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Why Do Traders Choose to Trade Anonymously?

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Abstract

This paper examines the use, determinants, and impact of anonymous orders in a market where disclosure of broker identity in the trading screen is voluntary. We find that most trading occurs nonanonymously, contrary to prior literature that suggests liquidity gravitates to anonymous markets. By strategically using anonymity when it is beneficial, traders reduce their execution costs. Traders select anonymity based on various factors including order source, order size and aggressiveness, time of day, liquidity, and expected execution costs. Finally, we report how anonymous orders affect market quality and discuss implications for market design.

I. Introduction

Anonymity plays a key role in market participants' trading strategies as part of their efforts to obtain best execution. It is also an important element of market design for exchanges, as it affects their competitiveness vis-à-vis other markets. However, the use of anonymity by strategic traders, and its impact on execution costs, is neither well understood nor widely documented. This paper examines the characteristics of anonymous orders on the Toronto Stock Exchange (TSX), where disclosure of the broker's identity (ID) is voluntary. We investigate the determinants of anonymous orders. We also examine if the strategic use of anonymity

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allows traders to reduce execution costs and assess how anonymous orders affect market quality.

In recent years, many exchanges including the TSX, NASDAQ, and the London Stock Exchange (LSE) (through its SETSmm system for small and medium-sized companies) have begun to offer the choice of trading anonymously when accessing the central order book. This has occurred largely in response to market demand for trading anonymity and increased competition from electronic communication networks (ECNs) that offer anonymous trading. Several U.S. exchanges, including the New York Stock Exchange (NYSE) and NYSE AMEX Equities, have introduced hybrid trading systems that offer users the choice of (anonymous) automated order execution and (nonanonymous) auction order execution systems.

Despite the increasing interest in side-by-side anonymous and nonanonymous trading, there is relatively little empirical evidence on how anonymous orders are used in such systems, or how their execution costs compare to those of nonanonymous orders. This issue is relevant given the regulatory requirements for intermediaries to be publicly accountable on their order execution practices. It is also important given the concern among market participants about the impact of anonymous orders on price discovery and market quality.

This study makes three main contributions to our understanding of the use of anonymity in securities trading. First, we provide an overview of the use of anonymous orders on a market where the disclosure of broker ID in the trading screen is voluntary. Our data allow us to circumvent problems inherent in previous studies that either: i) compare trading on separate anonymous and nonanonymous platforms (e.g., Barclay, Hendershott, and McCormick (2003), Grammig, Schiereck, and Theissen (2001), and Reiss and Werner (2005)); or that ii) compare trading before and after a one-off regulatory change in ID disclosure requirements (e.g., Foucault, Moinas, and Theissen (2007), Comerton-Forde and Tang (2009)). The detailed TSX data also allow us to investigate the use of anonymity for specific order sources: client, proprietary, nonclient, specialist, and options market maker accounts.

We find that, despite having the option of anonymity, most traders choose to trade nonanonymously. This raises the question of whether fully anonymous markets are optimal in meeting the needs of their users. The majority of anonymous orders are in the form of passive limit orders placed by client and proprietary accounts. However, specialists account for a large proportion of aggressive anonymous market orders. It is possible that specialists prefer to trade anonymously when they possess superior knowledge of pending large trades. One source of such information is from orders being "shopped" in the upstairs market (Griffiths, Smith, Turnbull, and White (2000), Davies (2003)). In such instances, anonymity is useful for concealing information, thus reducing the immediate price impact of their trades.

Our second contribution is in modeling the determinants of the decision to trade anonymously, and examining if these decisions result in lower execution costs. This is the first study to examine these issues on a common trading system within a common time period. We find that by strategically selecting anonymity when it is beneficial, traders reduce their execution costs. This is likely

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to be because informed traders use anonymity to reduce opportunities for trading ahead and piggybacking.[1] At the same time, patient uninformed traders can use anonymity to make it more difficult for other traders to identify their individual trading patterns and "pick off" their limit orders. Of all the order sources, specialists and options market makers benefit the most from the strategic use of anonymity.

Our third contribution is in assessing the effects of anonymous orders on short-term market quality and highlighting implications for market design. If anonymity is more advantageous to informed traders, as suggested by our results, ceteris paribus, anonymous markets could be expected to attract informed traders, leading to higher adverse selection costs. Further, our finding that the strategic use of anonymity is able to reduce price impact suggests that providing traders with the option to use anonymity may encourage traders to engage in more fundamental research or to trade more aggressively on their information.

II. Review of Literature

A. Determinants of Anonymous Trading

Many theoretical studies predict that informed traders prefer less transparent trading venues (e.g., Roëll (1990), Admati and Pfleiderer (1991), Forster and George (1992), Fishman and Longstaff (1992), and Rindi (2008)). This is because market participants are better able to infer the probability of informed trading by observing the IDs of traders (Linnainmaa (2007)) and subsequently engage in trading-ahead and piggybacking behavior, which increases informed traders' execution costs (Harris (1996)).

However, the empirical evidence on informed traders' preference for anonymity yields mixed results (e.g., Barclay et al. (2003), Grammig et al. (2001), Perotti and Rindi (2006), and Reiss and Werner (2005)). The mixed results may stem in part from the difficulty in fully controlling for fundamental differences in market structures, costs, and, in particular, accessibility across different trading systems. These factors often play a strong role in the trader's choice of trading system, rather than the attractiveness of anonymity on that trading system per se.

Large liquidity traders may also prefer anonymity if it allows them to reduce their execution costs. Economides and Schwartz (1995) report that large buy-side institutional investors value anonymity, as it allows them to conceal their trading needs and better manage their order exposure risk.

Order source is another potentially important determinant of anonymity. Anecdotal evidence indicates that a substantial amount of algorithmic trading by direct market access participants is conducted anonymously on the TSX. This may be because the lack of randomization in algorithmic trading makes such strategies more susceptible to frontrunning (Domowitz and Yegerman (2005)).

[1] While it may be argued that traders who submit market orders that execute immediately have no cause to be concerned about trading ahead, this concern remains if such orders are part of an order-splitting strategy.

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In addition, potential conflicts of interest arise where brokers can identify their clients' algorithmic trading patterns and position themselves to take advantage of these anticipated trades (Patel (2006)).

Specialists and proprietary traders may use anonymity in order to: i) prevent other traders from observing informed trades; ii) prevent other traders from tracking their inventory position, which can be an indicator of sentiment or order imbalance; iii) prevent issuers or clients from tracking proprietary trading that may be at odds with the issuer's or client's interests, for example, executing sell orders in a stock for which the broker issued a buy recommendation to a client; and iv) avoid complaints and retaliation from other traders for entering "annoying" orders such as "pennying" (posting an order 1 tick better than the best bid or ask in order to get execution priority over the orders at the prevailing best quotes). Specialists and proprietary traders may possess an informational advantage from their familiarity with order flow, knowledge of pending client trades, or in-house research (Davies (2003), Kurov and Lasser (2004), Naik, Neuberger, and Viswanathan (1999), and Reiss and Werner (2005)). In handling a public limit order, a TSX member firm is allowed 15 minutes to "shop" the order in the upstairs market before sending it to the downstairs market (Griffiths et al. (2000)). Some participants therefore become aware of the presence of a large order. Davies (2003) suggests that TSX specialists may be able to obtain information from upstairs traders on pending orders and exploit such knowledge accordingly.

The level of information asymmetry in a stock may also influence traders' preferences for anonymity. Theissen (2002) reports that traders generally prefer the nonanonymous German floor trading system for less liquid stocks and the anonymous electronic trading system for blue chip stocks. This is consistent with the prediction of Foucault et al. (2007) that anonymity tends to be less favorable for stocks with high information asymmetry (as it compounds adverse selection costs and illiquidity), but promotes liquidity in stocks with low information asymmetry.

Little evidence exists on the interaction, if any, between trade size and anonymity. Patient informed traders with slowly decaying information often use stealth trading strategies to conceal their presence (Barclay and Warner (1993), Patel (2006), Davies (2003), and Kurov and Lasser (2004)). If such traders make use of anonymity, anonymous orders would tend to be small or medium sized.

