Dealer Intermediation and Price Behavior in the Aftermarket for New Bond Issues *

Forthcoming, *Journal of Financial Economics*

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October 17, 2006

*We thank Sara Buss, Tal Heppenstall, Roger Hayes, Chris Fama, and John Roll for educating us about the structure of the muni market, and PriMuni LLC for providing the dataset. We also thank Shane Corwin, Espen Eckbo, Ron Goettler, Jean Helwege, Roni Michaely, Michael Piwowar, Enrique Schroth, and audiences at a number of seminars and conferences for helpful comments. We especially appreciate the efforts of an anonymous referee, whose comments improved the paper on several dimensions.

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Abstract

We study trading and prices in newly issued municipal bonds. Municipals, which trade in decentralized, broker-dealer markets, are underpriced when issued, but unlike equities the average price rises slowly over a period of several days. We document high levels of price dispersion in newly issued bonds, and show that the average drift upward in price is because of changes in the mix of trades over time. While large trades occur close to the reoffering price, and close to each other, small trades occur at a wide range of prices almost simultaneously. Some small investors appear to be informed about the status of the issue, and trade on attractive terms. Others appear uninformed, and often buy at prices as much as five percent above the reoffering price, at which informed traders buy. We estimate a mixed-distribution model that highlights ex-ante characteristics that discriminate between these types of investors, and quantifies the losses uninformed traders or issuers give up to broker-dealers.

1 Introduction

In his seminal paper, "A Model of Sales," Hal Varian wrote some twenty-five years ago: "Economists have belatedly come to recognize that the 'law of one price' is no law at all. Many retail markets are instead characterized by a rather large degree of price dispersion."

The recognition Varian refers to has arrived even more belatedly in financial economics, where through arbitrage arguments, the law of one price plays a central role in the major theoretical results of both corporation finance and asset pricing. Whether and when financial assets sell at multiple prices simultaneously is an empirical question that has received little attention.

We study the market for newly issued municipal bonds, and demonstrate that there is substantial price dispersion for the bonds. Trades on one side of the market occur at radically different prices almost simultaneously. We argue that the price dispersion is the result of dealers' ability to discriminate between sophisticated customers, who are informed about relative prices, or are perceived by dealers as likely to be so, and unsophisticated customers. We fit a mixed-distribution model that highlights characteristics separating informed and uninformed investors, and allows us to estimate the value dealers capture from uninformed buyers. Analogous to the models of costly consumer search, such as Shilony (1977), Varian (1980) and Burdett and Judd (1983), some buyers appear to know which bonds are "on sale" at a given point in time, and others do not.

The dispersion in prices appears to be sustainable because of the institutional mechanisms through which the bonds are issued, and the decentralized, opaque market setting in which the bonds are traded. This environment imposes search costs on small investors who trade infrequently. These search costs may be associated with switching to or finding the dealers offering better terms as in Shilony (1977), with consulting public sources of information as in Varian (1980), or with obtaining multiple price quotations as in Burdett and Judd (1983). In the market for municipal bonds, however, information about pricing is relatively easy to obtain for those who "know where to look." The search costs may therefore be best understood as the investment of time and effort needed to educate oneself about these sources of information. It may be costly to become a "sophisticated shopper" for municipal bonds.

The municipal bond market is a classic, decentralized broker-dealer market. Pricing information is costly to obtain, and transactions prices have not, until recently, been recorded in a central

source. Other over-the-counter markets, such as corporate and treasury bonds, are dominated by institutional investors trading in large quantities. The tax-exempt status of municipals, however, makes them attractive to individual, retail investors. As in equity markets, large institutional traders and small investors coexist in the municipal market, but unlike in equity markets there is no pre-trade transparency. Post-trade transparency was also limited in our sample period. Recently post-trade transparency has increased and currently, investors can observe transactions prices on-line at close to real time.

The transactions data in our sample was collected by the Municipal Securities Rule Making Board (MSRB) as a first step in their efforts to create a more transparent venue for trading. These data record all transactions by registered broker-dealers, but were only made available to the public with a lag. Transactions are identified as sales by dealers to customers, purchases by dealers from customers, and interdealer trades. We match these transactions data with information on new issues hand collected from prospectuses and provided to us by Primuni.com. Our data include 190,300 trades in 12,493 new bonds issued in 1,000 deals from February 2000 though July 2003.

We document substantial underpricing for new issues, particularly those targeted for the retail market. In the equity markets, the most underpriced issues are also likely to be the most over-subscribed, so that the underwriters themselves do not benefit directly from the underpricing. In the municipal market, bonds are likely to be taken into inventory, or sold to other dealers in the underwriting syndicate, at or below the reoffering price,[1] so that the underwriter-dealers do benefit directly from underpricing. Moreover, the underpricing only emerges gradually. An issuer who simply compared the reoffering price on the bond to average transactions prices on the first day of trading would underestimate the extent of underpricing, along with the profits to the underwriters.

While average prices increase steadily in the days following the start of trading in new issues, the price increase does not appear to be the result of gradual price discovery or the release of information. The prices at which dealers trade with each other and the prices at which dealers purchase bonds from customers do not drift upward. Instead, a large proportion of customers buy the bonds at the reoffering price, while others, simultaneously, purchase at a wide range of prices

[1]The "offering price" is the price the underwriter promises to the issuer, and the "reoffering price" is the price at which the bonds are sold to the public who participate in the primary offering. The difference between the two is the underwriter's spread. The reoffering yield is the yield computed using the reoffering price.

that can be much higher than the reoffering price.

Prices at which customers buy have a bimodal distribution in the early days of a bond's life. But the price dispersion does not coincide in a direct manner with dispersion in proxies for the customer's type. For a variety of reasons we might expect trading costs to be lower for large buyers. There are surely fixed costs associated with processing trades and identifying counterparties. Large, institutional traders are also likely to be more continuously engaged in the market, increasing their access to pricing information, and to have repeated interactions with broker-dealers, increasing their bargaining power with them. We might expect, then, that large traders obtain good prices, while small traders do not.

We find, however, that while large purchasers obtain their bonds at lower and less variable prices, many small purchases occur on very attractive terms. Other small trades do not. A natural explanation for such behavior is that small buyers differ widely in terms of how well informed they are about the bonds they are buying. Some small buyers know the bonds have recently been issued, and know the reoffering yield, which serves as a natural focal point in negotiating with broker-dealers. Others do not. Larger traders, in contrast, are more homogeneously informed. As time passes from the start of trading, information about the particular issue is more costly to obtain or less widely available, and the mix of informed and uninformed traders changes, leading to predictable rises in average prices.

We document the price behavior descriptively by stratifying the sample by trade size and days from the start of trading, and studying the extent of price dispersion. The price dispersion is economically significant. For bonds with high levels of retail participation, prices vary by five percent or more, which is roughly the annual yield on a municipal bond during the sample period.

We also estimate a mixed-distribution model, which treats trades as drawn from two distributions, one for informed buyers and the other for uninformed buyers. A latent variable for the cost of becoming informed about pricing determines the distribution from which an observation is drawn. Using the estimated parameters from the model, we calculate the "money left on the table" by buyers. Money left on the table is a measure of the surplus accruing to broker-dealers that buyers could have captured by becoming informed. To the extent the money left on the table accrues to the broker-dealers rather than the issuers, it also measures the surplus that issuers could

have captured by obtaining direct access to the ultimate buyers. On average, the money left on the table amounts to a quarter of the profits underwriter-dealers earn on an issue.

If trading is costly for individual investors, or if it is costly for them to acquire the institutional sophistication that would allow them to trade on better terms, then we would expect intermediaries to offer them this information indirectly through delegated portfolio management. Mutual funds are one way for individuals to trade on institutional terms, at the cost of fees and loss of direct control over their portfolio. Our estimates of the costs of trading to individuals suggest they value direct control.

Some delegation mechanisms may involve fees that are not directly observable in our data, and would lead us to overstate the apparent sophistication of some small traders and understate the costs of trading for them. Examples are so–called "managed accounts" with annual "wrap fees" that are a percentage of assets under management, and "agency trades" that involve a commission not reported in our data.

To evaluate the importance of such effects, we exclude or consolidate transactions that are likely to be agency or managed-account trades. We also include proxies for likely managed account trades in our mixed-distribution model. The robust nature of our findings suggests many retail investors obtain attractive terms of trade directly, which is not surprising given the wide availability of information about upcoming municipal bond issues. Moreover, both wrap fees and commissions on agency trades are small relative to the dispersion we observe in the prices retail investors pay. This is what we would expect if intermediaries compete more aggressively on dimensions that are transparent to investors. Competitive forces should limit relatively transparent sources of cost to investors, such as commissions or wrap fees.

The behavior of prices for newly issued municipals, which trade over the counter, stands in marked contrast to that of public offerings of equity, which trade on organized exchanges. For Initial Public Offerings (IPOs) there is a great deal of uncertainty about the value of the underlying assets. As with municipals, both retail and institutional investors are active in the aftermarket for equities. Yet price adjustment in IPOs takes place almost immediately in the secondary market—subsequent price movements are largely unpredictable over short horizons.

Underpricing is a cost to the issuer, and its sources are not fully understood. For IPOs, however,

the equity issuance process makes the underpricing transparent to everyone involved. The first transaction on the exchange gives issuers a good measure of how much their shares have been underpriced. The puzzle is why, given the market transparency, competition between underwriters and self-interested behavior by issuers does not reduce the underpricing. In the municipal market, on the other hand, there is no single "market price" by which to measure the costs to issuers or uninformed investors. There are market *prices*.

The price dispersion also creates complications for the tax authority. The tax code limits the returns issuers can earn on municipal bond proceeds to preclude tax-arbitrage strategies. These limitations are stated in terms of the "issue price" of the bonds. The bond counsel typically relies on a certificate from the underwriters to establish the issue price of the bonds, and in practice this price is generally the reoffering price agreed upon by the issuer and underwriter, and disseminated to the investing community via *The Bond Buyer* and *Bloomberg* news services.[2] In our sample, large portions of many issues are not sold at the reoffering yield, and in a substantial fraction of the issues *none* of the bonds are sold with yields at or above the reoffering yield.

Several papers have shown recently that the costs of trade for retail investors in over-the-counter bond markets can be very high, and that these costs are related to the degree of transparency in the market place. Harris and Piwowar (2005) use time-series methods to estimate trading costs for municipal bonds, and show the costs are decreasing in trade size. Green, Hollifield and Schürhoff (2005) match buys and sales in seasoned bonds to estimate the profits to dealers from liquidity provision. Their structural model yields estimates of relative bargaining power for customers and dealers that depend on trade size. Biais and Green (2005) compare trading costs in the current environment to costs during historical periods when bonds were actively traded on exchanges. Bessembinder, Maxwell and Venkataraman (2005), Edwards, Harris and Piwowar (2005) and Goldstein, Hotchkiss and Sirri (2005) study the costs of trade in corporate bonds, and show that increased post-trade transparency lowered trading costs.

