services and serving institutional clients (such as ODDO, CA Chevreux) or inter-dealer brokers (like GFI Securities Ltd)
  4. Private banks or wealth management-focused banks (PRV\_BANK) serving high-net-worth individuals with wealth management, asset management, and advisory services (such as Pictet or Staalbankiers N.V.)
  5. Regional banks (REG\_BANK), focusing on both retail or corporate banking but with limited market operations (such as Banca Aletti, BBVA, or Banco Popular Portugal);
  6. Investment Banks or securities division (INV\_BANK) handling services such as trading, underwriting, M&A advisory, proprietary trading (such as CM-CIC Securities, or Commerzbank Securities).

It is worth noticing that the SC category is very diverse: there might be substantial heterogeneity in the trading motives across the six sub-categories. Members are likely to differ in their degree of sophistication and informativeness. For instance, we expect retail brokers (R\_BROKER) to be little (if not) informed and rather unsophisticated, while investment or securities banking divisions (INV\_BANK) are expected to be more skilled and more informed.

Overall, in our 2007 data, we identify 85 members in the SP category, 106 in the SC category, and 44 in the OA category. We note that Slow Clients consist of the larger and more heterogeneous category, made of 10 asset managers, 16 private banks, 24 regional banks, 17 retail brokers, 26 full-line brokers, and 13 investment or securities banking divisions.

## **B Characteristics of the 2007 member categories**

This section explores whether our stylized facts obtained from the 2012-2013 classification of members hold under the earlier conditions of 2007.

### **B.1 Participation to the preopen by member category**

To perform this analysis, we build the following variables for each member: daily trading revenues valued at the closing price or five business days after, the number of orders, the total daily trading volume, and the proportion of aggressive orders. We then average these measures at the category level (SP, SC, or OA).

Table A.1 Panel A reports the main trading characteristics of the three different categories using our 2007 Euronext data. Sophisticated Prop traders are the only category that makes consistent trading profits across days. In contrast, Slow Clients face trading losses, consistent

with a group of traders with less price-sensitive trading strategies, less information, or fewer trading skills than the other two categories. Other Agency traders are more profitable than SC traders, though they still have a low profitability overall. We also find that preopening orders generate higher trading revenues than those submitted during the continuous session. Note that the member ID helps to pin down individual behavior and to obtain better estimates for variables like profitability. Note also that the number of orders reported in Table A.1 Panel A is not directly comparable to our 2012-2013 Eurofidai-Bedofih data since we report activity at the member level (the most granular level). Slow Clients use a higher proportion of marketable orders, but smaller than in 2012-13. Overall, the three categories' characteristics align with those from the categories formed using the 2012-2013 data.

Table A.1: **Descriptive statistics on 2007 members' groups**

Table A.1 reports summary statistics for trading characteristics for member category using Euronext data from January 2007 to April 2007. Panel A focuses on the three main categories: Sophisticated Proprietary traders (SP), Slow Clients (SC), and Other Agency traders (OA). Panel B reports statistics for the sub-categories constituting the Slow Clients category: AM (Asset Managers), Retail Brokers (R\_BROKER), Full-line Brokers (INST\_BROKER), Investment and Securities divisions (INV\_BANK), private banks (PRV\_BANK), and Regional Banks (REG\_BANK). *PROFIT* (resp., *PROFIT\_5D*) is the daily profit valued at the closing price (resp., 5 business days after) and standardized by the euro trading volume (expressed in bps). *PROFIT\_OPENTR* measures the profitability of orders sent during the pre-open once executed and valued at the closing price of the day of the execution. *ORD* is the total daily number of orders. *VOLUME<sub>d</sub>* is the daily trading volume on Euronext (expressed in 1,000 euros). *PROP\_MKTABLE* is the ratio of the number of marketable orders (i.e., any order triggering an immediate execution) over the total number of orders. All variables are calculated at (member, day, stock) level, and then averaged within each category or sub-category across days and stocks.

**Panel A: Trading characteristics for each member category (at member level)**

Member Category	PROFIT (in bps)	PROFIT_5D (in bps)	PROFIT_OPENTR (in bps)	ORD	VOLUME <sub>d</sub> (in €1,000)	PROP_MKTABLE
SP	5.41	4.94	14.74	268	4,516	18
SC	-0.54	-3.96	1.72	48	1,392	24
OA	0.17	-2.67	4.7	223	6,662	18
<i>All</i>	<i>1.71</i>	<i>-0.55</i>	<i>6.88</i>	<i>163</i>	<i>3,641</i>	<i>20</i>

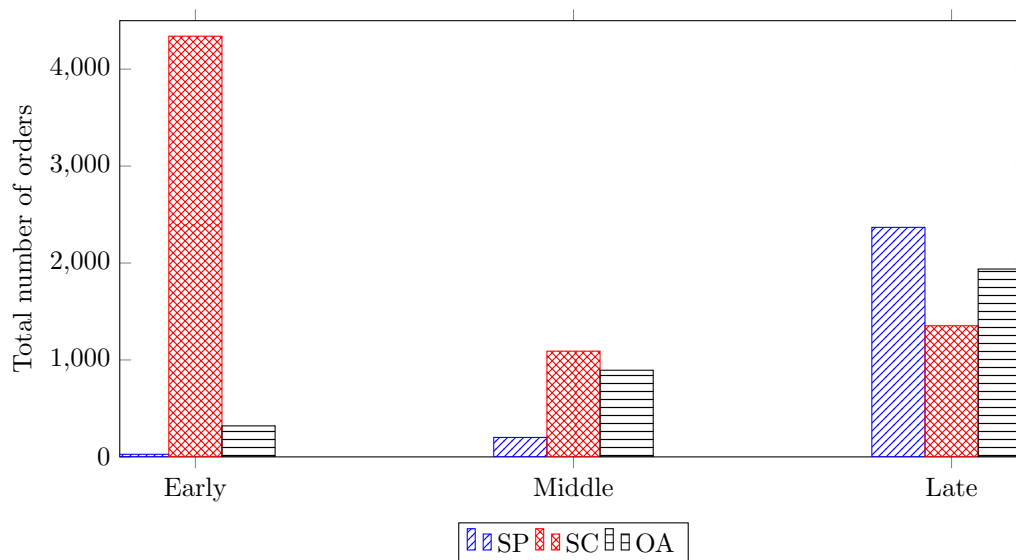
**Panel B: Trading characteristics for each sub-category of Slow Clients (at member level)**

Member Sub-category	PROFIT (in bps)	PROFIT_5D (in bps)	PROFIT_OPENTR (in bps)	ORD	VOLUME <sub>d</sub> (in €1,000)	PROP_MKTABLE
AM	0.06	-6.63	-10.01	15	758	33
R_BROKER	-4.12	-8.39	-1.36	44	437	14
INST_BROKER	-0.83	-0.3	3.34	79	2,326	25
REG_BANK	2.14	-3.56	6.55	18	795	15
INV_BANK	2.3	2.18	5.54	88	2,907	24
PRV_BANK	-3.78	-11.54	-3.8	8	403	39
<i>All</i>	<i>-0.54</i>	<i>-3.96</i>	<i>1.72</i>	<i>47</i>	<i>1,392</i>	<i>24</i>

Figure A.1 illustrates the preopening behavior of our 2007 member categories. It shows the total number of orders submitted by each category (SP, SC, and OA) for the three intervals: early ([7:15-7:45]), middle ([7:45-8:30]), and late ([8:30-9:00]). Slow Clients enter during the early phase, while the other two categories are more active in the late interval. The reverse J-Shape of Slow Clients and the J-Shape of the SP and OA are consistent with the patterns observed in our 2012-13 data.