B. Anonymity and Market Quality

The literature is not conclusive on how anonymity affects market quality. Theissen's (2003) study on the Frankfurt Stock Exchange suggests that anonymous markets are associated with higher adverse selection risk. This may deter uninformed liquidity. However, Foucault et al. (2007) report that the removal of broker IDs on Euronext Paris resulted in reduced quoted spreads and enhanced depth. Their theoretical model suggests the reduction in spreads is the result of informed traders posting better prices due to reduced risk of piggybacking by other traders. Similarly, Comerton-Forde and Tang (2009) find that liquidity increased on the Australian Stock Exchange (ASX) following the removal of

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broker IDs. Simaan, Weaver, and Whitcomb (2003) argue that the introduction of an anonymous order type on the NASDAQ could improve price competition and narrow spreads. A market consultation paper published by the ASX in 2003 argues that disclosing broker IDs encourages predatory trading and increases trading costs.[2] Consequently, disclosure of broker IDs may deter efficient price discovery as traders shift liquidity off-market. This is consistent with Barclay et al. (2003), who find that anonymous markets attract informed traders and consequently lead price discovery.

Rindi (2008) reconciles the seemingly mixed empirical findings with the following theoretical model: When information acquisition is exogenous (e.g., when insider trading is prevalent), anonymity increases information asymmetry and leads to reduced liquidity, as uninformed traders are less willing to supply liquidity. However, when information acquisition is endogenous (e.g., traders become informed through research), anonymity increases the incentive to acquire such information, consequently increasing the number of informed traders. The increase in informed traders in Rindi's model increases overall market liquidity because informed traders are effective liquidity suppliers. Perotti and Rindi (2006) support these theoretical insights, reporting that in an experimental market where information acquisition is endogenous, anonymity encourages information acquisition and increases market liquidity.

III. The Toronto Stock Exchange

The TSX is Canada's main stock exchange and is a fully electronic continuous auction market that trades from 9:30 AM to 4:00 PM. Since 22 March 2002, TSX brokers have had the option of displaying their broker IDs on their orders (an "attributed" order, the default setting) or not displaying their IDs (an "unattributed" order). This feature is similar to that offered by NASDAQ's trading platform and the LSE's SETSqx trading system for less liquid stocks. On the TSX, anonymous orders carry a generic "001" numeric tag in place of the broker ID, which remains with the order after execution. The market regulator has the capacity to identify and track all anonymous orders. At the end of the trading day the exchange relays the broker IDs of anonymous orders to the central depository for settlement purposes.

The decision to trade anonymously can be made by either the client or the trader. In general, client orders submitted to the trading desk are traded anonymously at the trader's discretion. The client may request that the order be submitted anonymously, although anecdotal evidence indicates that this is relatively uncommon. The ability of clients to use anonymity may also be restricted by the conflicting interests of brokers, for whom displaying the broker ID has valuable advertising effects. Some traders may choose to conceal their trading activity by using iceberg orders. However, we do not specifically consider iceberg orders

[2] See, "ASX Market Reforms: Enhancing the Liquidity of the Australian Equity Market," consultation paper published by the Australian Stock Exchange (25 November 2003).

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in our analysis, as they primarily represent another dimension of pretrade transparency (the concealment of volume rather than the concealment of ID).[3,4]

The TSX is a hybrid market combining an electronic order-driven market with market maker intermediation, similar to the NYSE, NASDAQ, NYSE AMEX Equities, and LSE. On the TSX, listed companies are assigned a specialist (also known as a Registered Trader) who performs a market making function. The specialist is required to trade all orders up to the "minimum guaranteed fill" (MGF) at the inside bid or ask when there are insufficient committed orders to fill the incoming order at that price. The MGF is determined by the specialist, with a required minimum size of 2 board lots less 1 share. Specialists can also trade in stocks other than their designated stocks.

IV. Data

The TSX's order and trading book data are provided by Market Regulation Services Inc. ("RS," now known as the Investment Industry Regulatory Organization of Canada), which is responsible for investor protection and the regulation of Canada's securities markets. Of the 1,421 companies listed on the TSX at end-2004, we include in our sample those that have a single stock code and are continuously listed with daily turnover exceeding $50,000 throughout the sample period.[5] The final sample consists of 141 securities and covers the 59 trading days over the period 1 May–31 July 2004. The data include the price, volume, date, and time stamp of every order and trade, the numeric identifier of the broker submitting the order, and a marker indicating whether or not the order is anonymous.

The data also identify the type of party initiating the order (i.e., client, proprietary, specialist, nonclient, or options market maker), which is not seen by market participants, and the direction of the order (i.e., buy or sell). Client orders include direct market access orders from participating institutions. Proprietary orders are made on behalf of the broker's principal account and can be motivated by either inventory or speculative reasons. Specialist orders are those submitted by designated specialists in both their designated stocks and nondesignated stocks. Nonclient orders include orders for the employees, directors, and officers of the broking firm and its affiliates. There are a total of 88 brokers in the sample. A key feature of this data set is that we are able to observe the IDs of the brokers submitting anonymous orders (which are not seen by other market participants) as well as those of nonanonymous orders.

[3]Anand and Weaver (2004) find that hidden limit orders represent less than 1% of all limit orders on the TSX, and less than 7% of total order volume.

[4]Traders can also conceal their IDs through the use of jitney orders, where brokers route orders to other brokers (i.e., jitney brokers) for subsequent execution. Such orders are a long-standing feature of the Canadian stock market and used for a variety of reasons, such as when a broker's volume of trade is so small that it is more economical to channel its orders through other brokers, who charge them a discounted brokerage fee. The jitney orders only constitute 2.42% of all orders and are not expected to play a major role in the analysis of the effects of anonymity.

[5]Some companies have multiple stock codes denoting different types of securities, for example, Alliance Atlantis Communications Inc., which is listed as AAC.A and AAC.B. These securities are excluded from our analysis.

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We limit our study to orders submitted for execution through the central limit order book and therefore exclude block trades executed in the upstairs market and in-house crossings.[6] This is done for several reasons. First, pretrade anonymity between the potential counterparties is not possible in upstairs trading and in-house crossings, as the brokers negotiating such trades know each other's IDs. It is possible to examine posttrade effects where upstairs and in-house crossing traders report their trades anonymously, but the use of anonymity in such cases is negligible (0.6% of all upstairs trades and in-house crosses are disclosed anonymously).[7] Second, we are unable to accurately observe the order initiation or negotiation times and therefore cannot determine the prevailing market conditions at the time of order initiation or at the time the trade is negotiated.

We exclude odd lot orders, trades initiated by the exchange's daily opening trade allocation mechanism, and orders submitted when the bid and ask quotes are temporarily overlapping.[8] The final sample contains 21.4 million orders, made up of 1.6 million market orders and 19.8 million limit orders. We define market orders as those orders that execute immediately, initiating trades (this includes marketable limit orders), and therefore the number of trades in our sample is equal to the number of market orders (1.6 million).

V. Characteristics of Anonymity Use

A. Anonymity Use and Order Size

Contrary to the prediction of Bloomfield and O'Hara (2000) that transparent markets will eventually lose order flow to less transparent markets, we find that traders normally disclose their IDs despite having the option of anonymity. Table 1 reports anonymous and nonanonymous volumes by order direction. Anonymous orders account for only 6% of limit order volume and 8% of market order (trade) volume (all volumes are denoted in dollar terms). A slightly higher proportion (57%) of anonymous limit order volume is in the form of sell orders compared to nonanonymous orders (51%), but the opposite is true for market orders.

Anonymous limit orders also tend to be much smaller than nonanonymous limit orders: The average anonymous limit order of $21,003 is less than half the average nonanonymous limit order of $49,579. Evidence from other markets demonstrates that traders sometimes attempt to smooth their market impact and reduce their execution costs by submitting small orders that are eligible for automatic fill by the specialist (Huang and Masulis (2003), Reiss and Werner (2005)). It is possible that some TSX traders not only use such a strategy to reduce their

[6] This results in the exclusion of 25,139 crossings and upstairs trades constituting 0.9% of the total number of trades and 38% of total traded value in the raw sample.