All of these studies are informative about the effects of the relative lack of price transparency on liquidity. The nature and direction of causality is difficult to assess, however. The trading venue, costs of trade, and frequency of trade are themselves jointly endogenous outcomes. Perhaps

[2]See "Recommendations by the National Association of Bond Lawyers Issue Price Study Group," August 25, 2006 for details on the underwriting process. The recommendations are posted at www.nabl.org.

the bonds trade in decentralized, opaque markets in part because investors rarely need or want to trade them, and the costs are high because it is extremely difficult for intermediaries to identify and match counterparties. The transactions we study are taking place in a setting with an exogenous need for relatively high volume of trade. The newly issued bonds must be moved through the inventories of intermediating dealers to final investors. Even though considerable trade is going on, we still see small investors trading on radically different terms than large investors, and on radically different terms from each other, at virtually the same instant in time. If price information were more transparent, especially pre-trade price information, it seems unlikely this could occur.

The municipal market is also a particularly appropriate venue in which to study the impact of transparency on trade terms, because individual, retail investors are a natural clientele for the bonds. Tax considerations make corporate and government bonds relatively unattractive to hold directly, as opposed to in tax-deferred accounts which are typically intermediated. If it proves costly for individuals to trade in the corporate market, therefore, it is unclear that this is in any way costly. In the municipal market, 39 percent of outstanding bonds are held directly by households,[3] and if it is costly for them to trade these holdings there is surely some associated welfare loss.

In the next section we describe the process through which municipal bonds are issued, and our sample of new bonds and trades. Section 3 analyzes the evolution and dispersion of prices through time. We also show that many offerings fail to meet IRS requirements that ten per cent of the bonds are sold at the reoffering yield. In Section 4 we estimate a mixture model of the determinants of the markup over the reoffering price for informed and naïve investors. Section 5 concludes by discussing the policy issues related to our research. The Appendix describes construction of our sample.

2 Municipal Bond Issuance and the Sample

The primary market for municipal bonds is large both in terms of value and the number of offerings. The value of new issues has risen steadily in the last two decades, from roughly $60 billion per year in the early 1980s to $458 billion in 2005.[4] In the municipal market the number of issuers is large,

[3]Statistics on holdings are available from The Bond Market Association at `http://www.bondmarkets.com`. Household holdings of municipals have varied between 36 and 55 percent of outstanding supply over the last 20 years.

[4]The source of these aggregate statistics is The Bond Market Association.

and the size of each issue is small in comparison to the corporate market. Municipal bonds are issued through private placement, through competitive bidding in auctions called competitive offerings, or through direct negotiations with an underwriter called negotiated offerings. Competitive offerings were once widely required by state law, but in most states these laws have gradually been repealed or relaxed, and currently most offerings are negotiated. In 2005, 18.6% of new issues were competitive, 80.9% were negotiated, and 0.5% were privately placed.

Municipal bonds are usually issued in series. A typical deal will involve the simultaneous offering of multiple coupon bearing bonds with a range of maturities. We will refer to bonds trading with separate CUSIP numbers as "issues" and the collections of bonds issued simultaneously in a single underwriting as "deals."

Our sample comes from two sources. We have data hand collected from prospectuses by Primuni.com for 1,048 deals involving 13,987 bonds and 862 issuers. The first deal was on February 15, 2000 and the last deal was on May 1, 2003. We apply a number of filters described in the Appendix to eliminate obvious data errors. After cleaning the sample, we are left with 1,000 deals and 12,493 separate issues from 833 different municipal entities. These data supply us with CUSIP number, coupon, maturity, issuer, state, underwriter discount or spread, reoffering price at which the bond is offered to the public, and reoffering yield. The number of different bonds in the sample is substantially larger than the number of deals, since municipals are issued in series. There are fewer issuers than deals, because some large issuers are in the market repeatedly over the sample period.

We have matched these bonds to transactions prices recorded by the Municipal Securities Rule Making Board (MSRB) data made available to the public as part of their attempts to gradually increase transparency in the municipal bond market. The MSRB database has been used to study trading costs in the municipal market by Green, Hollifield and Schürhoff (2005), Harris and Piwowar (2005), and Hong and Warga (2004). The database records all trades in municipal bonds by registered broker-dealers. The individual dealer codes are not recorded, but transactions are separately identified as purchases from a customer, sales to a customer, or interdealer trades. We follow the bonds for sixty trading days, or roughly three months after trading begins, so our transaction sample runs from February 15, 2000 to August 1, 2003. It includes 190,300 transactions.

Our sample is a small fraction of the total number of new issues in the MSRB data over this period. We would expect the issues selected by Primuni tend to be larger and more actively traded than the median issue. To evaluate the representativeness of our sample, we have searched the MSRB database for all transactions in new bonds during the Primuni sample period. As a check on the reliability of our search of the MSRB data, for bonds in the Primuni sample we compared data items common to the data collected by Primuni from official statements and the MSRB transactions data. The comparison suggests that the search procedure provides accurate results for the entire market, since both approaches provide virtually identical results for the Primuni sample.

The summary statistics in Table 1 for our sample, and for the broader universe of new bonds, include issue size and deal size, trading volume and number of transactions, bond characteristics such as rating, maturity in years, coupon rate, call features, tax status, use of funds, the issuer type and the state of issuance. We report means and medians for all applicable statistics at the individual issue level and aggregated to the deal level.

The Primuni sample comprises slightly larger and more frequently traded deals, though the bias is not uniform across the different measures and statistics. All of the credit rating, maturity, coupon, call features, tax status, and issuer types are very similar to the broader universe. Both the Primuni sample and the broader market are predominantly deals in large population-rich, high-net-worth states such as California, Texas, New York, and Pennsylvania. The Primuni sample contains more school district issuers and Pennsylvania issuers in comparison to the population of all new issues, which is not surprising given Primuni's location in Pittsburgh.

In a negotiated offering, the senior manager in the underwriting syndicate purchases the bonds from the issuer two to three weeks prior to the settlement date, when the bonds are actually delivered to the underwriter. In the intervening period, the underwriter bears price risk, and the senior manager and the comanagers can sell the bonds to customers or to other dealers on a "when issued" basis. When issued sales are forward contracts between the underwriters and customers to accept the bonds when they are delivered at the closing.

There is no formal distinction between the primary and secondary market for new issues of municipal bonds. For tax reasons, dealers must certify to the IRS that they sell at least ten percent of each issue at the reoffering yield. Subject to the constraint, however, once trading begins dealers

holding the bonds in inventory are free to sell bonds at whatever price the market will bear. Customers who are informed about an upcoming or recent issue, and about the reoffering price, can ask their broker to fill an order for that particular bond at the reoffering price, or close to it. Other customers, who simply wish to purchase a municipal bond with certain characteristics, may be quoted very different prices when their brokers contact their firm's retail trading desk.

The original purchases of bonds from the issuer by the senior managers are not recorded in the MSRB data, but the subsequent sales of the bonds to the public are. Suppose an investor places an order for bonds in an upcoming issue with a broker at the reoffering price. If the broker's firm is the senior manager, this will appear in our sample as a sale to a customer at the reoffering price in the when-issued market or immediately following the settlement date. If the broker's firm is not the senior manager, then there will first be an interdealer trade below the reoffering price followed by a sale to a customer at the reoffering price. Alternatively, members of the underwriting syndicate can take the bonds into inventory, and then hope to sell them to less well informed investors. For the senior manager, we will then just observe the sales to customer, typically above the reoffering price. For other syndicate members, there will be an interdealer trade below the reoffering price followed by sales to customers.

It is often the case that large hedge funds, or similar institutions, substitute for broker-dealers and intermediate the process through which large blocks of bonds are broken into smaller pieces as they make their way to the retail market, particularly when the senior manager does not have retail distribution capacity. Such intermediaries are referred to as "flippers." The flipper takes a large block of bonds from the underwriters, and then resells the bonds to dealers such as regional brokerage firms with retail sales networks. In such situations our sample shows a large sale to a customer at the reoffering price or close to it, followed by smaller purchases from customers, typically at a higher price. We then see even smaller sales to customers, with additional markups.

The economics of the underwriting process tend to discourage brokers from direct participation in the primary market on behalf of their customers, or from informing them about upcoming issues. For example, the average underwriter spread in our data is close to 0.8%. Most of the spread—0.5% to 0.6%—will be the sales credit, which represents the brokerage firm's gross commission. The individual broker dealing with a retail customer makes at most 40% of the brokerage firm's

gross commission, or 0.2% to 0.24% of the 0.8% underwriter spread. The broker dealing with a retail customer therefore ends up with a commission of roughly $20 on a $10,000 retail transaction. Such a commission is below many firms' minimum amount for writing a trade ticket.

Alternatively, suppose the broker sells newly issued bonds held in inventory. The markup over the reoffering price might, given our results, be over 2% on a retail-oriented, smaller issue. For a bond with a 2% markup, 0.125% is profit for the retail trading desk and the remaining 1.875% is the broker's gross commission. At most 40% of the broker's gross commission, or 0.75% is available to the individual broker; this amounts to $75 on a $10,000 retail transaction.

The basic patterns of trade for newly issued bonds are quite evident from the summary statistics in Table 2. During the first sixty trading days sales to customers constitute most of the transactions, but the transactions sizes are smaller than interdealer trades or purchases from customers. Sales to customers nevertheless represent 57% of the dollar volume.

Table 3 describes the distribution of transaction frequency across newly issued bonds in our sample over the first sixty days of trade. Trading activity is highly skewed in the cross section of bonds, with a relatively small number of issues accounting for most of the trading. For example, half of the bonds in our sample show four or fewer sales to customers, but the mean number of sales to customers is eleven, and the standard deviation of the number of sales is over three times the mean. The same patterns are evident in other measures of volume, in purchases from customers, and in interdealer trading.

Newly issued bonds are relatively actively traded, but as the bonds find their way into retail and mutual fund portfolios the volume of trade drops off dramatically. Table 4 illustrates the drop off. Conditional on sales to customers taking place on the first day of trade, the first day sales account for 73% of the par value of the issue. After five days of seasoning, this measure falls to around 12%, and after ten days to around 9%. Average trade size falls dramatically after the first day, but thereafter decreases slowly. Thus, while the bonds are finding their way to smaller buyers through time, both large and small buyers remain active throughout the period. The evolution of activity is not just driven by a search for smaller and smaller retail buyers.

The size of interdealer trades does not fall off as quickly over time as the size of trades to customers, and the average size of purchases from customers actually increases through time. The

trade sizes reflect two types of liquidity provision on the part of dealers. First, flippers re-enter the market and sell large positions to dealers with retail distribution capacity. Second, in the market for seasoned bonds, dealers typically provide liquidity for mutual funds and hedge funds by purchasing large blocks of bonds and reselling them in smaller quantities to other customers.