Figure A.1: **Preopening messages during each interval (early, middle, and late) of the preopen by member category**

Figure A.1 shows the total number of preopening messages for each phase of the preopen (early, middle, and late) and by member category: Sophisticated Prop traders (SP), Slow Clients (SC), and Other Agency traders (OA).



## B.2 Members' participation and price discovery

This section analyzes how members contribute to the daily price discovery. We use EUROFIDAI data to obtain adjusted daily returns, high and low prices of the day. We then build our main variables of interest: standardized order imbalances at the category level for each preopening interval (early, middle, late). We build the lagged volatility (measured by the high-low range) and the lagged daily trading volume, which are our main control variables. Finally, we conduct panel regressions based on Equation (8) in the main text.

Table A.2 Panel A reports the results of this estimation using the 2007 Euronext data. It shows that order imbalances from Slow Clients are significantly and positively related to the daily returns during all three intervals of the preopening period (early, middle, or late). In particular, early order imbalances from Slow Clients are the only ones to contribute to price discovery during this interval, which is a unique and distinctive feature also found in our 2012-2013 data. Order imbalances from the other two categories start to contribute to the daily price discovery only during the middle or/and late intervals, although only the late interval is significant in our 2012-13 data.

In conclusion, our three categories seem to behave in a consistent way across the two periods of our study (2007 and 2012-13) and have a similar contribution to price discovery. In turn, we think that we can reasonably zoom in on the trading behavior of Slow Clients using the sub-categorization described above on our 2007 data to better understand the results obtained in 2012.

Table A.2: **Price discovery and preopening activity of members in 2007**

Table A.2 presents cross-sectional estimates of the relationship between daily returns and variables representing member categories' order imbalances during the preopen, conditional on stock characteristics. The dependent variable is the close-to-close Euronext return  $r^{CC}$  (expressed in bps). The independent variables are the standardized order imbalances for each member category (SP, SC, and OA) and for each interval of the preopening period (early, middle, and late). The control variables are the lagged (log) high-low volatility and the lagged (log) euro trading daily volume, and stock fixed effects. Standard errors are clustered by stock and date. \*\*\*, \*\*, and \* denote significance levels of 1%, 5%, and 10%, respectively.

**Panel A: Price discovery and member preopening behaviors in 2007**

Interval	Determinants	$r^{CC}$
[7:15-7:45]	$\overline{\text{OI}}^{\text{SP}}$	1.28 (0.15)
	$\overline{\text{OI}}^{\text{SC}}$	14.849*** (3.13)
	$\overline{\text{OI}}^{\text{OA}}$	-1.116 (-0.19)
[7:45-8:30]	$\overline{\text{OI}}^{\text{SP}}$	7.495 (1.14)
	$\overline{\text{OI}}^{\text{SC}}$	12.025*** (2.79)
	$\overline{\text{OI}}^{\text{OA}}$	10.943** (2.57)
[8:30-9:00]	$\overline{\text{OI}}^{\text{SP}}$	14.612** (2.75)
	$\overline{\text{OI}}^{\text{SC}}$	12.685** (2.59)
	$\overline{\text{OI}}^{\text{OA}}$	12.104* (1.94)
	Controls	Yes
	Stock FE	Yes
	N	1,991
	Adj. R <sup>2</sup>	0.04

Panel B: Price discovery and Slow Clients in 2007

Interval	Determinants	$r^{CC}$
[7:15-7:45]	$\overline{OI}^{AM}$	-0.126 (-0.11)
	$\overline{OI}^{R\_BROKER}$	-2.871 (-0.66)
	$\overline{OI}^{INST\_BROKER}$	5.371 (1.07)
	$\overline{OI}^{REG\_BANK}$	7.797* (1.83)
	$\overline{OI}^{INV\_BANK}$	7.171 (1.39)
	$\overline{OI}^{PRV\_BANK}$	-1.943 (-0.19)
	[7:45-8:30]	$\overline{OI}^{AM}$
$\overline{OI}^{R\_BROKER}$		6.486 (1.43)
$\overline{OI}^{INST\_BROKER}$		12.231** (2.91)
$\overline{OI}^{REG\_BANK}$		1.965 (0.48)
$\overline{OI}^{INV\_BANK}$		1.969 (0.42)
$\overline{OI}^{PRV\_BANK}$		2.955 (0.40)
[8:30-9:00]		$\overline{OI}^{AM}$
	$\overline{OI}^{R\_BROKER}$	2.19 (0.53)
	$\overline{OI}^{INST\_BROKER}$	14.167*** (3.67)
	$\overline{OI}^{REG\_BANK}$	8.99 (2.15)
	$\overline{OI}^{INV\_BANK}$	16.247 (1.36)
	$\overline{OI}^{PRV\_BANK}$	21.121*** (3.77)
		$\overline{OI}_{[t]}^{SP}$
	$\overline{OI}_{[t]}^{GA}$	Yes
	Controls	Yes
	Stock FE	Yes
	N	2,007
	Adj. R <sup>2</sup>	0.04

## C Price discovery and the heterogeneity of the slow clients category

This section focuses on the Slow Clients category and its decomposition to analyze the contribution of each subgroup to price discovery.

Table A.1 Panel B reports the main trading characteristics of the subgroups constituting the Slow Clients category. Retail brokers (R.BROKERS) face trading losses (across our 4 measures of trading profit), consistent with a subgroup made of liquidity traders who are less or even not informed and less skilled. Note that retail orders (orders sent by R.BROKERS) represent 29% of orders sent by Slow Clients and 16% of the total preopening order flow. Private Banks (PRV\_BANK) are also facing trading losses, most probably because of a high proportion of aggressive (price-insensitive) orders (almost 40%). The trading profitability of the AM, INST\_BROKER, and REG\_BANK subgroups is higher, though still close to zero. In contrast, INV\_BANK are making trading profits across our 4 measures of trading profits. The daily trading activity (in terms of volume or number of orders) of this sub-category is also very high, even higher than INST\_BROKER.