[7] The types of traders that care about posttrade market effects are mainly the informed and those using order-splitting strategies. Upstairs trades and in-house crosses typically fall into neither of these categories.

[8] Temporary quote overlaps may occur when some stocks experience opening delays beyond the official opening time of 9:30 AM.

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TABLE 1

Anonymous and Nonanonymous Volumes by Order Direction

Table 1 reports the breakdown of anonymous and nonanonymous dollar volumes by order direction. The percentages of total dollar volume, mean, and median order size for market and limit orders are reported for the entire sample.

	Market Orders			Limit Orders		
Volume Types	% of Total	Mean	Median	% of Total	Mean	Median
Total volume	100%	$40,586	$12,680	100%	$46,108	$21,020
Nonanon. volume	92%	$40,002	$12,350	94%	$49,579	$22,820
Buy orders	53%	$38,837	$12,086	49%	$50,650	$23,430
Sell orders	47%	$41,380	$12,685	51%	$48,602	$22,410
Anon. volume	8%	$48,167	$20,250	6%	$21,003	$11,170
Buy orders	53%	$47,708	$20,340	43%	$17,787	$10,062
Sell orders	47%	$48,687	$20,160	57%	$24,304	$12,492

execution costs, but supplement it by using anonymity to further reduce their order exposure risk.

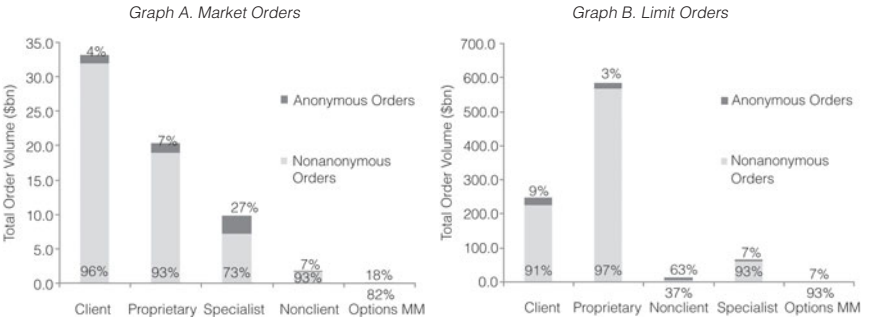
B. Order Source

The breakdown of anonymous order volumes by their sources reveals that proprietary and client accounts are responsible for the largest share of anonymous limit order volumes (Figure 1). This is expected, given that these order sources account for the bulk of all order volume. In fact, over 90% of proprietary, client, specialist, and options market maker limit order volume remains nonanonymous. Nonclient accounts, on the other hand, record over half of their limit order volume as anonymous, but only 7% of their market order volume.

FIGURE 1

Anonymous and Nonanonymous Volumes by Order Source

Figure 1 reports the total client, proprietary, specialist, nonclient, and options market maker order volumes that are submitted anonymously and nonanonymously. The percentage labels refer to the proportion of order dollar volume submitted anonymously and nonanonymously for each order source.



Specialists and options market makers contribute disproportionately large shares of total anonymous market order volume. They account for only 12% and 0.26% of total nonanonymous market order volume but 45% and 0.62% of total

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anonymous market order volume. This suggests that specialists and options market makers are more aggressive users of anonymous orders than other account types, despite their low market share of overall trading. Specialists also tend to submit larger anonymous orders (averaging $53,393) than nonanonymous orders (averaging $39,763). Figure 1 highlights that as much as 27% of specialists' market order volume and 18% of options market makers' is anonymous.

C. Order Aggressiveness

Table 2 reports the composition of anonymous and nonanonymous order volume in the following categories: "Behind-the-quote limit orders" refers to buy (sell) orders priced below (above) the best bid (ask). "At-the-quote limit orders" refers to orders priced at the best quotes. "Inside-the-quote limit orders" refers to orders priced between the best quotes. "At-the-quote market orders" refers to buy (sell) orders priced at the best ask (bid). "Walks-up-the-book market orders" refers to buy (sell) orders priced above (below) the best ask (bid).

TABLE 2

Distribution of Orders in the Order Book

Table 2 reports the proportions of total anonymous (Panel A) and nonanonymous (Panel B) order volumes by their location in the order book and by order source (proprietary, client, specialist, nonclient, or options market maker ("Options MM")). "Behind-the-quote limit orders" refers to buy (sell) orders priced below (above) the best bid (ask). "At-the-quote limit orders" refers to orders priced at the best bid and best ask. "Inside-the-quote limit orders" refers to orders priced between the best quotes. "At-the-quote market orders" refers to buy (sell) orders priced at the best ask (bid). "Walks-up-the-book market orders" refers to buy (sell) orders priced above (below) the best ask (bid).

Order Types	All Sources	Client	Proprietary	Nonclient	Specialist	Options MM
Panel A. Anonymous Orders						
Behind-the-quote limit orders	53.7%	27.4%	20.6%	4.2%	1.5%	0.02%
At-the-quote limit orders	36.9%	0.9%	24.0%	11.0%	1.0%	0.00%
Inside-the-quote limit orders	4.8%	0.7%	0.8%	2.1%	1.1%	0.00%
At-the-quote market orders	4.0%	0.9%	1.5%	0.2%	1.5%	0.01%
Walks-up-the-book market orders	0.5%	0.1%	0.1%	0.1%	0.2%	0.00%
Total	100.0%	30.0%	47.1%	17.6%	5.3%	0.05%
Panel B. Nonanonymous Orders						
Behind-the-quote limit orders	62.1%	23.4%	33.3%	0.2%	5.3%	0.05%
At-the-quote limit orders	20.4%	5.6%	12.8%	0.1%	1.8%	0.03%
Inside-the-quote limit orders	9.5%	5.9%	2.5%	0.1%	1.1%	0.01%
At-the-quote market orders	4.4%	2.4%	1.0%	0.1%	0.9%	0.02%
Walks-up-the-book market orders	3.5%	2.7%	0.7%	0.1%	0.1%	0.00%
Total	100.0%	40.0%	50.2%	0.6%	9.1%	0.10%

Over half of total anonymous order volume is in the form of limit orders behind the prevailing best quotes. However, this ratio is even higher for nonanonymous orders (slightly under ⅔). Client and proprietary sources are the main users of behind-the-quote anonymous limit orders: Their orders in this category alone account for 27.4% and 20.6%, respectively, of total anonymous volume. This is consistent with the notion that liquidity traders, which we expect proprietary traders and direct market access clients to be, prefer to conceal their IDs to reduce the risk of their limit orders being "picked off" by informed traders.

At nearly all levels of order aggressiveness, specialists and nonclients account for a larger share of total anonymous orders in the market, compared to their share of total nonanonymous orders in the market. There are no compelling

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reasons for using anonymity in the normal liquidity provision or price smoothing activities conducted by specialists. Furthermore, specialists' relatively high use of aggressive anonymous market orders indicates that liquidity provision is not the reason for their anonymous activity (specialists account for nearly half of total anonymous market orders that "walk up the book"). The high usage of anonymity is more likely to reflect attempts to minimize information leakage for information-motivated trades.

A relatively large proportion of anonymous volume (36.9%) is placed as limit orders at the best quotes. Prior literature documents that at-the-quote limit orders typically get filled with lower execution costs than behind-the-quote limit orders or market orders (Harris and Hasbrouck (1996)). Therefore, if traders are competing for fast execution, some of these orders represent attempts to "jump the queue" for execution. Anonymity is useful in such cases to avoid complaints or retaliation by other traders for engaging in "pennying."

Some orders are placed a considerable distance from the best quotes such that they have a very small probability of ever executing. Such orders contain little information regarding the use and effects of anonymity. From this point onward we report results including market orders and limit orders placed within 1 spread's distance on either side of the best quotes. This subset includes both limit orders that are executed and orders that are not. In robustness tests we confirm that we obtain similar results using all limit orders, although the results are generally smaller in magnitude.