3 New Issue Underpricing

3.1 The Evolution of Prices Through Time

Figure 1 illustrates the histories of sales to customers for eight individual bonds from our sample covering a range of typical behaviors. The panels include both actively and less actively traded bonds. In each plot, the horizontal axis is days since the initiation of trade, and the vertical axis is the difference between the transaction price and the reoffering price, measured as a percentage of the reoffering price. We refer to this percentage as the markup the dealer earns on the sale. All eight issues depicted show sales to customers with a zero markup on the first day of trading, and most of them continue to show sales to customers at that markup through time, although the frequency with which zero markups occur diminishes over time.

The markups show a general upward trend through time. What appears remarkable, however, is the degree of dispersion in the markups that emerges almost immediately after the bond is issued, particularly for the more actively traded bonds. On the more actively traded bonds, customers are buying, apparently simultaneously, at prices ranging between the reoffering price and premiums of 5% over the reoffering price. All of the bonds depicted were issued with annual coupons between 4% and 6%. The dispersion in prices ranges from half to almost all of a year's coupon payment. To what extent are such behaviors typical of the sample more broadly? To what extent is the heterogeneity in price associated with heterogeneity in trader type?

Figure 2 plots mean and median gross markups over the reoffering price on each type of transaction against days since the initial trade. The upward trend in the mean and median prices at which sales to customers are occurring is striking. Average and median prices at which customers buy increase dramatically over the first three days, and then continue to increase at a slower rate to 1.5% over the reoffering price. Prices at which dealers trade with each other are much flatter

through time.

From Table 2, purchases from customers are much larger in size during the early days of trade than are sales to customers, suggesting the customers selling to dealers are primarily institutions. The prices at which large customer sales to dealers occur also has a relatively flat trajectory. Dealers and large institutions are likely to be well informed traders. Since the prices at which dealers and large institutions trade do not show the same dramatic upward trend as sales to customers, it seems unlikely that the trend in average prices upward is attributable to the release of information, or biases in initial market expectations.

3.2 Price Dispersion

Inspection of the transactions histories for individual bonds in Figure 1 suggests that the predictable evolution of average and median prices may obscure heterogeneity in prices for particular bonds at any given time. Figure 3 illustrates the distribution of markups on sales to customers over the first five days for the whole cross section of bonds. The first panel is a frequency plot of the actual markups. The frequency distribution appears bimodal, with a large spike at zero and the remaining transactions spread out over a range from roughly -3% to 5%. The relative importance of the sales occurring at the reoffering price decreases across days. We would expect the distribution to become more spread out as information accumulates, moving expectations away from those prevailing when the bond was initially priced. But even five days after trading starts, a large portion of sales to customers occur at a zero markup.

The second panel of Figure 3 shows the same frequencies as in the first panel, but with the sales at the reoffering price—a markup of zero—eliminated. While we would expect information arrival to spread out the distribution of markups, the distribution appears remarkably stable aside from the decreasing frequency of trades at the reoffering price. On the first day of trading, the distribution is relatively symmetric. From that point on the distribution appears skewed upward, with very little change in the range of outcomes or the mass in the tails. We omit the plot for the distribution of markups adjusted for movements in a broad-based municipal bond index because it looks virtually identical. The pattern in Figure 3 suggests most of the changes in the average prices across days are attributable to the mix between customers purchasing at the reoffering price, and

customers purchasing at higher prices.

A natural interpretation of the changing mix of trades is that as the bond becomes more seasoned and trade becomes less frequent, fewer potential purchasers are informed about the new issue and the reoffering price. Alternatively, in may be that trader types are changing. Large traders are more likely to be able to trade on attractive terms, either because of superior bargaining power or because there are economies of scale for the dealers in servicing large traders. Suppose that larger traders dominate the set of potential purchasers in the early stages of an issue's life, and the bonds only gradually find their way to smaller investors who are more expensive to service. We would then expect to see average prices rising, reflecting the cost structure of the intermediaries.

Figure 4 sheds some light on how the evolution of prices depends on trader type. The top panel shows the evolution of average markups, stratified by trade size, across days. The second panel plots the same averages, with sales at the reoffering price removed. The upward trend in markups is evident for all but the largest trade sizes in the top panel. The price paths in the lower panel are flat for the smaller trade sizes, and almost all of the increase in price is associated with the first day for the medium-sized trades.

Unconditionally, a retail trader with a purchase of $10,000 should expect to pay a markup of 70 basis points on the first day. Conditional on *not* buying at the reoffering price, however, the same retail trader should expect to pay a 180 basis point markup. The differences between the unconditional expected markup and the markup conditional on not purchasing at the reoffering price for trades of $5,000 and $25,000 are equally dramatic. Trade size would seem to be the most obvious source of heterogeneity one would associate with the costs to the intermediaries of providing their services, and yet it appears that the broad behaviors we see in the aggregates are also evident for trades of any given size, as long as the trade size is retail.

In Table 5 we examine the within day dispersion of prices, and its evolution across days. The columns on the left define the conditioning information. For example, 54% of issues with sales to customers on the first day show multiple transactions, and for 27% of the issues with sales on the first day the price varies across transactions. The remaining four columns show the percentages of issues exhibiting price differences within a given range. On the first day, in just over half of the issues with price dispersion, that dispersion is limited to less than 50 basis points, while in 9% of

the issues the maximum difference between prices at which customers purchase exceeds 2%. The percentages of issues showing high levels of price dispersion increases after the first day. Consistent with the frequency plots for the pooled transactions data in Figure 3, the dispersion of prices within days remains quite stable after the first day.

Dealers surely face fixed costs in processing trades, and for this reason we would expect lower percentage markups on larger trades. Heterogeneity in trade size, rather than in customer information, might be an explanation for the behavior evident in the top panel of Figure 3. Large purchases are much more frequent in the first few days of trade. Perhaps large traders simply receive the reoffering price, while small traders have to pay a higher price.

We examine how the size of the customers' purchases affects the dispersion of the prices in Table 6. We report measures of the intraday range in markups for the three most frequent transaction sizes \$10,000, \$25,000, \$50,000 plus an aggregate measure for institutional transactions of \$250,000 or more. The dispersion in prices is apparent in a number of trade sizes. After the first day of trading, the intraday price dispersion exceeds 50 basis points for 25%-40% of all issues with multiple trades for all trades of up to \$50,000 in par value. Customers making very large purchases, in excess of \$250,000 in par value, face very little dispersion in prices.

The histograms in Figure 5 provide visual evidence of how the dispersion in prices varies with trade size. For each sale to customer within a trade-size category over the first sixty days, we subtract the within-day average markup for trades of that size in that bond. The upper panel plots the resulting markups for all trades, while the bottom panel plots only those trades on days with price variation. Evidently, the distribution is much more concentrated around the within-day mean for larger trade-size categories.

In a classically efficient financial market, the price process behaves like a martingale. Transactions prices close together in time should be tightly centered on a single point. As time progresses, the modal price should move up or down, and the variance of price changes from the starting point should increase through the accumulation of shocks to investors' information sets. Table 7 provides evidence that prices for large trades behave in this way, and much less evidence that the prices for small trades behave in this way.

The top panel reports the percentage of dealer sales to customers at the reoffering price for

trades in different categories across days after the start of trading. The bottom panel reports the percentages at or below the reoffering price. The percentage of customer purchases at the reoffering price is higher for all trade sizes over the first few days, as one would expect if it serves as a focal point. When one adds in the purchases by customers below the reoffering price, in the bottom panel, the percentages increase markedly for the largest traders, particularly as time progresses, and much less so for retail sized trades. Prices for small traders do not evolve as one would expect in a classically efficient, well-functioning financial market.

To summarize, the most natural proxy for heterogeneity in the costs dealers face is transaction size. We would expect economies of scale for dealers in intermediating trades. Were this the only source of dispersion in prices, we would expect small traders to pay high prices and large traders to pay lower prices when they buy newly issued municipal bonds. Similarly, trade size is a natural proxy for differences in bargaining power. Small traders are likely to be occasional market participants. Large traders have repeated interactions with the dealers' sales and trading personnel. Again, however, this would suggest small traders pay high prices and large traders low prices.

The patterns we observe in the data are more complex than either heterogeneity in dealer costs or customer bargaining power alone would suggest. Small customers do, on average, pay more than large customers. But small customers also face a high level of dispersion in the prices at which they trade, while large traders do not, suggesting heterogeneity in the information customers bring with them to the marketplace. Large traders are more homogeneously informed and sophisticated shoppers, because they trade frequently and incur the information gathering costs required to bargain effectively with dealers. Some small traders are similarly sophisticated, and are accordingly able to find attractive prices by purchasing newly issued bonds at or close to the reoffering price. Others arrive uninformed, and trade at prices that can be a half year's to a year's worth of interest higher than the reoffering price.

3.3 Agency and Managed-Account Trades

Differences in information, or in the costs of acquiring information, are one explanation for the variation in the terms at which small investors trade. If the costs of obtaining attractive terms are sufficiently high because of a lack of price transparency, then we might expect institutional

mechanisms to arise allowing investors to delegate trading to others, for whom the costs of gathering information are lower. Mutual funds are one mechanism through which small investors can trade on institutional terms, at the cost of annual fees and flexibility in structuring their own portfolio.

So–called "managed accounts," which involve annual "wrap fees," are another mechanism. Such vehicles have become particularly important in the municipal market. Because of ambiguity in how such trades are reported, and our inability to observe the wrap fees, the presence of managed account trades in our sample may lead us to overestimate the heterogeneity in the terms of trade for retail investors. Also, "agency trades," in which the broker-dealer does not take a position as a principal in the bonds, may be misleading about the costs of some trades in our sample, since the commissions charged may not be reported. In short, some of the heterogeneity we attribute to small investors being informed or sophisticated may be because of their trading indirectly through informed parties, whose compensation we do not directly observe in the measured markup over the reoffering prices.