When decomposing the preopening dynamics of order placement from Slow Clients, Figure A.2 shows that the dynamics of order submission from any sub-categories (AM, R.BROKER, INST\_BROKER, INV\_BANK, REG\_BANK), except PRV\_BANKS follows a reverse J-Shape, with a more intense cluster of order submissions in the early phase. The PRV\_BANK group seems to follow a trading strategy more similar to the Sophisticated Prop (SP) category, with a cluster of orders at the end of the preopening phase.

Figure A.2: **Preopening messages during each interval (early, middle, and late) by Slow Brokers subgroup**

Figure A.2 shows the average daily number of preopening messages for each phase of the preopen (early, middle, and late) for each Slow Clients subgroups: Asset Managers (AM), Retail Brokers (R.BROKER), Full-line Brokers (INST.BROKER), Investment and Securities divisions (INV\_BANK), Private Banks (PRV\_BANK), and Regional Banks (REG.BANK).

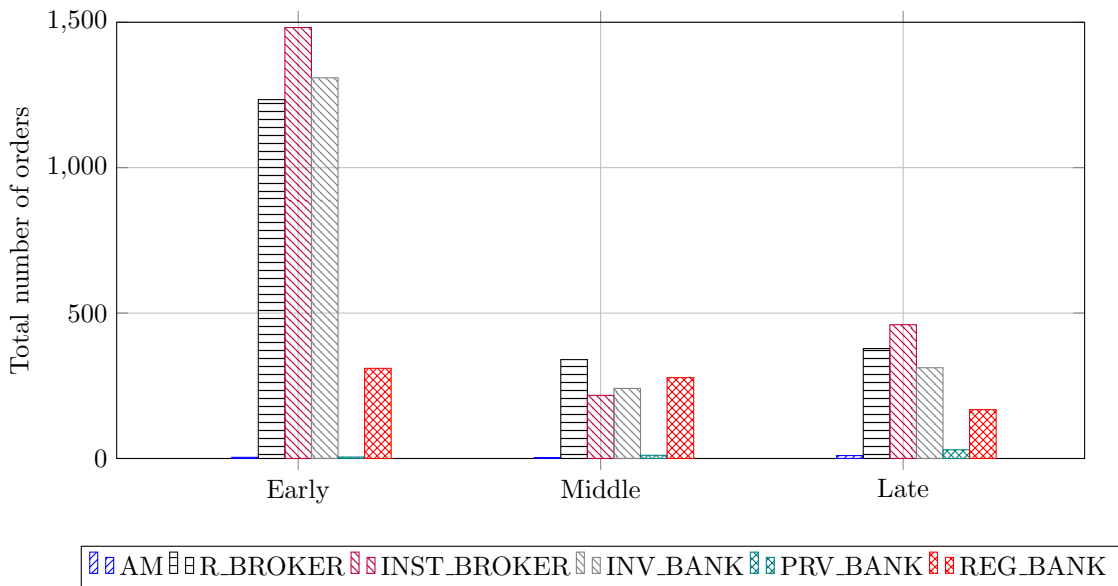


Table A.2 Panel B reports the result of the estimation of Equation (8) in the main text, breaking down the Slow Clients category into its subgroups. First, REG BANK is the only subgroup

which contributes positively and significantly in the early phase (maybe their clients cannot fully control the timing of the submission). Order imbalances from AM contribute systematically negatively, although not significantly, to the daily price discovery, regardless of the preopening interval (early, middle or late). Preopening order imbalances from R\_BROKER and INV\_BANK also do not participate significantly to the daily price discovery, although INV\_BANK always contributes positively. INST\_BROKER is the sub-category from which order imbalances contribute positively to the daily discovery and significantly in the middle and late phases. PRV\_BANK contributes positively and significantly in the late phase, consistent with a subgroup monitoring information leakages.

Results show that the Slow Clients category is diverse. R\_BROKER, directing retail orders, seems uninformed and submit a very high proportion of non-aggressive limit orders adversely selected, corroborating significant trading losses and the absence of contribution to the daily price discovery. INV\_BANK uses profitable trading strategies and is presumably more informed (potentially more on value) but seems to control the amount of information they might impound into prices. These results also show that the mapping between the daily trading revenues and the preopening contribution to the daily price discovery is complex and might reflect short-term vs. long-term information and trading strategies combining aggressive vs. non-aggressive orders more or less efficiently. Our results echo the findings of Menkhoff et al. (2016) in the FX market who find that financial customers (especially long-term investment managers) trade based on superior information, while non-financial customers engage in less informed trading. More recently, Menkveld and Saru (2024) also show that institutional clients on Eurex trade based on long-term fundamental information while intermediaries trade more on news.

## A.2 Order imbalances: two alternative measures

This section explores alternative approaches to measure order imbalances that are used to analyze who participates in the daily price discovery during the pre-open. We conduct robustness tests to understand whether results reported in Table 5 are sensitive to the order imbalance standardization scheme.

Table A.7 shows that there is considerable variation in the standard deviation of order imbalances across intervals and categories. We have standardized order imbalances to allow for meaningful interpretation within each interval. In the main text, we use order imbalances by dividing them by their standard deviation at the category-interval-stock level, along the same lines as Menkhoff et al. (2016). As robustness checks, we propose two alternative approaches to standardize order flows:

(1) The first measure consists of order imbalances standardized by the standard deviation of the total preopening order imbalance at the stock level,

$$OI\_ALT_{l,s,t}^c = \frac{OI_{l,s,t}^c}{\sigma(OI_{s,t})},$$

where  $OI_{s,t} = \sum_l \sum_c OI_{l,s,t}^c$  and  $OI_{l,s,t}^c$  is the measure of order imbalance defined in section .

(2) The second alternative measure defines imbalances as the difference in the number of buy and sell orders (net of cancellations) divided by the total number of orders for each member category  $c$ , and defined at the stock  $s$ , day  $t$ , and preopening time interval  $l$  level:

$$ROIMB_{l,s,t}^c = \frac{NB\_BUY_{l,s,t}^c - NB\_SELL_{l,s,t}^c}{NB\_ORD_{l,s,t}^c}.$$

A similar measure is used in the literature (see, for instance, Chordia et al., 2002, or more recently, Barber et al., 2023 or Jegadeesh and Wu, 2022). Instead of using the number of trades, we use the number of orders since the pre-open is characterized by an absence of transactions.

We conduct panel regressions based on Equation (8) in the main text as robustness exercises to test whether results on the informativeness of order imbalances vary with proxies. The results of these tests are reported below. Table A.3 shows that our results are not sensitive to the way we standardize order imbalances. In particular, SC order imbalances contribute significantly and positively during the entire preopening session.