D. Execution Costs and Market Quality

A key objective of both the ID disclosure decision and order placement strategy is the minimization of execution costs. Common measures of execution costs include price impact, the effective half spread, and the realized spread (see Huang and Stoll (1996), Bessembinder and Kaufman (1997a), (1997b)). Price impact is the most appropriate of these 3 measures to examine execution costs in our setting and is defined as follows:

$$\text{PRICE_IMPACT}_{it} = 100D_{it}(M_{it+n} - M_{it})/M_{it}. \tag{1}$$

Here, D_{it} is a dummy variable equal to +1 (–1) for buyer-initiated (seller-initiated) trades, P_{it} is the price at which the order executes, and M_{it} and M_{it+n} are the bid-ask midpoints immediately before the order and 5 minutes after the order, respectively.

Price impact measures the reaction of the limit order book quotes in a short time period following an order and is viewed as an undesirable cost by most traders. For example, liquidity-motivated traders perceive price impact as the cost of insufficient liquidity to accommodate an order at the prevailing price; for informed traders it represents the extent to which their information is being impounded into prices, possibly through the effects of piggybacking; and for traders using order-splitting strategies it represents unfavorable prices for subsequent parcels of a trade package.

Other common measures of execution cost include the effective half spread and realized spread. Effective half spread in a limit order market such as the TSX

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is equivalent to the proportional quoted spread (defined as the difference between the best bid and ask quotes divided by the midquote) and measures the cost of immediately executing a trade by crossing the spread to "hit" a limit order. The decision to go anonymous cannot affect this measure of execution cost at the time of order submission, because the quoted spread is set before the market sees the incoming order. However, future values of the quoted spread can be influenced by the submission of an anonymous order. We therefore examine the effects of anonymous orders on future quoted spreads using the variable CHANGE_IN_SPREAD, defined as the difference in proportional bid-ask spread from immediately prior to the order submission to 5 minutes after. From a trader's perspective, causing spreads to widen is generally undesirable, because this increases the execution costs of a trade package. From the perspective of overall market quality, an increase in spreads indicates a reduction in liquidity and often an increase in information asymmetry. Realized spread is simply the effective half spread minus the price impact and consequently provides no additional information in our setting where the effective half spread at the time of order submission cannot be affected by the anonymity decision.

We also examine the effect of anonymous orders on another aspect of market quality: short-term volatility. We calculate CHANGE_IN_VOLATILITY as the difference in volatility from the 5-minute interval immediately prior to the order submission to the 5-minute interval immediately after. Volatility is calculated as the standard deviation of the midpoint returns at every order within the interval.

Table 3 reports the averages of PRICE_IMPACT, CHANGE_IN_SPREAD, and CHANGE_IN_VOLATILITY across all anonymous and nonanonymous orders, as well as *t*-test statistics of the difference between anonymous and nonanonymous orders. As the results are similar for both buy and sell orders, we only report results for the full sample of orders.

Anonymous orders, both market and limit, tend to be associated with greater price impact than nonanonymous orders. The magnitude is in the order of 0 basis points (bp) to 5 bp for market orders, depending on the order source, and 0–4 bp for limit orders at or better than the best quote (with the exception of specialists). This is consistent with the bulk of the theoretical literature, which suggests anonymous orders are on average more informed (Roëll (1990), Admati and Pfleiderer (1991), Forster and George (1992), and Fishman and Longstaff (1992)), as well as a number of empirical studies (Barclay et al. (2003), Grammig et al. (2001)).

Anonymous orders have less dispersion in their effects on price impact and spreads across the various order sources. For example, the average price impact of anonymous market orders only varies between 10 bp and 12 bp, depending on the order source, but for nonanonymous orders it varies from 5 bp to 11 bp. When the broker ID is concealed, the market is less able to infer the order source, and therefore the effects of the order converge to the mean effects of all order sources.

Even though market participants cannot see the order's source, they are better able to infer the source of an order when the broker ID is displayed. The prevailing intuition of the theoretic literature suggests that market orders are more likely to be informed than limit orders. Therefore, the price impact of nonanonymous market orders gives the best indication of which order initiators are perceived to be most informed. On this basis, the results suggest that specialist and proprietary

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TABLE 3

Execution Costs and Market Quality around Anonymous and Nonanonymous Orders

Table 3 reports averages of price impact, change in spread, and change in volatility following anonymous (ANON) and nonanonymous (NONANON) market orders (Panel A) and limit orders (Panel B). PRICE_IMPACT is measured as a midpoint return in the 5 minutes following the order and is reported in bp. CHANGE_IN_SPREAD is the difference in proportional bid-ask spread from immediately prior to the order submission to 5 minutes after, reported in bp. CHANGE_IN_VOLATILITY is the difference in volatility from the 5-minute interval immediately prior to the order submission to the 5-minute interval immediately after. Volatility is calculated as the standard deviation of the midpoint returns at every order within the interval, as a percentage. The results are reported separately for the order sources CLIENT, PROPRIETARY, NONCLIENT, SPECIALIST, and OPTIONS_MM (market maker). The *t*-statistics report the significance of the mean differences between the anonymous and nonanonymous metrics. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Measures	CLIENT	PROPRIETARY	NONCLIENT	SPECIALIST	OPTIONS_MM
Panel A. Market Orders					
PRICE_IMPACT					
ANON	10.58	10.64	9.99	12.15	9.53
NONANON	5.26	10.98	4.99	10.83	6.14
t-statistic	11.28***	–0.90	7.24***	3.73***	1.90*
CHANGE_IN_SPREAD					
ANON	5.65	5.86	6.70	9.62	2.83
NONANON	3.86	6.61	3.04	10.28	4.63
t-statistic	6.21***	–2.54**	8.66***	–2.42**	–2.59**
CHANGE_IN_VOLATILITY					
ANON	0.49	0.21	0.49	0.48	0.63
NONANON	–0.38	0.54	0.56	0.15	0.58
t-statistic	7.72***	–3.17***	–0.63	2.87***	0.39
Panel B. Limit Orders					
PRICE_IMPACT					
ANON	3.46	3.26	4.90	5.66	3.87
NONANON	1.77	1.93	4.37	3.07	3.35
t-statistic	6.51***	5.81***	0.64	8.41***	0.26
CHANGE_IN_SPREAD					
ANON	–12.73	–5.18	–4.56	–8.72	–3.52
NONANON	–5.42	–4.89	–6.34	–8.02	–4.71
t-statistic	–23.68***	–1.32	2.50**	–2.23**	1.28
CHANGE_IN_VOLATILITY					
ANON	–1.15	–1.06	0.26	–2.08	0.17
NONANON	–0.91	–1.05	0.07	–1.66	0.01
t-statistic	–4.10***	–0.02	1.54	–4.43***	1.26

market orders are perceived to be the most informed. Nonanonymous market orders from these sources incur price impact of approximately 11 bp, compared to around 5 bp for client and nonclient nonanonymous market orders. The specialist's informational advantage is likely to be associated with better access to order flow information (e.g., orders being "shopped" in the upstairs market), whereas for proprietary trades it could be order flow or fundamental information. Consistent with this result, the nonanonymous market orders of specialists and proprietary accounts lead to a greater increase in spreads (7–10 bp) than client and nonclient orders (3–4 bp).

VI. Determinants and Execution Costs of Anonymous Orders

Models of the determinants and unconditional execution costs of anonymous orders must recognize that a trader's selection of anonymity depends on his expected execution cost of doing so. We use the 2-stage estimator introduced by

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Heckman (1979).[9] The 1st stage is a probit model of the determinants of traders' decisions to trade anonymously. The 2nd stage is an endogenous switching regression that uses the 1st-stage estimates to overcome selection bias in estimating the execution costs of anonymous and nonanonymous orders.