In an agency trade a broker-dealer arranges for the exchange of bonds between two customers, or between another dealer and a customer, without taking the bonds into inventory. The broker-dealers are compensated by commission. The two sides of the exchange will appear in the transactions data with the same time stamp, and, unless adjusted to account for the commission, at the same price. If the commission is not included, the buyer would appear to be getting better terms than they are actually getting, and we might mistakenly ascribe this to the investor's information or superior bargaining power. There appears to be some ambiguity in whether and how the prices the MSRB reports adjust for the commission.[5]

Agency trades would seem unlikely to be of great importance for new issues, since dealers are

[5]The MSRB notices available to us suggest the MSRB adjusts reported prices to reflect the commissions. "MSRB Interpretive Notices: Rule G-30 Interpretive Notices," available at `http://www.msrb.org/msrb1/not_table.asp`, states, "The transactions data provided by the MSRB's Transaction Reporting System includes 'net' prices of dealer-customer transactions, as well as inter-dealer and broker's brokers' transactions prices." A footnote elaborates as follows: " 'Net' prices include the effect of commission, mark-up, or mark-down." In a question and answer section of their notices, `http://www.msrb.org/msrb1/TRSweb/qa630.htm` question 24, "When reporting dollar prices on agency transactions, should the effect of commissions be included in the dollar price reported to the Board?" is answered with "No. There is a separate field for reporting the commission on agency transactions. The MSRB will include the effect of the commission in the dollar price when aggregating principal and agency transactions and reporting price information on the public daily report." These documents suggest the transactions prices we have are net of commissions. An MSRB official contacted by the authors, however, states that the dealers themselves report prices net of commissions. Thus, the reporting procedures appear unclear, and it is possible some trades in the data are not net of commissions.

acting as principals when they initially purchase the bonds from the issuer. A search of our data for customer sales that match dealer purchases from customers or other dealers at the same time or earlier on the same day in terms of par value and price produce 1,904 such transactions. Such trades are candidates for possible agency trades not reported net of commissions. These trades amount to only 1.3 percent of all the sales to customers in our data. Excluding them has virtually no qualitative or quantitative effect on any of our results.[6] Finally, commissions advertised by dealers who routinely act as agents are small relative to the amount of dispersion in prices we observe.[7]

Trades for managed accounts are likely to be more significant in this context. These arrangements involve an intermediary, known as an "investment advisor," who purchases bonds on behalf of individual investors and allocates them across individual accounts. The intermediaries involved are compensated by an annual fee, known as a "wrap fee," which is a percentage of the assets under management. In effect, the accounts are managed much like a mutual fund, but instead of owning shares in a large portfolio, clients retain legally separate accounts. The investment advisor arranging a trade may not take the bonds into inventory, but instead may instruct the selling dealer to deliver the bonds to other dealers who act as custodians for the final customers' accounts. The receiving dealers are then instructed how to allocate the bonds across individual accounts. The receiving dealer has no control over the terms of the trade, and the selling dealer may not be aware of the identities of the final customers.

MSRB Notice 2003-20, issued in May of 2003 near the end of our sample, resolves the ambiguity regarding how these trades should be recorded. In the context of an example involving a $1 million trade, it states: "With respect to transaction reporting requirements in this situation, the Selling Dealer should report a $1 million sale to a customer. No other dealer should report a transaction."[8] Prior to this notice, however, some of these trades might have been reported as interdealer transactions, representing the transfer from the selling dealer to the receiving custodians,

[6]We have reproduced all of our tables and figures excluding potential agency trades. To illustrate the impact this has on the results in the tables that document price dispersion, none of the percentages in Table 5 change by more than a point. None of the percentages in the first three panels of Table 6 change by more than a point. In the last panel four of the reported percentages change by two points, and two by three points. Only one of the percentages in Table 7 changes by two points, and the rest by only one point or less. In Table 8, after rounding to the nearest percentage, only three of the numbers in the body of the table change by two points, the rest by one or less.

[7]For example, Fidelity's web site report commissions of 20 basis points on a $10,000 trade.

[8]This notice is available at `http://www.msrb.org/msrb1/archive/TRSIANotice.htm`.

followed by multiple smaller sales to customers, when the receiving custodians allocate the bonds to individual accounts. All these trades would be recorded at the same price, and very close together in time. Such reporting would lead us to overstate the heterogeneity in the terms at which retail-level customers trade for two reasons. First, the wrap fees are not reflected in the recorded transactions prices. Second, economically these are large block trades arranged by a professional intermediary, as the MSRB's ruling acknowledges. The receiving dealers and final customers have no direct control over its terms.

With regard to the unobserved fees, we note that they are not of sufficient magnitude to alter our conclusion that there is a great deal of dispersion in the costs of trade for retail investors. For example, Nuveen Investments is one of he largest providers of managed accounts in the municipal market. Marketing materials on their web site present historical performance of portfolios with wrap fees varying from 75 to 125 basis points. Allocating these costs across several trades a year, it appears that managed accounts are a cost effective way for retail level investors to buy municipal bonds.

To evaluate the importance of managed trades for our empirical analysis, we searched our data for examples of three or more sales to customers at the same price on the same day, preceded by an interdealer trade at the same price, with par value greater than any of the individual trades. This selection procedure is conservative, in that it is likely to include many trades that are not managed account trades. Simply requiring that the preceding interdealer trade be for more than $250,000 in par value, for example, decreases the number of trades selected by half. The search produced 1,369 potential transactions involving 10,222 individual sales to customers, 7.2 percent of the sales to customers in our data. We then aggregated these sales to customers, treating each group of same-day, same-price sales as one large trade, and repeated all of our analyses.

Aggregating possible managed account sales to customers has only minor quantitative effects on our findings, and has no effect on the qualitative conclusion that retail investors face considerable price dispersion, while large traders trade at attractive terms with little price dispersion.[9]

[9]To illustrate, of the 42 percentages reported in the body of Table 5, which concerns intra-day price variation, only five of these change at all, and in each case by only a percentage point. Table 6 stratifies the intra-day price variation by trade size. Only 33 of the 96 percentages reported there change, when the possible managed account trades are aggregated. In two cases this change is three percent, in three cases it is 2 percent, and in the remaining cases it is only one percent. Most of the percentages reported in Table 7 rise somewhat. The managed account trades are likely to be informed ones, leading to fewer customer buys at or below the reoffering price when they are

3.4 Underwriter Performance on Sales at the Reoffering Yield

Tax regulations limit the yields that can be earned on the proceeds from municipal issues to preclude the obvious tax arbitrage that can be gained by tax-exempt institutions who can borrow at a tax-exempt rate and then invest at taxable rates. These regulations are stated in terms of the "issue price." In the words of the National Association of Bond Lawyers Issue Price Study Group (NABL Study Group), "The determination of the issue price of tax-exempt obligations is one of the linchpins for measuring compliance with Sections 141 and 150 of the Code. A wide variety of the constraints on and rules governing the issuance of tax-exempt bonds use the definition of issue price as their starting point."[10] The bond counsel relies on certificates from the underwriter to establish the issue price, and this price that is used is generally the reoffering price, which is disseminated to the public through *The Bond Buyer* or *Bloomberg* news wires.

When bonds are being sold by the underwriters at multiple prices the "issue price" is ambiguous, but even highly informed commentators appear to overlook the price dispersion, and discuss the regulations as if there were a single price. For example, in a book published by the American Bar Association, *ABCs of Arbitrage: Tax Rules for Investment of Bond Proceeds by Municipalities*, Ballard (2006) writes, "The regulations state that the issue price of bonds may not exceed their fair market value as of the sale date...The 'value' on which the limit is based is clearly the price at which the bonds can be sold to the public, this is, the retail value, as distinguished from the wholesale value at which an underwriter would purchase from the issuer." Indeed, the NABL Study Group has recently sought clarification from, and made recommendations to, the Office of Tax Policy concerning the definition of the issue price. Specifically, they suggest actual market prices be ignored and recommend: "...if certain standard marketing procedures are followed, the initial offering price at which the bonds are offered to investors by the underwriter shall be deemed to be the issue price of a bond, regardless of the prices at which they are actually sold and regardless of prices at which other trades may occur." (p. 2)[11]

aggregated. The mass of the trades in the lower tail, however, increases much more through time for the large trades than the small ones, as reported in the previous section. With wrap-fee trades aggregated, for example, 63 (days 3-5), 47 (days 6-10), and 30 (> 10 days) percent of the largest trades are at or below the reoffering price, while 31, 16, and 5 percent (respectively) are at the reoffering price. The comparable percentages for the trades from $10,000 to $25,000 in par value are 13, 10, and 14 percent (at or below) and 11, 7, 4 percent (at the reoffering price).

[10] "Recommendations by the National Association of Bond Lawyers Issue Price Study Group," August 25, 2006, www.nabl.org.

[11] The NABL Study Group Recommendations refer to a earlier working-paper version of this paper that described

Treasury Regulation §1.148-1(b) states:

> Generally, the issue price of bonds that are publicly offered is the first price at which a substantial amount of the bonds is sold to the public. Ten percent is a substantial amount. The public does not include bond houses, brokers, or similar persons or organizations acting in the capacity of underwriters or wholesalers. The issue price does not change if part of the issue is later sold at a different price. The issue price of bonds that are not substantially identical is determined separately. The issue price of bonds for which a bona fide public offering is made is determined as of the sale date based on reasonable expectations regarding the initial public offering price.

Evidently, the intent of this definition is to ensure that the yield reported to the tax authority is economically meaningful. Our data allows us to evaluate the extent to which it is.

We compute the fraction of issues with sales to customers at the reoffering price over the first sixty trading days after the issue. For 35% of the issues, all the sales to customers are at the reoffering price, suggesting that the reoffering price is, indeed, an economically meaningful quantity. For almost as many issues, 25%, there are no sales to customers at all at the reoffering price over the first sixty days, and for 15% of the issues there are none at or below the reoffering price.

Table 8 provides some evidence on the robustness of the finding. We report several different measures of the sales to customer, at or below the reoffering price ("Discount Sales"), as a fraction of the total issue. For example, we compute the total par value of sales below the reoffering price over the first sixty days of trading. We also consider all the sales to either customers or other dealers that exhaust the dealers' initial inventory in the bond; and the last sales in time, within the first sixty days, that aggregate to the size of the issue. The body of the table reports the percentage of issues where the fraction of par value sold, computed using the different measures, falls in the range on the left hand side.

By all the measures, a substantial fraction of the issues show less than the ten percent guideline being sold at or below the reoffering price. Depending on the measure used, between 5.4% and

the tax rules as requiring "that at least ten percent of each issue be sold at the reoffering yield." The Study Group Recommendations point out, correctly, that this does not accurately state the requirements of the tax law, as the ten percent is "helpful guidance" and is qualified by the "reasonable expectations" language of the regulation. (See footnote 1 and page 8 of the NABL Study Group Recommendations.)

15.9% of issues sell none of the issue at or below the reoffering price. If we consider issues selling less than the ten percent at or below the reoffering price, these percentages rise: 6.1% to 19.1%, depending on the measure used. When we consider entire deals, however, these percentages are much lower. We have no way of establishing whether, in these specific cases, at the date of sale the reoffering price was based on a "bona fide public offering" and "reasonable expectations regarding the initial offering price" as required by Treasury Regulation §1.148-1(b). Obviously, however, it is well within the underwriter's power to sell more bonds at the reoffering price if he so desires. It is rarely difficult to sell bonds for *less*.

4 A Mixture Model

The behavior evident in Figure 3 suggests dealer markups are drawn from two distributions. Some investors trade at or close to the reoffering price, while simultaneously other investors are buying bonds at a diffuse set of prices that can be very far from the reoffering price. From Figure 4 and Table 6 it is apparent that large buyers are more homogeneous in the terms of trade they receive, suggesting they are more consistently informed.