**Table A.3: Price discovery and preopening members' activity: Alternative standardization schemes for order imbalances**

The setup of this table is identical to Table 5 in the main text but reports results for two alternative standardizations for order flow. We denote standardized order flow by  $Std\_OIMB$ : Column (1) reports results when  $Std\_OIMB = OI\_ALT$  where  $OI\_ALT$  is the ratio between order imbalances and the within-stock standard deviation of order imbalances; Column (2) reports results when  $Std\_OIMB = ROIMB$  where  $ROIMB$  is the ratio between order imbalances and raw volume (in number of orders). Standard errors are clustered by stock and date. \*\*\*, \*\*, and \* denote significance levels of 1%, 5%, and 10%, respectively.

Interval	Determinants	Dependant Variable= $r^{cc}$	
		$Std\_OIMB = OI\_ALT$ (1)	$Std\_OIMB = ROIMB$ (2)
[7:15-7:45]	$Std\_OIMB^{SP}$	-7.84 (-1.12)	2.29 (0.41)
	$Std\_OIMB^{SC}$	38.16*** (3.83)	9.17** (2.12)
	$Std\_OIMB^{OA}$	15.79 (0.69)	4.67 (0.51)
[7:45-8:30]	$Std\_OIMB^{SP}$	8.92*** (2.77)	0.95 (0.37)
	$Std\_OIMB^{SC}$	15.41*** (4.08)	11.72*** (4.41)
	$Std\_OIMB^{OA}$	8.37** (2.34)	4.22 (1.17)
[8:30-9:00]	$Std\_OIMB^{SP}$	22.19*** (6.08)	19.12* (1.67)
	$Std\_OIMB^{SC}$	33.77*** (10.28)	40.66*** (9.50)
	$Std\_OIMB^{OA}$	12.75*** (3.25)	48.31*** (5.37)
	Controls	Yes	Yes
	Stock FE	Yes	Yes
	N	40,043	40,043
	Adj R <sup>2</sup>	0.0175	0.0156

## A.3 Supplementary tables and figures

Table A.4: Variables description

Table A.4 defines the variables used in the paper. Variables are defined by day  $d$  and stock  $s$ . Subscripts are omitted for brevity.

Variable	Definition	Measure
<b>Dummy variables</b>		
$D\_Liq$	A dummy variable that takes the value of 1 if the trading day $t$ is a day with an expected liquidity shock	Witching day and the next day, dividend payment day, the first and last trading day of the quarter
$D\_Inf$	A dummy variable that takes the value of 1 if the trading day $t$ is a day on which an informational shock occurs	Earnings' announcement days
<b>Trade variables</b>		
$p_k$	The price of transaction $k$	
$q_k$	The signed number of shares of transaction $k$	
$\# TRADES\_d$	The daily number of transactions	
$HILO$	Volatility measure based on the price range (Parkinson (1980))	$((\ln(High_t)) - \ln(Low_t))^2 / 4 \ln(2)) \times 100$ , where $High_t$ (resp. $Low_t$ ) is the highest (resp. lowest) transaction price on day $t$ .
$CLOSEP$	The closing call auction price of Euronext	
$TICK\_INCREASE$	A dummy variable that takes the value of 1 if the stock $s$ experience an increase in the tick size.	
$TICK\_DECREASE$	A dummy variable that takes the value of 1 if the stock $s$ experience a reduction in the tick size.	
$OPENP^m$	The price of the first trade on the trading venue $m$	$m = E$ for Euronext and $m = C$ for Chix-X
$r^{CC}$	Close-to-close return	$(CLOSEP_t + DIV_t - CLOSEP_{t-1}) / CLOSEP_{t-1}$
$r^{CO^m}$	Close-to-open return on trading venue $m$	$(OPENP_t^m + DIV_t - CLOSEP_{t-1}) / CLOSEP_{t-1}$
$r_t^{C,IP^\tau}$	Close to time $\tau$ return	$r_t^{C,IP^\tau} = (IP_t^\tau + DIV_t - CLOSEP_{t-1}) / CLOSEP_{t-1}$ where $IP_t^\tau$ is the indicative preopening price at time $\tau$ ( $\tau = 7:30, 7:45, 8:00, 8:15, 8:30, 8:45$ am)
<b>Message traffic variables during the pre-open</b>		
$ORD$	Number of orders (either newly submitted or following an update)	
$CANC$	Number of updates (modification or cancellation)	
$MONITORING$	Monitoring ratio	$CANC / (CANC + ORD)$
$AGGR$	Number of market, market-to-limit, and orders at the call price	
$PCT\_AGGR$	Order aggressiveness ratio	$AGGR / ORD$
$HIDDEN$	Number of orders with a hidden quantity	
$PCT\_HID$	Proportion of hidden orders	$HIDDEN / ORD$
$PCT\_EXEC$	Proportion of orders executed at least partially	
$y_\kappa$	Signed size of order $\kappa$	
<b>Member-types variables</b>		
$N_{s,t}^c$	Total number of transactions executed by member category $c$ on day $t$ in stock $s$	
$PROFIT$	Standardized daily profit (in bps)	$(\sum_{k=1}^{N_{s,t}^c} (-q_k) p_k + \sum_{k=1}^{N_{s,t}^c} q_k \times CLOSEP_{s,t}) / \sum_{k=1}^{N_{s,t}^c}  q_k  p_k \times 10,000$
$ INVENTORY $	Standardized end-of-day inventory position	$ \sum_{k=1}^{N_{s,t}^c} q_k  / \sum_{k=1}^{N_{s,t}^c}  q_k $
$D_c$	A dummy variable that takes the value of 1 if the member category is $c$	$c = SP, LT$ or $OA$
$\overline{OI}_{[l]}^c$	Order imbalances standardized by their within-stock standard deviation generated by the member category $c$ during the interval $[l]$	$\overline{OI}_{[l]}^c = \sum_{\kappa=1}^{N_{[l]}^c} y_\kappa / \sigma(OI_{[l],s}^c)$ where $y_\kappa$ is the signed size of order $\kappa$ (net of cancellations) and $N_{[l]}^c$ is the total number of orders submitted by $c$ in interval $[l]$ ( $[l] = [7:15, 7:45], [7:45-8:30], [8:30-9:00]$ ).