The 2 stages are represented in the following system:

$$(2) \qquad A_i^* = \gamma Z_i + \theta_i, \quad \text{where} \quad A_i = \begin{cases} 1, & \text{if } A_i^* > 0 \\ 0, & \text{otherwise} \end{cases},$$

$$(3) \qquad \mathrm{E}[y_i^n \mid A_i = 0] = \beta^n X_i + \alpha^n \lambda_i^n + \varepsilon_i,$$

$$(4) \qquad \mathrm{E}[y_i^a \mid A_i = 1] = \beta^a X_i + \alpha^a \lambda_i^a + \varepsilon_i.$$

Here, A_i^* is a latent variable representing the trader's preference to submit an anonymous order $(A_i = 1)$ or a nonanonymous order $(A_i = 0)$; y_i^n and y_i^a are the price impacts of orders submitted nonanonymously and anonymously, respectively; $Z_i = (W_i, X_i)$ is a vector of variables that influence the anonymity decision, comprised of the order characteristics that affect execution cost, X_i, and state variables that capture the prevailing market conditions, W_i (see Madhavan and Cheng (1997) for more detail). The term θ_i represents unobservable (to the econometrician) characteristics of an order that affect both the decision to use anonymity and the subsequent price impact, for example, the amount of information possessed by the order initiator or the nature of their trading strategy. This is the term that leads to biases in models that do not address the endogeneity of the anonymity decision.

The 2nd stage, equations (3) and (4), models the price impact of orders conditional on the choice of anonymity. The terms λ_i^n and λ_i^a on the right-hand side of equations (3) and (4) are nonlinear combinations of the 1st-stage estimates.[10] Their purpose is to correct for the endogenous selection of anonymity. Consequently, the 1st term on the right-hand side of equations (3) and (4) estimates the unconditional price impact of a random order submitted nonanonymously and anonymously, respectively. This model allows the explanatory variables to affect the dependent variable (price impact) in different ways for anonymous and nonanonymous orders. It also allows for different means for the price impact of anonymous and nonanonymous orders.

The market reaction to an order is important in determining the order's execution cost. While our data allow us to identify the source of an order (client, inventory, specialist, nonclient, and options market maker), the market only observes the broker ID associated with an order (if submitted nonanonymously). From their knowledge of the type of broker, market participants can infer the

[9] See Maddala (1983) and Greene (2003) for detailed general discussions and Bessembinder and Venkataraman (2004), Madhavan and Cheng (1997), and Conrad, Johnson, and Wahal (2003) for examples of the model's application.

[10] The selectivity correction terms are defined as $\lambda_i^n = -\phi(\hat{\gamma}Z_i)/(1 - \Phi(\hat{\gamma}Z_i))$ and $\lambda_i^a = \phi(\hat{\gamma}Z_i)/\Phi(\hat{\gamma}Z_i)$, where $\hat{\gamma}Z_i$ are the predicted values from the 1st-stage probit, ϕ is the standard normal density function, and Φ is the cumulative normal distribution function.

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probable source of the order. Therefore, in the analysis that follows we group orders by the type of broker initiating the order. We classify brokers into 3 groups using information available to market participants.[11] The 1st group, AGENCY, consists of brokers who trade primarily on behalf of clients, both institutional and retail. The 2nd group, DUAL, consists of integrated brokers that trade for their proprietary accounts as well as serving largely institutional clients. The 3rd group, MARKET_MAKERS, consists of designated specialists and options market makers.

Although agency brokers trade predominantly for clients, a proportion of their trades are from other sources such as proprietary or nonclient accounts. Similarly, designated specialist firms and options market makers may engage in trading other than market making and submit client, proprietary, and nonclient orders under the same broker ID that is associated with their market making role. Therefore, from a market participant's perspective the broker classifications are noisy signals of the order source.

To capture differences in the use of anonymity and execution costs between different order sources within a broker type, we include a dummy variable, D^{NONCORE}, that takes the value 1 for orders that are from sources other than the broker type's core business. For agency brokers, noncore orders are those from proprietary and nonclient accounts; for dual capacity brokers, noncore orders are client and nonclient orders; and for market makers, noncore orders are those not associated with their stock or option market making roles (client, proprietary, and nonclient orders). This design allows us to examine differences between order sources within a broker type, and differences in the market's reaction to orders based on the information market participants could reasonably infer from the broker ID.

A. First-Stage Probit Model of the Anonymity Decision

The dependent variable in the 1st stage, D^{ANON}, is equal to 1 if the order is submitted anonymously, and 0 otherwise. The order characteristics, X_i, contain the following variables: VALUE, the dollar volume of the order divided by the average order dollar volume that stock-day; AGGR (aggressiveness), a continuous variable that measures the order placement relative to the prevailing best quotes (scaled to give the value 0 at the midpoint, and +1 and –1 at the best ask and best bid, respectively, for a buy order (opposite for a sell order)); D^{BID}, a dummy variable for bids (buy orders); and $D^{\text{FIRSTHALF}}$ and D^{LASTHALF}, dummy variables for orders submitted in the 1st and last half-hours of the trading day, respectively. The variables that capture prevailing market conditions, W_i, include: SPREAD, the proportional bid-ask spread at the time of the order placement; VOLATIL (volatility), the standard deviation of the midpoint returns over the previous 50 orders; and MOMEN (momentum), the average midpoint-to-midpoint return over

[11] We use the Investment Dealers Association of Canada's (now part of the Investment Industry Regulatory Organization of Canada) list of member firms by peer group to identify agency and dual brokers, and TSX monthly reports of specialists and their stocks of responsibility. At the start of each day the TSX broadcasts a list of stocks and their assigned specialist firms.

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the previous 50 orders (signed to the trade direction, i.e., multiplied by –1 for sell orders). We include fixed effects for stocks and brokers in both stages to control for unobservable cross-sectional characteristics. Therefore, we do not include variables for which almost all of their variation is cross-sectional, such as stock size.

Table 4 reports the results of the 1st-stage probit model estimated separately for each of the broker types. For easier comparison of magnitudes across variables, we standardize all variables to have a mean of 0 and standard deviation of 1.

TABLE 4

Determinants of Anonymous Orders

Table 4 reports 1st-stage probit estimates where the dependent variable is D^{ANON}, a dummy variable equal to 1 if the order is anonymous. AGENCY, DUAL, and MARKET_MAKER refer to brokers that: predominantly trade for clients; trade for their proprietary accounts as well as clients; and are options market makers and specialists in their designated stocks, respectively. VALUE is the dollar volume of the order divided by the average order dollar volume that stock-day; AGGR is a continuous variable that measures where the order was placed relative to the best quotes at the time of order submission (scaled to give the value 0 at the midpoint, and +1 and –1 at the best ask and best bid, respectively, for a buy order (opposite for sell order)); D^{BID} is a dummy variable for bids (buy orders); $D^{FIRSTHALF}$ and $D^{LASTHALF}$ are dummy variables for orders submitted in the 1st and last half-hours of the trading day, respectively; SPREAD is the proportional bid-ask spread just prior to the order placement; VOLATIL is the standard deviation of the midpoint returns over the previous 50 orders; MOMEN (momentum) is the average midpoint-to-midpoint return over the previous 50 orders (signed to the trade direction, i.e., multiplied by –1 for sell orders); and $D^{NONCORE}$ is a dummy variable that takes the value 1 for all orders other than client, proprietary, and specialist/options market maker orders submitted by agency, dual, and market maker brokers, respectively, and 0 otherwise. All regressions include broker and stock fixed effects, and all nonbinary variables are standardized to have a mean of 0 and standard deviation of 1. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Order Source	Constant	VALUE	AGGR	D^{BID}	$D^{FIRSTHALF}$	$D^{LASTHALF}$	SPREAD	VOLATIL	MOMEN	$D^{NONCORE}$
AGENCY	–1.73***	0.01***	–0.06***	–0.57***	0.19***	0.10***	0.30***	–0.02***	0.00***	0.76***
DUAL	–0.66***	0.01***	–0.16***	–0.02*	–0.29***	–0.02	0.04	0.00	–0.01***	–0.48***
MARKET_MAKER	–1.28***	0.03***	0.02***	–0.01	–0.02	–0.03*	0.21***	–0.01***	0.01***	–0.45***

Holding all other variables constant, anonymous orders tend to be larger than nonanonymous orders, indicated by the positive coefficients of VALUE. Hasbrouck (1991) finds that large trades lead to wider spreads and attributes this effect to specialists who infer from the large trade that an information event has occurred. Thus, a trader with short-lived private information that does not have the time to execute an order-splitting strategy may opt for anonymity in an effort to reduce market impact and prevent other traders from identifying the extent of his position in the market. This is consistent with Harris (1996), who reports that impatient informed traders are generally believed to prefer large anonymous orders.