We report estimates from a mixture model for the markups investors pay when they purchase newly issued municipal bonds. The empirical analysis provides new insights into the value of non-fundamental pricing information and into the determinants of underpricing in municipal bonds.

The market for new municipal bond issues is relatively opaque. Information about upcoming issues is immediately at hand to institutional investors, who are trading frequently. Retail investors must exert more effort to obtain information that might help them evaluate whether a particular price quotation is reasonable, but it is available. For example, the reoffering price or yield can be found in trade publications and the financial press, such as *The Bond Buyer* and *Bloomberg*, in the final official statement for the bond issue, and from retail brokers if the customer knows to ask for it. Our earlier results suggest this is a natural focal point for negotiating with broker-dealers. Transactions prices are now available quickly on-line, through *Investinginbonds.com*, although the value of this source was much more limited during most of our sample period.

Nevertheless, an individual investor who trades infrequently in the municipal market may still find it costly to put himself in an informed position. First, some investment of time and effort is

required to gain sophistication regarding the need for pricing information and its sources. Retail brokers and other intermediaries who serve retail customers have minimal incentives to educate existing customers about alternative sources of information. Even a customer who suspects that a broker's terms are punitive might find it costly to arrange to trade elsewhere. Setting up a new brokerage account is costly. The transactions data available does not reveal broker-dealer identities. Knowing a better price is available is therefore not equivalent to knowing who to contact without additional costly search.

Models of price dispersion in consumer markets correspond, to some extent, to the market for new issues of municipal bonds, and provide some guidance regarding the existence and persistence of price dispersion for these securities. In such models, consumers choose between paying the price offered for a good by a particular seller, or incurring a cost and paying the minimum price offered by other sellers. Sellers, in turn, optimally follow mixed strategies in setting prices. For example, Shilony (1977) assumes the cost is due to location. Each store has preferential access to certain customers. If the price the store posts is sufficiently high, customers incur the cost of traveling and buying at the store offering the lowest price, which is common knowledge. Such a setting corresponds to investors in the municipal market who know where to look for price information, yet face switching or convenience costs buying from the low cost broker-dealer.

Varian (1980) interprets the cost as one of information acquisition. Stores advertise prices. Consumers choose a store at random, or, at some cost, they gather information from advertisements and buy from the low-price seller. Such a model would describe investors in the municipal market who need to incur some cost to educate themselves about information sources that are free to those who "know where to look." Burdett and Judd (1983) assume it is costly for consumers to gather prices from each potential seller. Such a model corresponds to a market without public sources of price information, where investors simply called multiple dealers to obtain take-it-or-leave-it offers.

To the extent that the puzzle in the municipal market is that small investors fail to educate themselves about sources of information at hand, none of these models correspond precisely to the municipal market. Indeed, all of these explanations for heterogeneity in investor information and prices may be at work. For investors fully cognizant of the resources available to them, the Shilony (1977) model most aptly describes the costs they face. Those who lack this sophistication may well

operate as do agents in the Varian (1980), or even the Burdett and Judd (1983), model.

Our empirical approach in this section attempts to capture the determinants and consequences of being an informed or sophisticated shopper in the market for new municipal issues. We assume there are both observable and unobservable sources of heterogeneity in the costs investors face in gathering and using information about prices.

4.1 Model

An investor's information depends in part on exogenous or predetermined factors such as chance or word-of-mouth advertising, and in part endogenously on the trade-off between the costs and benefits of acquiring information. Assume that for investor i, the difference between the benefit and cost of learning about a new issue is z_i^*, with

$$z_i^* = w_i\delta + u_i, \tag{1}$$

where w_i is a vector of conditioning variables, δ is a parameter vector, and u_i is an error term observed by the investor but not the econometrician. Investor i becomes informed about the issue price if and only if $z_i^* \geq 0$. We do not observe z_i^*, but we do observe w_i and the price the investor pays for the bond.

The model categorizes individual transactions as likely to be "informed" or "uninformed" on the basis of observable characteristics of the trade. Informed investors should know where to go to obtain information at relatively low cost. We cannot observe the identity of individual traders and so we cannot model such heterogeneity in costs directly. It is subsumed in the error terms in the choice equation (1).

An investor who is uninformed about the reoffering price for a new bond issue is willing to pay the percentage markup y_U of

$$y_{Ui} = x_i\beta + \epsilon_{Ui}, \tag{2}$$

with x_i a vector of conditioning variables, β a parameter vector, and ϵ_{Ui} an error term. An investor who is informed about the underwriter's pricing of the bond issue is willing to pay the percentage

markup y_I of

$$y_{Ii} = x_i\gamma + \epsilon_{Ii}, \tag{3}$$

with x_i a vector of conditioning variables, γ a parameter vector, and ϵ_{Ii} an error term. We expect the uncertainty about the percent markup to be lower when the investor is informed than when the investor is uninformed:

$$\sigma_I < \sigma_U. \tag{4}$$

In the empirical implementation, we use condition (4) to identify the informed versus uninformed distributions from which the observed transactions are drawn.

Observed values of y_i—defined as the relative markup over the reoffering price—come from one of two distributions. We do not directly observe which distribution produced any given observation. The observed distribution of markups is, therefore, a mixture of the markup equations (2) and (3). The markup y_i observed in transaction i is

$$y_i = \begin{cases} y_{Ui} & \text{if } z_i^* < 0, \\ y_{Ii} & \text{if } z_i^* \geq 0. \end{cases} \tag{5}$$

The realized markup y_i is observed but y_{Ui}, y_{Ii}, and z_i^* are unobserved.

Using iterated expectations,

$$\begin{aligned} E(y_i|w_i, x_i) = {} & E(y_i|\text{Informed}_i, w_i, x_i)\Pr(\text{Informed}_i|w_i) \\ & + E(y_i|\text{Uninformed}_i, w_i, x_i)\Pr(\text{Uninformed}_i|w_i). \end{aligned} \tag{6}$$

The investor takes the markup into account when deciding whether to become informed about an upcoming bond issue or not. As a consequence, u_i and ϵ_{Ui} are correlated, and u_i and ϵ_{Ii} are correlated. Denote the correlation between u_i and ϵ_{Ui} as ρ_U and the correlation between u_i and ϵ_{Ii} as ρ_I.

To estimate the model, we assume that the error terms are drawn independently and identically

from a multivariate normal distribution:

$$\begin{pmatrix} u_i \\ \epsilon_{Ui} \\ \epsilon_{Ii} \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{bmatrix} 1 & \rho_U\sigma_U & \rho_I\sigma_I \\ \rho_U\sigma_U & \sigma_U^2 & 0 \\ \rho_I\sigma_I & 0 & \sigma_I^2 \end{bmatrix} \right). \tag{7}$$

Here, the variance of the error term in equation (1), u_i, is normalized to be to one, and the error terms in the pricing equations, ϵ_{Ui} and ϵ_{Ii}, are uncorrelated to each other.

Let Φ denote the cumulative standard normal distribution, and ϕ the standard normal density. Investor i is informed if and only if $z_i^* \geq 0$, implying that

$$\begin{aligned} \Pr(\text{Informed}_i|w_i) &= \Pr(z_i^* \geq 0|w_i) \\ &= \Pr(u_i \geq -w_i\delta|w_i) \\ &= \Phi(w_i\delta), \end{aligned} \tag{8}$$

and

$$\Pr(\text{Uninformed}_i|w_i) = 1 - \Phi(w_i\delta). \tag{9}$$

Using equation (3),

$$E(y_i|\text{Informed}_i, w_i, x_i) = x_i\gamma + E(\epsilon_{Ii}|z_i^* \geq 0). \tag{10}$$

Using the distributional assumption for the error terms,

$$\begin{aligned} E(\epsilon_{Ii}|\text{Informed}_i, w_i) &= E(\epsilon_{Ii}|z_i^* \geq 0) \\ &= \rho_I\sigma_I\frac{\phi(w_i\delta)}{\Phi(w_i\delta)}, \end{aligned} \tag{11}$$

so that

$$E(y_i|\text{Informed}_i, w_i, x_i) = x_i\gamma + \rho_I\sigma_I\frac{\phi(w_i\delta)}{\Phi(w_i\delta)}. \tag{12}$$

Similarly,

$$E(y_i|\text{Uninformed}_i, w_i, x_i) = x_i\beta + \rho_U\sigma_U\frac{-\phi(w_i\delta)}{1 - \Phi(w_i\delta)}. \tag{13}$$

The expected markup therefore is

$$E(y_i|w_i, x_i) = \left(x_i\gamma + \rho_I \sigma_I \frac{\phi(w_i\delta)}{\Phi(w_i\delta)} \right) \Phi(w_i\delta) + \left(x_i\beta + \rho_U \sigma_U \frac{-\phi(w_i\delta)}{1 - \Phi(w_i\delta)} \right) (1 - \Phi(w_i\delta)). \quad (14)$$

We estimate equation (14) as a switching regression using the EM algorithm.[12]

4.2 Results

Table 9 describes the explanatory variables used in the estimation. Table 10 summarizes the coefficient estimates for the markup equation. The first set of columns in the body of Table 10 contains estimation results from a linear regression of percent markups over reoffering price against observed characteristics of the bond and trade, using the pooled sample of all sales transactions during the first five days of trading. Results, reported below, are very similar over longer horizons and for market-adjusted markups.

The OLS estimates reported in the first column show that traders with large orders pay less than traders with small orders. Consistent with the descriptive analysis, the expected markup on an average transaction increases by 19 basis points per day starting with the first day of trading. When-issued trades, i.e., transactions that occur before the settlement date of the issue, are priced four basis points cheaper on average than ordinary trades. Markups on competitive offers are, on average, ten basis points lower than in negotiated deals.

The remaining columns in the body of Table 10 report coefficient estimates from the mixture model. The regressors—x_i in equations (2) and (3)—are de-meaned using the unconditional sample means. Sales to customers that appear to be agency trades are excluded. Sales that we identify as possible trades for managed accounts are included in disaggregated form, but we include an indicator for such trades as a conditioning variable.

The coefficients indicate that there are two pricing regimes. There is little variation in transaction prices for informed investors; most coefficient estimates are close to zero. The higher intercept term indicates that uninformed buyers pay higher prices on average (135 basis points). The economically large values for the other coefficients shows there is substantial variation in the prices paid by uninformed investors. Even for uninformed buyers, large transactions still occur at more

[12] See Hartley (1978) for details on the implementation of the iterative estimator.

favorable prices, and when-issued trades are priced at nine basis points below ordinary trades. We would expect this, because whether buyers are well informed or not, there are surely returns to scale in processing trades and dealers will sacrifice profits to avoid holding bonds in inventory.

Higher rated bonds transact, in general, at more favorable prices for uninformed investors. The negative coefficient on days since trading begins for both types suggests the upward trend in prices is explained mostly by time-series variation in the composition of investor types.