Table A.5: Summary statistics by member-type

Table A.5 reports summary statistics on member-types' activity (per stock and day). We use the proprietary information contained in the speed flag defined by the AMF (HFT, NHFT, and MX) and the account flag (PROP, CLIENT, LP, RP, and RT). The product of the 2 flags gives fifteen combinations, there are no data observed for three types (HFT-RT, HFT-RP, and MX-RT). We classify the twelve remaining combinations into 3 categories: Sophisticated Proprietary traders (SP), Slow Clients (SC), and Other Agency (OA) traders (see Section 3.2.). Panel A measures are based on our trade data.  $VOLUME_d$  is defined as the daily trading volume (in thousands euros) on Euronext (conditional on a trade).  $PCT\_OPEN\_VOL$  is the proportion of daily volume traded at the open.  $PCT\_CLOSE\_VOL$  is the proportion of daily volume traded at the close.  $PROFIT\_OPENTR$  is the daily profit of trades at the open marked-to-market at the closing price.  $PROFIT\_5D$  is the daily profit marked-to-market at the closing price five business days after divided by the euro trading volume (expressed in bps).  $TR\_SIZE$  is the daily average size of the transaction. Panel B measures are based on message data.  $PCT\_MKTABLE$  is the proportion of marketable orders, i.e., orders that trigger an immediate execution (defined only during trading hours and computed from a matching of orders and trades.) The other variables are described in Appendix A.4.

	Sophisticated Proprietary traders					Slow Clients		Other Agency Traders				
	PROP HFT	PROP MX	PROP NHFT	LP HFT	LP MX	CLIENT NHFT	RT NHFT	CLIENT MX	RP MX	CLIENT HFT	LP NHFT	RP NHFT
<b>Panel A: Daily trades</b>												
N	40,086	40,138	40,121	19,343	19,776	40,138	6,241	40,055	37,487	10,873	10,695	11,556
# stocks	97	97	97	47	51	97	54	97	97	62	34	92
# days	416	416	416	416	416	416	231	416	416	387	415	282
$VOLUME_d$ (in 1,000 euros)	1,237	18,753	3,455	17,142	7,036	5,982	75	5,060	2,514	230	176	306
PCT_OPEN_VOL	3.8%	1.1%	2.1%	0.0%	0.7%	3.3%	7.8%	2.2%	0.6%	4.5%	4.2%	1.5%
PCT_CLOSE_VOL	11.1%	25.2%	36.6%	0.3%	10.1%	13.4%	0.5%	24.8%	31.0%	8.1%	7.5%	83.9%
PROFIT_OPENTR	2.33	8.81	10.48	0.32	7.27	-4.22	-7.58	3.71	1.25	4.31	-6.09	10.25
PROFIT_5D	2.19	1.90	3.19	0.53	-1.79	-1.84	-18.00	1.04	-3.40	-4.52	4.73	8.24
TR_SIZE	3,607	4,561	4,498	5,208	5,879	4,749	5,696	4,722	5,369	6,879	6,854	9,010
<b>Panel B: Message traffic during the continuous trading phase</b>												
ORD	4,794	13,447	1,228	32,266	19,690	1,104	1	2,708	2,083	17	78	1
CANC	4,553	12,384	1,058	31,365	19,333	649	0	2,409	1,984	14	75	0
MONITORING	47%	48%	44%	24%	24%	35%	1%	46%	39%	11%	10%	1%
PCT_HID	3%	1%	5%	0%	0%	13%	0%	36%	0%	7%	5%	1%
PCT_AGGR	0%	0%	0%	0%	0%	9%	6%	0%	0%	1%	0%	0%
PCT_EXEC	8%	8%	20%	2%	1%	39%	13%	12%	10%	12%	11%	4%
PCT_MKTABLE	12%	15%	35%	7%	3%	50%	81%	24%	18%	44%	37%	83%

Table A.6: Breakdown of trading volume by member category

Table A.6 reports the cross-sectional averages for the proportion of trading volume (all expressed in %) by member-type (Panel A) and by member category (Panels B and C). Proportions are computed by stock and day, then averaged across stock-day observations. We split the trading day into 3 different phases: (1) Opening call auction, (2) Continuous trading session, and (3) Closing call auction. In Panel A, we report the breakdown of trading volume by member-type (resulting from the product of the speed and account flags). In Panels B and C, we use the classification of member-types into 3 categories: Sophisticated Proprietary traders (SP, in light gray), Slow Clients (SC, in light blue), and Other Agency traders (OA) (see Section 3.2). Panel B reports the market share for each category in each trading phase. Panel C reports the breakdown of the daily trading volume by trading phase for each category.

	(1) Opening call auction				(2) Continuous trading session				(3) Closing call auction				<i>All</i>
	HFT	MX	NHFT	<i>All</i>	HFT	MX	NHFT	<i>All</i>	HFT	MX	NHFT	<i>All</i>	
<b>Panel A: Details</b>													
PROP	6	32	7	45	8	35	5	49	2	52	12	66	52
LP	0	1	2	3	12	4	1	17	0	2	1	3	14
CLIENT	0	12	38	50	0	10	21	31	0	13	12	25	31
RT	-	-	0	0	-	-	0	0	-	-	0	0	0
RP	-	2	0	2	-	3	0	3	-	5	1	6	3
<i>All</i>	6	48	46	100	20	52	28	100	2	72	26	100	100
<b>Panel B: By trading phase, market shares for each member category</b>													
SP		46				65				68			65
SC		38				21				12			20
OA		16				14				20			15
<i>All</i>		100				100				100			100
<b>Panel C: By member category, trading activity in each trading phase</b>													
SP	1				79				20				100
SC	3				83				13				100
OA	2				73				25				100
<i>All</i>	2				79				19				100

Table A.7: Descriptive statistics on order imbalances

Table A.7 reports summary statistics (per stock and day) for order imbalances (expressed in 1,000 shares) generated for each member category  $c$  in each interval  $[l]$  and denoted  $OI_{[l]}^c$  ( $c = SP, SC,$  and  $OA$  and  $l =$  early, middle, late phase of the pre-open, and the overall pre-opening session). See Table A.4 for a description of the standardized version of order imbalances presented non-standardized in this table.

Interval	Determinants	N	Mean	Std. Dev.	Min	Max
[7:15-7:45]	$OI^{SP}$	40,138	-0.0553	8.94	-500	1,163
	$OI^{SC}$	40,138	-1.892	21.72	-1,301	285
	$OI^{OA}$	40,138	0.0311	1.75	-130	250
[7:45-8:30]	$OI^{SP}$	40,138	2.485	74.39	-955	1,523
	$OI^{SC}$	40,138	-0.784	19.50	-1,024	505
	$OI^{OA}$	40,138	1.240	19.02	-1,012	1,012
[8:30-9:00]	$OI^{SP}$	40,138	-9.980	69.55	-1,704	2,201
	$OI^{SC}$	40,138	1.019	33.13	-1,042	945
	$OI^{OA}$	40,138	2.481	55.16	-1,994	1,640
[7:15-9:00]	$OI^{SP}$	40,138	-7.551	105.42	-1,972	1,990
	$OI^{SC}$	40,138	-1.658	46.47	-1,165	1,439
	$OI^{OA}$	40,138	3.753	57.87	-2,003	1,653