Order size has the largest effect on market makers' decision to use anonymity (VALUE coefficient of 0.03 for market makers and 0.01 for the other broker types). To illustrate the magnitude of these coefficients, unreported marginal effects estimates suggest that for market makers, a 1-standard-deviation increase in the relative size of an order (from the mean) increases the probability that the order is submitted anonymously by 11%. For the other order sources, a 1-standard-deviation increase in relative size increases the probability of anonymity by 3%.

Sellers, on average, prefer anonymity more than buyers. This is indicated by the negative coefficients on D^{BID} and is strongest for agency brokers. Averaging

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across the broker types, buy orders are 31% less likely to be submitted anonymously than sell orders. One explanation for this result is that liquidity-motivated traders seeking to offload their long positions may prefer anonymity in order to prevent predatory trading by other traders (see Brunnermeier and Pedersen (2005) for a discussion of predatory trading strategies). It is also possible that the sell side of the order book is perceived to be more informative during periods of positive market performance (Ranaldo (2004)), as was the case for the TSX during the sample period. Hence, informed sellers may prefer anonymity to avert trading ahead and piggybacking by other traders.

Aggressively priced orders from agency and dual capacity brokers are less likely to be submitted anonymously (a 1-standard-deviation increase in aggressiveness decreases the probability of anonymity by 13%), but aggressively priced market maker orders are more likely to be submitted anonymously (a 1-standard-deviation increase in aggressiveness increases the probability of anonymity by 9%). Aggressive trading is more likely to be associated with short-lived information and urgent liquidity needs than long-lived information and nonurgent liquidity needs. The results suggest that anonymity is generally more valuable to agency and dual capacity traders with long-lived information because it allows them to retain their informational advantage for longer, and to nonurgent liquidity traders because it minimizes the risk of their orders being picked off. For market makers, on the other hand, nonaggressive trading (liquidity provision) is their assigned role, and in undertaking this role they are willing to advertise their ID. However, market makers may trade aggressively when they have information about future price movements based on their knowledge of order flow, or when they have to adjust their inventory quickly. In such cases, market makers are more likely to use anonymity to avoid revealing their information about order flow or signaling their need to adjust their inventory.

The coefficients for $D^{\text{FIRSTHALF}}$ and D^{LASTHALF} vary across the different broker types. For example, agency brokers tend to use proportionally more anonymous orders in the early and late parts of the trading day (coefficients of 0.19 and 0.10), whereas dual capacity brokers and market makers tend to use less (coefficients of –0.29 and –0.02 for dual capacity brokers and –0.02 and –0.03 for specialists).

The VOLATIL and SPREAD coefficients suggest that agency brokers and market makers prefer to use anonymity when spreads are wide (coefficients of 0.30 and 0.21, respectively) and volatility is low. The effects are particularly strong for spreads. A 1-standard-deviation increase in spreads from the mean increases the probability of anonymity by 32% and 17% for agency broker and market makers, respectively. A possible explanation is that environments characterized by high information asymmetry amplify informed traders' informational advantage, and consequently concealing their ID is more important to avoid trading ahead and piggybacking. Momentum does not have a large effect on the choice of anonymity.

Within broker types, order source has a large effect on the probability that an order is submitted anonymously (D^{NONCORE} coefficients of 0.76, –0.48, and –0.45). Agency brokers primarily trade on behalf of clients. Marginal effects estimates suggest that their noncore orders (proprietary and nonclient orders) are

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11 times more likely to be submitted anonymously. Similarly, dual capacity brokers are 25% more likely to submit a proprietary order anonymously than other order sources such as client orders. Market makers are 81% more likely to use anonymity when submitting a specialist or options market maker order than an order from another order source such as a client or proprietary account. Finally, the magnitude of the coefficients suggest that the decision to submit an anonymous order is most sensitive to the broker type, order source, aggressiveness of the order placement and, for agency brokers and market makers, size of the spread.

B. Second-Stage Model of Price Impact

In the 2nd stage we estimate the coefficients in equations (3) and (4) with PRICE_IMPACT as the dependent variable. Table 5 reports the estimates with all variables standardized to a mean of 0 and standard deviation of 1. For the independent variables, we include the same vector of order characteristics, X_i, as in the 1st stage, as well as broker and stock fixed effects. Due to the inclusion of the selectivity correction variables, λ, the β^n (rows NONANON in Table 5) are unconditional estimates of the effect of the independent variable on the price impact of a random order submitted nonanonymously. Similarly, the $\beta^a - \beta^n$ (rows ANON-NONANON in Table 5) are unconditional estimates of the difference in the effects of the independent variable on the price impact of a random order submitted anonymously relative to a random order submitted nonanonymously.

We find that price impact tends to increase with order size and order aggressiveness (positive coefficients of VALUE and AGGR). Large and aggressive orders are perceived as relatively informed, causing prices to follow in the same direction. Additionally, large market orders are more likely to create liquidity imbalances that affect prices.

Buyer-initiated orders are associated with greater price impact than seller-initiated orders (except for anonymous market maker orders). This is consistent with the explanation that liquidity-motivated sales are more likely than liquidity-motivated purchases, and therefore buy orders are more informed on average and have a larger effect on prices (Allen and Gorton (1992)). Orders in the 1st hour of trading are associated with greater price impacts, particularly anonymous market maker orders (positive coefficients for $D^{\text{FIRSTHALF}}$). An explanation is that proportionally more informed trading, relative to total trading activity, occurs early in the trading day in response to overnight news and events.

Using the selectivity-corrected parameter estimates and the average order characteristics, $\bar{X}_i$, we calculate the unconditional expected price impact for a random order submitted nonanonymously, as well as the difference in price impact for a random order submitted anonymously and nonanonymously:

$$\text{E}[y_i^n] = \beta^n \bar{X}_i, \tag{5}$$

$$\text{E}[y_i^a - y_i^n] = (\beta^a - \beta^n)\bar{X}_i. \tag{6}$$

Similarly, we calculate the conditional expected price impact for a nonanonymous order and the difference in price impact for an anonymous and nonanonymous

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TABLE 5

Effects of Anonymous Orders on Price Impact

Table 5 reports 2nd-stage regression estimates of the 2-stage selection model, where the dependent variable is price impact (measured as a midpoint return in the 5 minutes following the order). AGENCY, DUAL, and MARKET_MAKER refer to brokers that: predominantly trade for clients; trade for their proprietary accounts as well as clients; and are options market makers and specialists in their designated stocks, respectively. VALUE is the dollar volume of the order divided by the average order dollar volume that stock-day; AGGR is a continuous variable that measures where the order was placed relative to the best quotes at the time of order submission (scaled to give the value 0 at the midpoint, and +1 and −1 at the best ask and best bid, respectively, for a buy order (opposite for sell order)); D^{BID} is a dummy variable for bids (buy orders); $D^{FIRSTHALF}$ and $D^{LASTHALF}$ are dummy variables for orders submitted in the 1st and last half-hours of the trading day, respectively; $D^{NONCORE}$ is a dummy variable that takes the value 1 for all orders other than client, proprietary, and specialist/options market maker orders submitted by agency, dual, and market maker brokers, respectively, and 0 otherwise; λ is the selection bias adjustment; UNCOND and COND are estimates of the price impact of a random order and an order conditional on the anonymity decision, respectively; and SELECT is the difference of UNCOND and COND and represents the effect of strategic anonymity selection on price impact. All regressions include broker and stock fixed effects. All nonbinary variables are standardized to have a mean of 0 and standard deviation of 1, except UNCOND, COND, and SELECT, which are reported in bp. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