Curiously, premium bonds trade at yields well above those of bonds with reoffering price below par. The price difference is about half a percent. Underwriters and brokers argue that retail investors are behaviorally averse to buying bonds at a premium, and underwriters accordingly use this device to signal that an issue is targeted to institutional investors. Trades identified as possible wrap-fee trades involve lower markups over all, as we would expect if they are carried out by sophisticated intermediaries. Since our mechanism for identifying wrap-free trades likely includes many trades that are not for managed accounts as well, and since the classification of trades as informed and uninformed is noisy, the wrap fees variable continues to have explanatory power within each regime.

Table 11 summarizes the coefficient estimates for the investors' decisions to become informed or not, equation (1). The coefficient on trade size shows that large buyers are more likely to be informed about the bond issue and the reoffering price. We would expect that the repeated nature of the interactions with intermediaries and their access to infrastructure would allow them to acquire information at relatively low cost. Further, the mix of informed and uninformed investors is changing over time, as time elapsed since issuance decreases the probability of being informed. Informed investors buy soon after issuance and are therefore the more likely counter-party early on. If a trade is identified as a possible wrap-fee trade, it is more likely to be an informed trade, as we would expect.

Longer maturity bonds are more likely to be bought by uninformed investors. Lower rated bonds see more informed trading than prime bonds. First-time issuers also attract more informed investors, but so do frequent issuers. This may be because first-time issuers lack the visibility to attract broad and unsophisticated retail participation. Frequent issuers, while attracting retail investors, also have lower costs of becoming informed about upcoming issues for the traders.

The coefficient on the underwriter discount is positive; an increase in the underwriter discount increases the probability that the bond will be sold to informed investors. One interpretation of the finding is that the issuers face a tradeoff between paying a higher spread or imposing higher costs on retail investors.

In Table 12 we report the results from estimating the mixture model over a longer time horizon and using an alternative definition of the dependent variable. We use all transactions during the first sixty days, and we adjust the markups for market-wide returns. We define the market-adjusted markup used in Table 12 as the difference between the transaction price and the reoffering price, as a percentage of the reoffering price (i.e., the gross markup), minus the return on a broad-based maturity-matched municipal bond index over the same time period. The coefficient estimates are similar to the ones reported in Tables 10 and 11, and they convey the same intuition. Informed investors transact at quite more favorable prices than uninformed investors.

One variable that changes sign in the choice equation with the longer time period—60 rather than 5 days—is issue frequency. The sign switch suggests that informed trading for frequent issuers occurs entirely in the first few days. When an issuer comes to the market more frequently, sophisticated investors anticipate the issues.

4.3 Money Left on Table by Uninformed Investors

How economically significant is the money left on the table by uninformed investors to the broker–dealers? The answer provides insights into the incentives and trade-offs faced by the broker–dealers and underwriters in the underwriting process and into the competitiveness of the industry. The answer may also help explain the reluctance of the bond underwriters to introduce more pre-trade transparency in the muni market.

We use our parameter estimates to classify each transaction into either the *Informed* or *Uninformed* regime. We also use our parameter estimates to form estimates of the expectation of the difference between the benefit and cost of learning about the new issue in equation (1), conditional on the observed markup and the conditioning variables. The transaction is classified as coming from the *Informed* regime if the expected benefit is greater than the cost, and classified as coming

from the *Uninformed* regime otherwise:

$$\begin{aligned} \text{Informed}_i = 1 \quad &\Leftrightarrow \quad E(z_i^*|y_i, w_i, x_i) \geq 0, \\ \text{Uninformed}_i = 1 \quad &\Leftrightarrow \quad E(z_i^*|y_i, w_i, x_i) < 0. \end{aligned} \tag{15}$$

The difference in the expected markup between an informed investors and an uninformed investor is:

$$E(y_{Ui} - y_{Ii}|\text{Uninformed}_i, w_i, x_i) = x_i(\beta - \gamma) + (\rho_U \sigma_U - \rho_I \sigma_I)\frac{-\phi(w_i\delta)}{1 - \Phi(w_i\delta)}. \tag{16}$$

We define the money left in each transaction with an uninformed investor as

$$\Delta_i = \begin{cases} \max\{E(y_{Ui} - y_{Ii}|\text{Uninformed}_i, w_i, x_i), 0\}, & \text{if Uninformed}_i = 1, \\ 0, & \text{else.} \end{cases} \tag{17}$$

We form estimates of Δ_i by plugging our parameter estimates into equation (17). Let $\hat{\Delta}_i$ denote the resulting estimates.[13]

To obtain a cumulative measure we aggregate the estimates of $\hat{\Delta}_i$ across all sales transactions i in a given bond issue j, and then across all issues in a deal. For a given deal,

$$\text{Money } \widehat{\text{Left on}} \text{ Table} = \sum_{\text{Issues } j} \sum_{i \in j} \hat{\Delta}_i. \tag{18}$$

Table 13 shows statistics for the money earned by underwriters from uninformed investors across all bond deals in the sample. On the first two rows we report statistics for the conditional markup difference, Δ_i. In the third row we aggregate all sales transactions in a given issue, and in rows 4-6 we aggregate amounts earned in a given deal. The last lines give the underwriter discount as a percent of par value per deal. The money left by uninformed investors is a significant fraction of overall expected profits to the broker-dealers and underwriters. Total expected profits are defined as the sum of the underwriter fees, and the money left on the table. As with the markups in general, the distribution of money left on the table is highly skewed. Figure 6 plots the cross-sectional

[13] We also compute $\hat{\Delta}_i$ without truncating at zero. The results are similar to the ones computed using the truncation.

distribution. More than two thirds of all bond deals generate at least 5% of their expected profits from trading profits with uninformed investors, about half of the deals generate 5-50% of profits with uninformed investors, while for a small fraction of deals the trading profits with uninformed traders amounts to more than 50% of profits.

5 Conclusions

The behavior of prices for newly issued securities are informative about the role of financial intermediaries in the security issuance process, the situations in which they can exercise market power, the nature of the costs they face, and the efficiency with which capital is provided to those who demand it.

In contrast to trading venues with more transparency such as equity markets, the market for municipal bonds exhibits high levels of price dispersion, even within trade size categories. Perhaps some smaller investors face high search or information acquisition costs. Alternatively, behavioral considerations may suggest reasons that some investors trade at such unattractive terms.

Policy makers can control the degree of transparency in securities markets. Indeed, the post-trade transparency in the municipal market has, through changes mandated by the MSRB, increased dramatically. Prices are now available on-line within fifteen minutes of a trade. The consequences that this will have for small investors, institutional investors, issuers, and broker-dealers is an open theoretical and empirical question.

Some caveats should be kept in mind before confidently attributing the high costs of trade some investors bear directly to the transparency of the trading venue. First, the trading venue and trading costs are jointly endogenous outcomes. There may simply be much less demand by retail investors for liquidity in municipals bonds than in equities. Second, intermediaries such as mutual funds and investment advisors provide means through which small investors can circumvent the high costs of trading small quantities, or the information acquisition costs associated with such trading. The measures our mixed-distribution model provides of the costs of trading as an uninformed investor, however, suggest that the losses such investors actually incur are economically meaningful, especially for issues with high levels of retail participation. The willingness of some investors to bear these costs suggests they ascribe a high value to the freedom to directly control

the maturity, tax-exposure, and credit risk of their portfolios.

Our results suggest that both issuers and investors could benefit from mechanisms that give retail investors more direct, low cost access to the primary bond market through participation in the offering. Underwriter spreads and fees are a relatively transparent cost to the issuer, and we would expect underwriters to compete vigorously for new business on this dimension. The profits earned in distributing the bonds to smaller investors, on the other hand, are more difficult for issuers to evaluate because of the opacity of the market in which municipal bonds trade. Currently, because underwriter spreads are relatively low in the primary market, retail brokers have little incentive to fill customers' orders by participating directly in the bond offering. Retail investors hold roughly 35% of municipal bonds outstanding. Broker-dealers and large institutions in the market seem unlikely to support the development of such mechanisms, since this will eliminate what appears to be an important, and relatively opaque, source of profits to them.

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Appendix A Sample Construction

The two main data sources are the Primuni sample of municipal bond deals and the MSRB database of all secondary market transactions. We have applied a sequence of simple rule-based filters to identify outliers and fix clerical errors in both datasets. In the following we describe each of the filters in the order in which they have been applied, and we summarize how many transactions, issues, and deals were affected by the corresponding filters. We start by screening the Primuni sample of new issues, and then we check for consistency in the MSRB sample of customer transactions. The filters we have applied address the most common problems in the data.

Primuni New Issues Sample: First, we check for duplicate deals and CUSIPs, and eliminate all duplicates. Next, we search for missing, erroneous, and incomplete CUSIP numbers, reoffering prices, and issue sizes, respectively. We eliminate the corresponding bond from the sample if any of these items are missing. If there are obvious errors such as misplaced decimal points in the reoffering price, the reoffering yield, or the coupon rate, we correct the data. We double-check all other fields for consistency and formatting errors.

MSRB Secondary Market Transactions: First, we erase all dealer purchases from customers recorded before the first recorded sales transaction. This filter captures initial purchases from the issuer that are reported in the MSRB database with a wrong time stamp or in error. The first filter removes a total of 2,091 transactions.

Second, we determine the aggregate dealer inventory at each point in time. We individually look at all bonds with a calculated dealer inventory during the first sixty trading days after issuance that exceeds the size of the issue[14], and at all bonds with negative dealer inventory. If the maximum inventory is larger than the issue, we erase a single dealer purchase from the sample if at least one of following two criteria is satisfied:

- The par amount of the purchase is equal in magnitude to the remaining aggregate dealer

[14]For the screening we adjust the issue size number in the Primuni sample if the hand-collected size of the issue is not consistent with the MSRB transactions in the following way. We merge the new issues data with the corresponding secondary market transactions in the MSRB database. We then compare the hand-collected issue size to the par amounts associated with all transactions in the MSRB database. We set the issue size to the par amount of the largest secondary market transaction, if the recorded size is less than the largest transaction and the following two additional conditions are satisfied: First, the original issue size leads to an aggregate dealer inventory after sixty trading days that is not nil and, second, the aggregate dealer inventory falls within the first sixty trading days from issuance by a par amount exactly equal in magnitude to the largest transaction. We adjust the issue size only if all three of the above conditions hold.

inventory after sixty trading days, and after deletion the dealer inventory does not exceed the size of the issue at any point in time.

- The par amount is equal to the issue size, the purchase transaction would increase the current dealer inventory to more than the par size of the issue, and the aggregate dealer inventory after sixty trading days would be above the original issue size. For these bonds it is likely that tickets on sales transactions are missing from the MSRB database.

The second filter eliminates 209 transactions.