**Table A.8: Determinants for trading on Chi-X before Euronext open: Selection equation**

Table A.8 reports the estimates of the likelihood of a first trade taking place on Chi-X before the Euronext open, i.e., the estimates of a probit regression of the following selection equation:

$$T_{s,t} = \Phi(a + b \cdot Z_{s,t} + \eta_{s,t}),$$

where  $T$  is a dummy variable that takes the value of 1 if stock  $s$  belongs to Group  $T$  on day  $t$ .  $Z$  is a vector of control variables that include the (log) number of opening trades on Euronext ( $\# OPEN\_TR$ ), the (log) number of preopening orders submitted by each category of members,  $ORD^c$  (with  $c = SP, SC,$  and  $OA$ ), the (log) high-low volatility ( $HILO$ ), and the (log) firm's size proxied by the market capitalization ( $MARKET\_CAP$ ). All variables are lagged and measured on the last day of the previous week. Column (1) reports estimates for the delayed opening on the day of the preopening glitch, June 6, 2013. Column (2) shows estimates for other delayed openings (excluding the glitch). t-statistics are reported in parentheses. \*\*\*, \*\*, and \* denote significance levels of 1%, 5%, and 10%, respectively.

	Group $T$	
	Glitch (1)	Other delayed openings (2)
Lagged.ORD <sup>SP</sup>	1.283*** (7.11)	0.317*** (2.39)
Lagged.ORD <sup>SC</sup>	-0.265 (-1.78)	-0.413*** (-2.26)
Lagged.ORD <sup>OA</sup>	0.707*** (6.66)	-0.057 (-0.35)
Lagged.# OPEN_TR	-0.598*** (-3.27)	0.666*** (3.39)
Lagged.HILO	14.91*** (2.89)	-8.73 (-1.64)
Lagged.MARKET_CAP	0.388*** (4.06)	0.471*** (2.95)
Constant	-10.58*** (-11.34)	-6.10*** (-4.21)
N	479	337
Pseudo R <sup>2</sup>	0.43	0.19

Table A.9: Daily price discovery on days with delayed openings

Table A.9 reports estimates from regressions capturing the impact of preopening order imbalances on Euronext price discovery on the glitch day or on days with delayed openings (excluding the glitch). In Columns 1 and 3, the dependent variable is the Euronext close-to-close return  $r^{CC}$ . In Columns 2 and 4, the dependent variable is the Euronext close-to-open return ( $r^{CO^E}$ ). The explanatory variables of interest are the interactions of standardized order imbalances measured on the early interval ( $> 30'$  before open), or late interval ( $< 30'$  before open) by member category  $c$  ( $c = \text{SP, SC}$ ), with a dummy variable  $Delay$  that is equal to one on the day of the glitch or on days with other delayed openings. We also show the dummy  $Delay$ , the interactions of standardized order imbalances of OA traders with the dummy capturing delayed openings, and order imbalances for all member categories ( $c = \text{SP, SC, OA}$ ). All specifications use the following control variables: the lagged (log) high-low volatility ( $HILO_{-1}$ ), the lagged (log) total daily number of trades in euros ( $\#TRADES_{-1}$ ) that control for the level of the daily activity of the previous trading day, and the total (log) number of preopening orders for each member category ( $ORD^c$ ) ( $c = \text{SP, SC, and OA}$ ). Standard errors are clustered by stock. \*\*\*, \*\*, and \* denote significance levels of 1%, 5%, and 10%, respectively.

Variables	Glitch		Other delayed openings		
	$r^{CC}$ (1)	$r^{CO^E}$ (2)	$r^{CC}$ (3)	$r^{CO^E}$ (4)	
Early $_{>30' \text{ before open}}$	$\overline{OI}^{\text{SP}} \times \text{Delay}$	-0.135 (-0.24)	0.032 (0.08)	12.16 (1.39)	-0.708 (-0.18)
	$\overline{OI}^{\text{SC}} \times \text{Delay}$	-0.285 (-0.52)	0.477 (1.12)	-29.52* (-1.66)	3.661 (0.44)
	$\overline{OI}^{\text{OA}} \times \text{Delay}$	0.519 (0.78)	0.565 (1.15)	19.21 (0.71)	6.032 (1.08)
Late $_{<30' \text{ before open}}$	$\overline{OI}^{\text{SP}} \times \text{Delay}$	1.552*** (2.99)	-0.068 (-0.20)	-17.29 (-0.80)	8.635** (2.03)
	$\overline{OI}^{\text{SC}} \times \text{Delay}$	1.417*** (2.84)	0.598* (1.78)	24.60 (1.64)	2.267 (0.44)
	$\overline{OI}^{\text{OA}} \times \text{Delay}$	0.337 (0.53)	0.095 (0.27)	-34.91*** (-2.87)	-0.188 (-0.03)
Early $_{>30' \text{ before open}}$	$\overline{OI}^{\text{SP}}$	-27.48*** (-3.27)	-5.396 (-1.63)	12.19* (1.79)	2.123 (0.62)
	$\overline{OI}^{\text{SC}}$	3.350 (0.32)	16.36*** (2.61)	-16.73 (-0.92)	10.23 (1.31)
	$\overline{OI}^{\text{OA}}$	-0.365 (-0.05)	1.471 (0.42)	0.628 (0.07)	-0.145 (-0.04)
Late $_{<30' \text{ before open}}$	$\overline{OI}^{\text{SP}}$	10.26 (1.23)	5.321 (0.88)	-5.432 (-0.73)	-0.571 (-0.12)
	$\overline{OI}^{\text{SC}}$	20.88** (2.14)	10.66* (1.87)	26.46** (2.43)	9.194** (2.15)
	$\overline{OI}^{\text{OA}}$	14.00 (1.12)	15.90*** (2.67)	-10.82 (-0.97)	7.592 (1.58)
Delay	-64.12*** (-4.19)	8.686 (1.02)	-4.202 (-0.22)	16.59*** (2.79)	
Constant	52.67 (0.84)	7.011 (0.24)	-34.21 (-0.36)	-30.65 (-0.74)	
Controls	Yes	Yes	Yes	Yes	
Stock FE	No	No	No	No	
N	479	479	337	337	
R <sup>2</sup>	0.0923	0.0946	0.0631	0.0693	

Table A.10: Descriptive statistics about delayed openings (excluding the glitch)

Table A.10 reports the cross-sectional averages of different preopening and opening activity variables on days with delayed openings (excluding the glitch) and during normal or “control” days of the same week. Group *C* consists of stocks for which we observe a trade on Chi-X *after* the open on Euronext. Group *T* includes stocks starting to trade on Chi-X *before* the open on Euronext. For Euronext, we report the number of orders sent during the preopening phase (*ORD*), the monitoring ratio (*MONITORING*), the proportion of hidden volume (*PCT\_HID*), and the aggressiveness ratio (*PCT\_AGGR*). All these variables are defined in the caption of Table A.4. We also report the number of trades executed at the opening auction (*# OPEN\_TR*) and the relative bid-ask spread measured 15 minutes after the opening call auction (*QUOTED\_SPREAD (OPEN+15')*) and expressed in bps. For Chi-X, we report the following variables: *Delay of the 1st trade relative to the Euronext open* (expressed in minutes and negative if trades occur before the Euronext open) and *QUOTED\_SPREAD (1st trade+15')*, which is the relative quoted spread on Chi-X measured 15 minutes after the first trade on Chi-X (expressed in bps). \*, \*\*, and \*\*\* denote statistical significance at the 10%, 5% and 1% levels, respectively, for the two-tailed hypothesis t-student test that the difference between means in the two periods equals zero.