									UNCOND		COND		SELECT	
Order Source	Constant	VALUE	AGGR	D^{BID}	$D^{FIRSTHALF}$	$D^{LASTHALF}$	$D^{NONCORE}$	λ	Buy	Sell	Buy	Sell	Buy	Sell
AGENCY														
NONANON	−0.03***	0.03***	0.07***	0.01***	0.02***	0.00***	0.02***	−0.06***	0.09	−0.24	0.13	−0.19		
ANON-NONANON	0.04***	0.01***	−0.01**	0.04***	0.01	0.01	−0.05***	0.00	1.70	0.65	1.44	0.25	−0.25	−0.39
DUAL														
NONANON	0.03***	0.04***	0.06***	0.02***	0.03***	0.00	−0.07***	−0.06***	1.12	0.59	1.95	1.29		
ANON-NONANON	−0.06**	0.01***	0.06***	0.00	−0.02***	0.07***	0.06***	0.00	−0.90	−1.01	−2.32	−2.30	−1.43	−1.29
MARKET_MAKER														
NONANON	0.01***	0.05***	0.08***	0.04***	0.05***	0.01*	−0.14***	−0.07*	0.59	−0.71	0.48	−0.78		
ANON-NONANON	0.16***	−0.01**	0.02***	−0.05***	0.13***	−0.03	0.28***	−0.11***	9.15	10.86	6.06	7.07	−3.08	−3.80

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order given the choice of anonymity, $\mathrm{E}[y_i^n \mid A=0]$ and $\mathrm{E}[y_i^a \mid A=1]-\mathrm{E}[y_i^n \mid A=0]$, respectively. The difference of the conditional and unconditional price impact differences, $\text{SELECT} = \{\mathrm{E}[y_i^a \mid A=1]-\mathrm{E}[y_i^n \mid A=0]\} - \{\mathrm{E}[y_i^a - y_i^n]\}$, measures the extent to which traders influence the price impact of their orders by strategically selecting anonymity when it is beneficial to them. This estimate is important because it measures the effect of strategic behavior. Table 5 reports these estimates (UNCOND, COND, and SELECT) separately for buy and sell orders. Unlike the regression coefficients that correspond to standardized variables, here we report estimates in bp for easier interpretation of the magnitudes.

The unconditional estimates for nonanonymous orders (random orders submitted nonanonymously) indicate that dual capacity brokers (primarily trading on behalf of their proprietary accounts and institutional clients) typically have the greatest price impact, followed by market maker buy orders (0.6–1.1 bp). This suggests that dual capacity brokers and market makers are perceived to be the most informed broker types. This is consistent with the regression coefficients of D^{NONCORE}, which suggest price impact, and therefore informativeness, is greater for proprietary and market maker orders than for client and nonclient orders.

The estimates of SELECT indicate that the price impact of anonymous orders relative to nonanonymous orders is lower for the estimates that are conditional on the choice of anonymity than the unconditional (random order) estimates. The magnitude of the difference is around 3–4 bp for market makers, around 1.3–1.4 bp for dual capacity brokers and around 0.3–0.4 bp for agency brokers. This demonstrates the key result that by strategically selecting anonymity when it is beneficial to them, traders reduce the price impact of their orders. This does not suggest that submitting a random order anonymously is expected to lower its price impact. In fact, the unconditional price impact estimates suggest that a random order submitted anonymously by an agency broker or market maker is expected to have greater price impact (by 1–11 bp) than an order submitted nonanonymously by the same broker type.

The key point is that anonymity is used strategically rather than randomly, based on order characteristics, market conditions and, importantly, the unobservable characteristics, θ_i, which affect not only the anonymity decision but also the subsequent price impact. The intuition is that the average order is relatively uninformed, and because anonymity is more likely to be used on informed trades, submitting a random order anonymously signals that it is more informed than in fact it is and therefore results in greater price impact than submitting the order nonanonymously. On the other hand, in certain circumstances, by not revealing the broker's ID, an informed or strategic trader can conceal his information or trading strategy and avoid some of the price impact that would occur by trading nonanonymously.

The magnitudes of the effects suggest that market makers benefit the most from strategic use of anonymity when submitting market orders, followed by dual capacity brokers. The effect of their strategic use of anonymity on price impact is in the order of 3–4 bp per order. Two possible explanations are: i) Market makers have the most control over whether their orders are submitted anonymously; or ii) the nature of their trading strategies or information makes hiding the ID of the submitting broker more important.

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The proportion of orders submitted anonymously by client, proprietary, and nonclient sources may be smaller than would be optimal for minimizing execution costs. From the broker's perspective, anonymity has the undesirable effect of reducing apparent market share and the advertising effects of displaying the broker ID in the order book. In fact, for dual capacity brokers, the unconditional estimates suggest that a random market order would be expected to have lower price impact if it were submitted anonymously. This supports the argument that factors other than simply minimizing price impact influence the use of anonymity for client, proprietary, and nonclient orders.

VII. Effects of Anonymous Orders on Market Quality

So far we have found that the strategic use of anonymity benefits traders that have certain types of information or trading strategies. These benefits can explain why some groups of market participants have pushed for anonymity in markets. From the perspective of an exchange that determines the degree and form of anonymity, however, there are other considerations, such as the effects on overall market quality.

A. Effects on Liquidity and Short-Term Volatility

In this section, we examine how anonymous orders affect 2 aspects of market quality: liquidity (proxied by future spreads) and short-term volatility. Similar to price impact, we expect unobservable characteristics, such as the degree of information or type of trading strategy, to affect both the decision to use anonymity and the posttrade effects on spreads and volatility. Therefore, we use the selectivity correction model as in the previous section, utilizing the same 1st stage. The dependent variables, CHANGE_IN_SPREAD and CHANGE_IN_VOLATILITY, are as defined in Section V. Table 6 reports estimates corresponding to UNCOND, COND, and SELECT (defined in the previous section).

Similar to the price impact results, unconditional estimates for nonanonymous orders suggest that orders submitted by dual capacity brokers and market makers typically lead to the largest increase in spreads (in the order of 2–7 bp). This is consistent with our previous finding that dual capacity brokers (particularly their proprietary orders) and market makers are perceived to be the most informed broker types, and hence adverse selection costs and spreads are higher in their presence.

The unconditional estimates of the effect of anonymity on spreads suggest that a random order submitted anonymously leads, on average, to narrower future spreads than if it is submitted nonanonymously (by 10–81 bp). The same effect holds conditional on the choice of anonymity. Unreported results (analyzing market and limit orders separately) suggest that this effect is driven predominantly by limit orders. Unlike market orders that execute just as quickly whether submitted anonymously or nonanonymously, limit orders provide the market with an option to trade. By revealing less information about the order source, anonymous limit orders make market participants more reluctant to take up the option to trade and are less frequently picked off by traders that recognize a patient liquidity trader's

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TABLE 6

Effects of Anonymous Orders on Market Quality

Table 6 reports estimates of the impact of anonymous and nonanonymous orders on market quality variables estimated from the 2nd stage of a 2-stage selectivity-corrected regression model. AGENCY, DUAL, and MARKET_MAKER refer to brokers that: predominantly trade for clients; trade for their proprietary accounts as well as clients; and are options market makers and specialists in their designated stocks, respectively. CHANGE_IN_SPREAD is the difference in proportional bid-ask spread from immediately prior to the order submission to 5 minutes after, reported in bp; CHANGE_IN_VOLATILITY is the difference in volatility from the 5-minute interval immediately prior to the order submission to the 5-minute interval immediately after. Volatility is calculated as the standard deviation of the midpoint returns at every order within the interval, as a percentage. UNCOND and COND are estimates of the change in the market quality variable in response to a random order and an order conditional on the anonymity decision, respectively. SELECT is the difference of UNCOND and COND and represents the effect of strategic anonymity selection on the market quality variable.