Third, we determine the minimum dealer inventory over the first sixty trading days and check all bonds with a negative dealer inventory. We identify all sales transactions that are immediately followed (in the order transactions appear in the MSRB database) by another sales transaction with the same par amount, time stamp, and price (type I), same par amount and time stamp (type II), or with the same par amount, trade date and with negative dealer inventory immediately after the transaction (type III). We delete the first of the two sales transactions if the minimum aggregate dealer inventory before deletion (measured during the first sixty trading days) is negative and after deletion it is exactly zero. These are likely transactions that were entered repeatedly to correct the previously reported transaction price, in error, or for some other reason. The third filter eliminates 173 transactions.

Forth, we eliminate the last sales transaction that occurs before the aggregate dealer inventory turns negative for the first time and that matches the negative inventory amount after sixty trading days. In this case it is likely that data on purchase transactions is missing from the MSRB database. The fourth filter eliminates 804 transactions.

Fifth, we erase the sales transaction with the smallest par amount that leads to a non-negative minimum dealer inventory while keeping the dealer inventory bounded above by the issue size during the first sixty trading days after issuance. If there is more than one transaction satisfying the criteria, we pick the last. The fifth filter eliminates 472 transactions.

Deals and Bond Issues Eliminated: In the last step we eliminate all bonds in which transactions take place at a par amount larger than the adjusted issue size. We also erase all bonds that after filtering the transactions history remain to have a maximum dealer inventory greater than their issue size, or a minimum dealer inventory below zero or equal to the size of the issue.

If there are a number of irregularities for different bonds of the same deal, we eliminate the entire deal. The last step eliminates 1,494 bonds.

After data cleaning a total of 1,000 out of 1,048 deals remain in the sample, and 12,493 out of 13,987 individual bond issues remain in the sample.

Table 1: Sample Selection.
The table describes the sample's characteristics. The first two columns in the body of the table list the characteristics of the bonds appearing in our sample falling into the category in question. The second set of columns gives the characteristics in the population of new issues during the sample period. The first number in each column is the cross-sectional mean, and the number in parenthesis is the cross-sectional median. The proxy for size are the net sales to customers during the first sixty days if they exceed the maximum transaction size. Maturity, coupon, callability, and taxable status are size-weighted averages per deal. The percentages for the different ratings categories are conditional on a rating being available. Data on the ten states with the highest proportion of millionaires is from the *Statistics of Income Bulletin, Winter 2002*. No-Tax States are states with no state income tax. In these states bonds issued either in-state or out-of-state are tax exempt at the state level. Tax States are states where both in-state and out-of-state issuers are taxable.

	Sample		Market	
	Issues	Deals	Issues	Deals
Par Size (proxy)	2.2 (0.6)	27.2 (9.6)	2.5 (0.4)	24.2 (5.7)
Volume (in million $)	4.3 (1.0)	53.8 (17.9)	5.4 (0.7)	52.2 (9.9)
Sales to Customers	2.3 (0.6)	29.5 (10.0)	3.1 (0.4)	29.7 (6.0)
Purchases from Customers	0.4 (0.0)	5.4 (0.6)	1.0 (0.0)	9.4 (0.1)
Interdealer Transactions	1.5 (0.2)	19.0 (5.5)	1.3 (0.1)	13.1 (0.5)
Transactions	17.3 (6.0)	215.7 (97.5)	13.8 (4.0)	134.0 (29.0)
Sales to Customers	11.3 (4.0)	162.3 (65.5)	10.2 (3.0)	98.8 (20.0)
Purchases from Customers	0.6 (0.0)	7.7 (2.0)	0.6 (0.0)	6.0 (1.0)
Interdealer Transactions	3.7 (1.0)	45.8 (23.0)	3.0 (1.0)	29.2 (3.0)
Maturity	9.7 (8.9)	11.9 (11.4)	9.7 (8.5)	11.5 (10.0)
Coupon	4.7 (4.8)	4.7 (4.8)	4.4 (4.5)	4.1 (4.3)
Rating				
AAA	71.5%	76.7%	73.8%	77.5%
AA	20.6%	19.8%	19.4%	19.6%
A-BBB	7.4%	6.0%	6.5%	7.0%
BB-D	0.4%	0.4%	0.3%	0.3%
Bond Type/ Issuer Type				
Callable Bond	33.6%	41.5%	37.6%	43.4%
Taxable Bond	0.8%	1.8%	2.4%	3.2%
Development Revenue Bond	0.7%	0.9%	0.7%	2.1%
Pollution Revenue Bond	0.2%	0.2%	0.2%	0.4%
Certificate of Participation	2.5%	2.5%	2.9%	2.5%
Tax Revenue Bond	2.1%	2.1%	3.1%	2.2%
School District Issuer	36.3%	37.2%	23.7%	18.2%
Health Care Issuer	2.2%	3.4%	2.2%	3.0%
Transportation Issuer	2.8%	3.0%	2.8%	2.6%
Utility Issuer	10.0%	9.2%	10.7%	8.9%
State of Issuance				
No-Tax States	16.3%	15.7%	18.2%	15.4%
Tax States	7.7%	9.2%	11.9%	13.5%
U.S. Territories	0.2%	0.2%	0.3%	0.3%
Ten Most-Populated States	55.0%	55.8%	49.2%	47.3%
Ten Most-Millionaires States	20.9%	21.0%	23.6%	23.4%
Top 3 States	PA (16.3%)	PA (18.7%)	TX (9.1%)	CA (7.2%)
	TX (7.6%)	TX (6.7%)	CA (8.8%)	NY (6.9%)
	CA (6.5%)	CA (5.4%)	NY (7.0%)	TX (6.5%)

Table 2: Patterns of Trade in Filtered Sample.

The table reports aggregate summary statistics for the MSRB transactions data associated with the Primuni sample of new issues after application of the various filters. Summary statistics are reported separately for transactions constituting a sale from a registered broker-dealer to a customer, a dealer purchase from a customer, and a transaction between dealers. In reporting the transaction size, we compute median transaction size per bond measured in thousand $. Total volume is the cumulative dollar amount of all transactions of the given type during the first sixty days.

	All Transactions	Sales to Customers	Purchases from Customers	Interdealer Transactions
No. of Transactions (in thousands)	190.3	141.3	5.4	43.6
Transaction Size (in thousand $)	49.9	30.0	163.4	156.6
Total Volume (in billion $)	50.5	28.8	3.7	18.0

Table 3: Transactions and Volume per Issue.

The table reports summary statistics for the cross-section of new bond issues. The first row in each panel reports the fraction of issues with transactions during the first sixty business days after issuance. The issuance date is defined as the earliest date on which transactions are reported in the MSRB database and as the settlement date if no trades are recorded before then. The first day trades are recorded typically precedes the settlement date and differs from the dated date. The statistics of the cross-sectional distribution reported in the remaining rows in each panel are conditional on occurrence of transactions of the given type for the given bond issue. In reporting the transaction size, we compute median transaction size across all trades measured in thousand $. Total volume is the cumulative dollar amount of all transactions of the given type during the first sixty days.

	Median	Mean	S.D.
Sales to Customers			
Issues with Transactions		100%	
Number of Transactions	4	11	39
Transaction Size (in thousand $)	81	474	1,629
Total Volume (in thousand $)	594	2,309	9,402
Purchases from Customers			
Issues with Transactions		17%	
Number of Transactions	1	3	6
Transaction Size (in thousand $)	250	798	1,847
Total Volume (in thousand $)	425	1,754	4,865
Interdealer Transactions			
Issues with Transactions		66%	
Number of Transactions	2	5	10
Transaction Size (in thousand $)	158	370	1,300
Total Volume (in thousand $)	515	2,177	7,342

Table 4: Transactions per Issue and Day since Issuance.
The table reports summary statistics for the transactions associated with a given bond issue for each day since issuance. The first column in the body of the table reports the fraction of bond issues with transactions of the given type on the given day. The statistics for the cross-sectional distribution reported in the remaining columns are cross-sectional averages conditional on a transaction of the given type occurring in a bond issue on the given day.

	(1)	Cross-Sectional Mean Conditional on (1) Issue-Days with Transactions			
	Issue-Days with	Daily Turnover	Daily Volume	Number of	Transaction Size
Day	Transactions	(% of Issue Size)	(in thousand $)	Transactions	(in thousand $)
			Sales to Customers		
All	6%	27%	614	3	243
1	86%	73%	1,725	4	602
2	31%	30%	625	5	199
$3-5$	19%	18%	297	3	131
$6-10$	12%	12%	230	3	114
>10	3%	9%	222	2	133
			Purchases from Customers		
All	0%	28%	1,084	2	852
1	4%	41%	993	2	593
2	2%	34%	977	2	614
$3-5$	1%	21%	918	2	777
$6-10$	1%	27%	1,228	2	1,000
>10	0%	25%	1,128	1	941
			Interdealer Transactions		
All	3%	44%	854	2	346
1	54%	76%	1,216	2	462
2	13%	45%	1,120	3	352
$3-5$	8%	34%	759	2	319
$6-10$	5%	29%	599	2	262
>10	1%	22%	583	2	276

Table 5: Intraday Price Variation in Sales to Customers per Issue and Day since Issuance. The table reports statistics on cross-sectional variation in intra-day variation of transaction prices across bond issues and days since issuance. The first column in the body of the table reports the fraction of issues with sales transactions on the given day. The second column reports the relative fraction with multiple sales transactions among all issues with transactions. The third column reports the relative fraction with intra-day transaction price variation among all issues with multiple transactions. The last four columns characterize the cross-sectional variation in the intraday price range (high minus low). Each of the four columns reports the relative fraction of issues with daily high-minus-low falling in the corresponding category.

Day	(1) Issue-Days with Sales	(2) % of (1) with Multiple Sales	(3) % of (2) with Price Variation	Intraday Price Range (measured in basis points, % of (3)) [1,50)	[50,100)	[100,200)	[200,∞)
All	6%	45%	51%	31%	27%	29%	13%
1	86%	54%	27%	51%	24%	17%	9%
2	31%	52%	53%	36%	26%	28%	10%
$3-5$	19%	48%	61%	31%	29%	29%	11%
$6-10$	12%	43%	62%	29%	26%	32%	13%
>10	3%	38%	60%	24%	27%	34%	16%

Table 6: Intraday Variation in Markups on Sales to Customers per Issue, by Transaction Size and Day since Issuance.
The table reports measures of the intraday variation in transaction prices on sales to customers across different bond issues. The first column in the body of the table shows the number of issues with multiple sales of a fixed number of bonds, given in each panel. The transaction sizes chosen are the most frequent ones. The second column in the body provides the number of sales transactions by day since issuance given multiple sales of the same number of bonds occur. The remaining columns characterize the cross-sectional distribution, by day and transaction size, of the intraday range in gross markups. The numbers reported are conditional on multiple sales of the same size category occurring.