	Trading on Chi-X					
	Before the open on Euronext			After the open on Euronext		
	Delayed	Normal	<i>t</i> -stat	Delayed	Normal	<i>t</i> -stat
# stock-events	12	10		62	59	
<b>Panel A: Euronext</b>						
Time of the opening call auction	09:21:27	09:00:00	(2.39) **	09:11:47	09:00:00	(4.69) **
ORD	82	108	(-0.98)	73	88	(-1.54)
MONITORING	8.9%	13.1%	(-1.72)	9.0%	11.6%	(-1.96) *
PCT_HID	12.5%	11.0%	(0.52)	15.2%	13.6%	(0.82)
PCT_AGGR	2.2%	7.2%	(-3.69) ***	1.8%	6.2%	(-7.49) ***
# OPEN_TR	1	8.11	(-6.75) ***	1	7.45	(-14.98) ***
QUOTED_SPREAD (OPEN+15')	21.2	25.9	(-1.21)	33.7	36.2	(-0.78)
<b>Panel B: Chi-X</b>						
Delay of the 1st trade relative to the Euronext open	-12'	21'	(-0.70)	55'	48'	(1.39)
QUOTED_SPREAD (1st trade +15')	40.4	74.8	(-1.04)	110.1	102.5	(0.43)

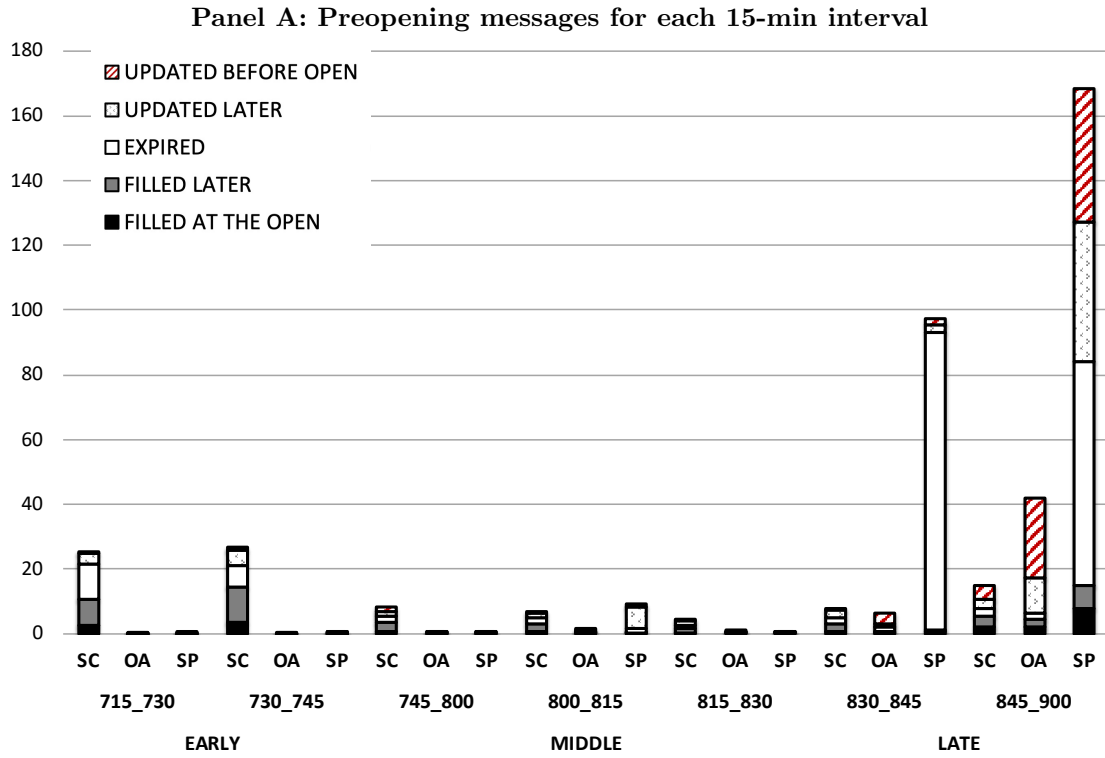
Table A.11: Price discovery measures and late preopening activity of member categories, decomposing SP traders by speed and account

The setup of this table is identical to Table 5 in the main text but reports results for splitting SP imbalances in sub-categories. We use the speed and account flag and denote the member-type (PROP+HFT) as SP\_HFT, the member-type (PROP+MX) as SP\_MX, the member-type (PROP+NHFT) as SP\_NHFT, and the last two member-types, (LP+HFT) and (LP+MX), as Liquidity Providers (SP\_LP). Orders imbalances  $\overline{OI}_t^c$  in intervals [7:15-7:45] and [7:45-8:30] for sub-categories  $c \in \{SP\_LP, SP\_HFT, SP\_MX, SP\_NHFT, SC, OA\}$  and  $\overline{OI}_{[8:30-9:00]}^{OA}$  are omitted for brevity. Standard errors are clustered by stock and date. \*\*\*, \*\*, and \* denote significance levels of 1%, 5%, and 10%, respectively.