	CHANGE_IN_SPREAD						CHANGE_IN_VOLATILITY					
	UNCOND		COND		SELECT		UNCOND		COND		SELECT	
Order Source	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell
AGENCY												
NONANON	0.69	0.72	0.55	0.58			–0.41	–0.40	–0.41	–0.40		
ANON-NONANON	–14.23	–11.47	–11.04	–9.78	3.19	1.69	–0.10	–0.07	–0.16	–0.12	–0.06	–0.05
DUAL												
NONANON	2.35	2.17	2.33	2.12			–0.53	–0.51	–0.46	–0.44		
ANON-NONANON	–10.01	–9.58	–9.85	–9.35	0.16	0.24	0.60	0.60	0.51	0.51	–0.10	–0.09
MARKET_MAKER												
NONANON	7.05	7.24	4.87	5.26			–0.45	–0.45	–0.42	–0.42		
ANON-NONANON	–80.78	–79.16	–35.34	–31.28	45.44	47.88	0.50	0.52	0.43	0.30	–0.07	–0.22

order patterns. Therefore, anonymous limit orders remain in the market longer, contributing to liquidity and narrower future spreads.

The estimates for SELECT measure the effect of strategic anonymity selection relative to random selection. Strategic anonymity selection on average leads to wider future spreads (by 0–48 bp) relative to the random use of anonymity. This is consistent with the earlier finding that anonymity tends to be strategically used by informed traders because by concealing their information, informed traders increase adverse selection costs for the market as a whole. This does not, however, mean that future spreads are wider following anonymous orders. The conditional estimates, in fact, suggest that future spreads are *narrower* following anonymous orders. This is consistent with the explanation that anonymous limit orders are less readily picked off and therefore remain in the market for longer, contributing to liquidity. The key point is that the effect of using anonymity strategically rather than randomly increases information asymmetry, suggesting anonymity is used to conceal information. The magnitude is largest for market makers, consistent with the earlier results that these traders benefit the most from the strategic use of anonymity.

The results also suggest that anonymous orders submitted by dual capacity brokers and market makers tend to increase short-term volatility relative to orders submitted nonanonymously (by 0.3%–0.5%), whereas anonymous orders from agency brokers decrease short-term volatility (by 0.1%–0.2%). For all broker types, using anonymity strategically rather than randomly decreases future volatility by 0.05%–0.22%. This effect is consistent with the earlier result that traders reduce their price impact by strategically selecting anonymity. When traders strategically conceal their IDs, prices are more stable because less new information is revealed and therefore volatility is lower.

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B. Implications for Market Design

Our results offer insight into how anonymity at the order level affects market quality, and who gains and loses from the ability to choose anonymity. This differs from studies that compare regimes (time periods or markets) with varying degrees of anonymity (e.g., Foucault et al. (2007), Barclay et al. (2003), Grammig et al. (2001), and Reiss and Werner (2005)) for the following reasons: First, the use of anonymity in our setting has two concurrent effects. It removes a signal about the order (broker ID) that could be used to revise beliefs about the order source, informativeness, and so on, and it adds a signal that the order is likely to be one for which anonymity is advantageous. The latter effect is not present in studies where anonymity is not an order-level choice. Second, unlike interregime studies where aggregate liquidity, adverse selection costs, and price accuracy can change between regimes, in our setting these are fixed in aggregate, but they are redistributed at the order level depending on each trader's ability to benefit from strategic use of anonymity.

Our results have the following implications: On average, across broker types, a random order submitted anonymously is associated with greater price impact than a nonanonymous order. Anonymity is generally used strategically for orders that will benefit from it, and such orders tend to be more informed than the average order. Therefore, upon seeing an anonymous order, the market attaches a high probability to that order being informed and adjusts prices accordingly. If anonymity is more advantageous to informed traders as suggested by theoretical studies and reinforced by our findings, then, ceteris paribus, anonymous markets can be expected to attract informed traders. This would increase adverse selection costs and reduce the amount of liquidity supplied by uninformed traders, consistent with Theissen (2003) and Rindi (2008). However, if information acquisition is endogenous, the ability to submit orders anonymously is likely to increase the number of informed traders (due to greater incentives to acquire information) and, therefore, may increase the information supplied by informed traders (Perotti and Rindi (2006), Rindi (2008)). The additional liquidity supplied by informed traders offsets the reduction in liquidity supplied by uninformed traders.

Further, we find that the strategic use of anonymity is able to reduce price impact. For a given number of informed traders with a given amount of information and a constant level of trading aggressiveness, this would tend to decrease the informational efficiency of prices by slowing the process of impounding of information into prices. However, anonymity may encourage traders to engage in more fundamental research, thereby increasing the precision of their information. Anonymity may also induce a migration of informed traders from more transparent markets, or may cause informed market participants to trade more aggressively on their information. These effects tend to increase the informativeness of prices, and consequently it is difficult to predict the overall effect of anonymity on informational efficiency.

One of our main results regarding spreads and volatility is that random orders submitted anonymously are expected to decrease future spreads and increase future volatility (except agency broker orders, for which random anonymous orders decrease future volatility). We cannot, however, infer from these results

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the expected volatility, for example, of an anonymous market compared to a nonanonymous market. The strategic use of anonymity (rather than random use) increases adverse selection costs and decreases volatility by allowing better concealment of the trader's information. These results support the notion that the ability to choose anonymity is valuable to those that are able to use it strategically.

In light of the value in being able to choose anonymity, an important consideration in market design is that not all traders are able to use anonymity freely. For example, brokers may sometimes be directed by clients to trade nonanonymously. Brokers may also face a conflict of interest where they benefit from the advertising effects of displaying the broker's ID in the order book. Within an anonymity regime such as the one studied in this paper, the aggregate level of informed trading and adverse selection has its limits. Hence, the ability of some traders to benefit from their strategic use of anonymity comes at the expense of others. For example, the informed traders' benefits from being able to better conceal their information through strategic use of anonymity are at the expense of less informed traders that are their trade counterparties. Consequently, when not all traders have equal access to anonymity, potentially significant equity issues arise that should be considered in market design. Our results suggest that market makers benefit the most from the option of anonymity.

VIII. Conclusions

Despite the considerable value often placed on anonymity in securities trading, little is known about the determinants of the decision to trade anonymously and how this decision affects execution costs. This study is the first to analyze anonymous and nonanonymous trading in a single market and time period, thus removing the confounding effects often present in this literature.

While anonymous orders constitute a relatively small proportion of overall market activity, we find that their determinants, execution costs, and effects on market quality are significantly different than those of nonanonymous orders. Specialists, relative to their total volume, make the greatest use of anonymity in submitting market orders, whereas nonclient accounts make the greatest use on limit orders. We find that, ceteris paribus, anonymous orders are more likely to be large orders, tend to be relatively informed, and are more aggressively priced for specialist and options market maker brokers but less aggressively priced for agency and dual capacity (agency and proprietary) brokers. The likelihood of an order being submitted anonymously is higher when spreads are wide because higher uncertainty increases informed traders' informational advantage.

We find that by strategically selecting anonymity when it is beneficial, traders reduce their execution costs. It is important to note that submitting a random order anonymously is not expected to reduce its execution costs. In fact, consistent with our finding that anonymous orders tend to be relatively informed, submitting a random order anonymously is expected to increase execution costs for most types of brokers because of the signal conveyed to the market. The key to this difference is that anonymity is used strategically, not randomly, based on order characteristics, market conditions, and unobservable characteristics such as information and trading strategy. Our results suggest that market makers and dual capacity brokers

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that trade predominantly for their proprietary accounts and institutional clients tend to be the most informed about short-term price movements. Market makers benefit the most from the strategic use of anonymity, and the use of anonymity is suboptimal from the perspective of execution cost minimization for some order sources. We attribute the latter finding to the fact that other factors, such as the advertising effects of displaying the broker's ID in the limit order book, limit the use of anonymity.

Finally, we report how anonymous orders affect market quality and discuss implications for market design. The effects of anonymous orders on future spreads and short-term volatility are consistent with the strategic selection of anonymity. If anonymity is more advantageous to informed traders, as suggested by our results, ceteris paribus, anonymous markets could be expected to attract informed traders, leading to higher adverse selection costs and wider spreads. Our finding that the strategic use of anonymity is able to reduce price impact suggests that providing traders with the option to use anonymity may encourage more fundamental research or more aggressive trading on information. The results demonstrate that the ability to choose anonymity is valuable in reducing execution costs and influencing future spreads and volatility. Because not all market participants have equal access to anonymity, some market participants benefit at the expense of others. Market design should consider whether the distribution of benefits is desirable.

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