	$r^{CC}$	$r^{CC}$	$r^{CC}$
		If D.Liq= 1	If D.Inf= 1
	(1)	(2)	(3)
	$\overline{OI}^{SP\_LP}$	-12.41*** (-7.23)	-9.472* (-1.97)
	$\overline{OI}^{SP\_HFT}$	-0.062 (-0.04)	-0.004 (-0.00)
[8:30-9:00]	$\overline{OI}^{SP\_MX}$	12.38*** (6.78)	18.27*** (3.44)
	$\overline{OI}^{SP\_NHFT}$	3.740*** (2.88)	0.203 (0.09)
	$\overline{OI}^{SC}$	18.04*** (12.21)	9.126*** (2.67)
	$\overline{OI}_{[7:15-7:45]}^c, \forall c$	Yes	Yes
	$\overline{OI}_{[7:45-8:30]}^c, \forall c$	Yes	Yes
	$\overline{OI}_{[8:30-9:00]}^{OA}, \forall c$	Yes	Yes
	Controls	Yes	Yes
	Stock FE	Yes	Yes
	N	40,043	4,690
	Adj R <sup>2</sup>	0.0252	0.0256
			0.2071

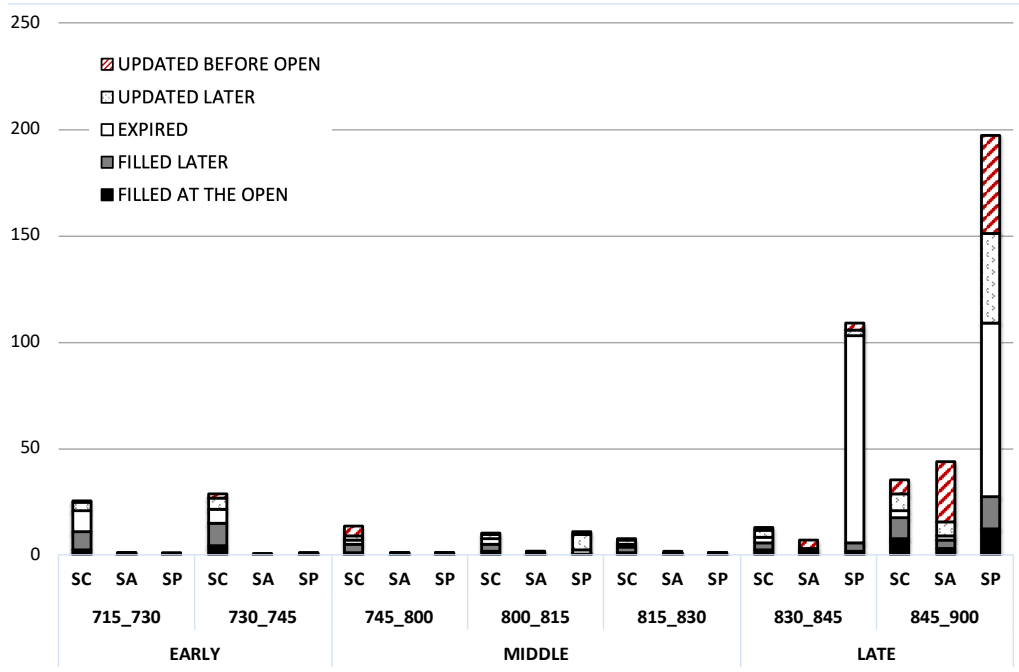
**Figure A.3: Preopening messages for each 15-min interval on normal days and on days with informational or liquidity shocks**

Figure A.3 illustrates the total number of preopening orders (per stock and day) for each 15-min interval between 7:15 am and 9:00 am. The total number of orders is split by category of members, namely Sophisticated Proprietary (SP), Slow Clients (SC), and Other Agency (OA) traders. The bars are then broken down into five order events, namely (i) filled at least partially at the open; (ii) filled after the open; (iii) expired; (iv) updated (i.e., modified or canceled) after the open; or (v) updated before the open. Panel A report averages across all stock-day observations. Panel B focuses on days with informational shocks (Graph (a)) and on days with liquidity shocks (Graph (b).)

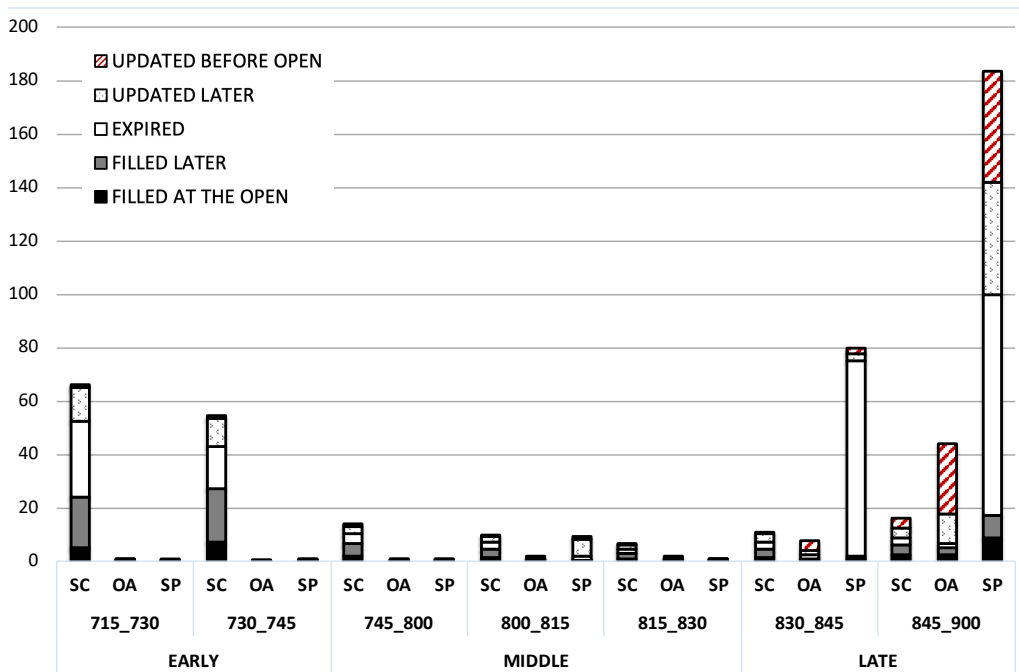


Panel B: Preopening messages for each 15-min interval on days with informational shocks or on days with expected liquidity shocks

Graph (a) : Earnings announcement days



Graph (b) : Expected Liquidity Shocks days



## References

- Barber, B.M., Lin, S., Odean, T., 2023. Resolving a paradox: retail trades positively predict returns but are not profitable. Available at SSRN 3783492 .
- Chordia, T., Roll, R., Subrahmanyam, A., 2002. Order imbalance, liquidity, and market returns. *Journal of Financial Economics* , 111–130.
- Daures-Lescouret, L., Moinas, S., 2023. Fragmentation and strategic market-making. *Journal of Financial and Quantitative Analysis* 58, 1675–1700.
- Jegadeesh, N., Wu, Y., 2022. Closing auctions: Nasdaq versus NYSE. *Journal of Financial Economics* 143, 1120–1139.
- Menkhoff, L., Sarno, L., Schmeling, M., Schrimpf, A., 2016. Information flows in foreign exchange markets: Dissecting customer currency trades. *Journal of Finance* 71, 601–634.
- Menkveld, A.J., Saru, I.L., 2024. Who knows? information differences between trader types. Vrije Amsterdam working paper.
- Parkinson, M., 1980. The extreme value method for estimating the variance of the rate of return. *Journal of Business* 53, 61–65.