Day	(1) Issue-Days with Multiple Sales	Number of Transactions	Intraday Markup Range (measured in basis points, % of (1)) No Variation	[1,50)	[50,100)	[100,∞)
			Transaction Size = $10k$			
All	3,109	13,636	57%	10%	13%	21%
1	478	2,908	78%	5%	5%	12%
2	332	2,297	64%	8%	11%	17%
$3-5$	630	2,594	51%	11%	17%	21%
$6-10$	577	2,246	53%	10%	12%	24%
>10	1,092	3,591	50%	11%	14%	25%
			Transaction Size = $25k$			
All	2,999	10,145	58%	13%	12%	17%
1	772	2,936	80%	8%	4%	7%
2	358	1,810	55%	14%	9%	22%
$3-5$	552	1,679	51%	18%	17%	14%
$6-10$	468	1,374	47%	16%	17%	20%
>10	849	2,346	50%	12%	13%	24%
			Transaction Size = $50k$			
All	2,748	8,531	60%	14%	11%	15%
1	960	3,271	80%	9%	5%	6%
2	368	1,556	58%	14%	13%	15%
$3-5$	449	1,198	45%	19%	17%	19%
$6-10$	361	936	44%	20%	16%	19%
>10	610	1,570	48%	15%	14%	23%
			Transaction Size $\geq 250k$			
All	2,365	8,436	78%	14%	4%	4%
1	1,707	6,328	86%	10%	3%	2%
2	210	785	65%	19%	8%	9%
$3-5$	149	415	48%	36%	8%	7%
$6-10$	99	373	59%	27%	5%	9%
>10	200	535	60%	23%	6%	12%

Table 7: Fraction of Transactions at or below Reoffering Price, by Par Range and Day since Issuance. The table reports for each day since issuance and each par range the fraction of sales transactions taking place at or below the reoffering price. The first line in each panel reports the cumulative numbers for the first sixty trading days.

Day	All Transactions	Transaction Size $[1k, 10k)$	$[10k, 25k)$	$[25k, 50k)$	$[50k, 100k)$	$[100k, 250k)$	$[250k, 1m)$	$[1m, \infty)$
				Transaction at Markup = 0				
All	35%	19%	23%	30%	37%	47%	60%	67%
1	76%	54%	65%	75%	80%	81%	82%	82%
2	52%	36%	47%	53%	56%	59%	58%	61%
$3-5$	16%	10%	12%	15%	17%	22%	28%	30%
$6-10$	9%	9%	8%	8%	9%	11%	20%	20%
>10	5%	4%	5%	5%	6%	7%	9%	4%
				Transaction at Markup ≤ 0				
All	42%	24%	28%	36%	45%	57%	71%	82%
1	82%	56%	67%	79%	85%	88%	90%	94%
2	56%	38%	49%	55%	60%	64%	66%	80%
$3-5$	20%	12%	14%	19%	22%	29%	42%	62%
$6-10$	16%	13%	11%	14%	17%	22%	37%	49%
>10	18%	14%	14%	17%	20%	25%	31%	29%

Table 8: Fraction of Issue and Deal Sold at or below Reoffering Price.

The table reports statistics across bond issues and deals for the value sold at or below the reoffering price relative to the issue size. The body of the table gives the percentage of times when the fraction heading the columns falls into the range on the left hand side. The definition of the fraction of bond value sold below the reoffering price varies across columns. Discount sales are all sales (to customers and/or other dealers) at or below the reoffering price. Underwriter sales are all sales to customers and interdealer transactions starting from the first day of trading until the underwriter's inventory drops to zero during the first sixty trading days. Portfolio sales are the last sales to customers during the first sixty trading days that aggregate to the issue size. These customers are the likely holders of the bond after sixty days. Total sales are all sales to customers during the first sixty trading days.

Fraction Sold at or below Reoffering Price	Total Sales at Discount over		Underwriter Sales at Discount over		Portfolio Sales at Discount over	
	Issue Size	Total Sales	Issue Size	Underwriter Sales	Issue Size	Portfolio Sales
			Issues			
$= 0\%$	14.6%	14.5%	5.4%	5.4%	15.9%	15.9%
$< 10\%$	17.6%	17.2%	6.1%	6.1%	19.1%	18.7%
$< 33\%$	24.2%	23.3%	7.7%	7.6%	26.0%	25.0%
$< 50\%$	29.4%	28.4%	9.1%	9.0%	31.4%	30.0%
$< 100\%$	59.6%	54.1%	30.7%	26.4%	62.0%	54.1%
			Deals			
$= 0\%$	1.9%	1.9%	1.3%	1.3%	2.0%	2.0%
$< 10\%$	4.3%	3.9%	1.6%	1.6%	4.8%	4.3%
$< 33\%$	11.3%	11.8%	2.8%	2.8%	13.1%	12.0%
$< 50\%$	20.7%	23.0%	4.9%	5.4%	23.9%	22.3%
$< 100\%$	89.3%	86.1%	78.1%	83.9%	90.4%	85.4%

Table 9: Definitions of the Explanatory Variables

Table 9 describes the conditioning variables. More detailed information on the various types of municipal bond securities can be found at `http://www.msrb.org`.

Variable	Description
Reoffering Price	Price set by the underwriter at which newly issued securities are offered for sale to the public.
Markup	Price at which transaction between dealer and customer takes place, minus reoffering price and over reoffering price. Winsorized at 0.5% and 99.5% and measured in basis points.
Par	Par value of the transaction. Measured in millions of dollars.
No. of Days since Issuance	Number of business days since the first day of trade in the new issue.
Wrap-Fee Trade	Trade occurs as part of a managed account trade through an intermediary compensated by a commission.
When-Issued Trade	Trade occurs during the "when, as and if issued" period, which spans from the original date of the sale by the issuer to the delivery of the securities to, and payment by, the underwriter. Sales made during this period are subject to issuance of the securities.
Fraction of Issue Sold	Issue size minus aggregate dealer inventory over issue size.
Issued at Premium	Reoffering price of the new municipal security at its original issuance exceeds its par value. The amount of original issue premium received by the issuer in a primary offering is generally treated as proceeds of the issue.
Issue Size	Natural logarithm of the total par value of the bond.
Coupon	Coupon rate of the bond. If missing the value is imputed based on reported values for price, yield, maturity, call feature, call date. Measured in percent.
Maturity	Years between date of transaction and maturity of the bond.
Callable Bond	Issuer is permitted or required to redeem the bond between the transaction date and maturity.
Taxable Bond	Bond is not tax exempt.
Rating Available	Bond issue is rated and the rating at issuance is available to us.
Rating	Average bond rating assigned by S&P and Moody's. Coded on the scale: 1=AAA, 2=AA, 3=A, 4=BBB, 5=BB, 6=B.
Competitive Offer	The underwriting of the deal is through public sale. In contrast to a negotiated sale, underwriters submit purchase proposals and the securities are awarded to the underwriting syndicate presenting the best bid.
Deal Size	Natural logarithm of the total par value of all bond issues in a deal. There are between 10 and 30 issues with different maturity, coupon, etc. in a typical deal.
No. of Bond Issues	Total number of bond issues in the deal.
Underwriter's Discount	Spread between the underwriter's purchase price of the entire bond deal from the issuer and the reoffering price.
First-Time Issuer	Bond issuer has no trades in bonds issued before the issue date of the deal under consideration.
Issue Frequency	Average number of bond deals per year between the first issue date of all traded bonds and the issue date of the deal under consideration. Winsorized at 99%.
Development Revenue Bond	Industrial development revenue bond, where the proceeds are loaned directly to private users to finance facilities.
Pollution Revenue Bond	Private activity bond issued by a state or local authority and used to finance the acquisition of pollution control equipment by a corporation.
Certificate of Participation	Revenue bond evidencing a pro rata share in a specific pledged revenue stream, usually lease payments by the issuer that are subject to annual appropriation.
Tax Revenue Bond	Bond backed directly by tax revenues from a specific source.
Tobacco Settlement Bond	Tobacco settlement asset-backed bonds.
School District Issuer	Issuer is a school district.
Health Care Issuer	Issuer is a health care provider.
Transportation Issuer	Issuer is a transportation authority.
Utility Issuer	Issuer is a public utility.

Table 10: Estimation Results for Mixture Model: Markup Equation

Table 10 summarizes estimation results for the coefficients in the markup equation. The first column reports OLS estimates from a pooled regression. The coefficients in the remaining two columns contain the estimated coefficients on the markup determinants for the *Informed* and the *Uninformed* regime. The dependent variable is the actual markup over the reoffering price paid by investors. All conditioning variables, except for the Mill's ratio, are demeaned. The sample contains all sales to investors during the first five days after issuance. Possible agency trades are excluded and possible trades for managed accounts are disaggregated.

	Pooled Transactions		*Informed* Regime		*Uninformed* Regime	
	Coef.	t-Stat	Coef.	t-Stat	Coef.	t-Stat
Constant	57.61	(226.83)	−0.02	(−3.36)	135.36	(57.74)
1/Par	0.30	(53.17)	−0.00	(−2.95)	0.16	(17.66)
No. of Days since Issuance	18.93	(83.38)	−0.04	(−12.13)	−5.49	(−7.91)
Wrap-Fee Trade	−51.41	(−57.87)	0.04	(7.68)	−24.65	(−5.19)
When-Issued Trade	−4.09	(−3.64)	−0.04	(−8.07)	−8.59	(−3.44)
Fraction of Issue Sold	1.59	(1.71)	0.01	(3.02)	8.78	(5.51)
Issued at Premium	−4.91	(−6.88)	−0.23	(−71.40)	−46.21	(−34.18)
Issue Size	1.13	(3.53)	−0.01	(−9.35)	0.28	(0.58)
Coupon	−21.42	(−49.02)	0.01	(5.13)	−12.14	(−13.68)
Maturity	7.29	(118.49)	−0.00	(−9.35)	7.06	(59.63)
Callable Bond	−25.06	(−31.66)	0.01	(3.73)	−17.70	(−13.27)
Taxable Bond	31.86	(7.40)	−0.02	(−0.75)	−26.75	(−4.67)
Rating Available	1.31	(1.16)	−0.02	(−2.97)	−48.42	(−25.93)
Rating (1=AAA, 2=AA, etc.)	−6.48	(−17.35)	−0.02	(−12.31)	10.65	(15.77)
Competitive Offer	−9.69	(−11.17)	−0.06	(−12.53)	−17.08	(−13.76)
Deal Size	3.39	(9.10)	0.00	(2.42)	1.37	(2.43)
No. of Bond Issues	−0.58	(−13.21)	−0.00	(−3.04)	−0.52	(−7.25)
Development Revenue Bond	−19.84	(−5.73)	0.04	(3.49)	−18.94	(−3.64)
Pollution Revenue Bond	7.32	(2.44)	−0.12	(−8.04)	−22.41	(−4.95)
Certificate of Participation	−9.41	(−6.61)	0.03	(4.50)	−1.22	(−0.54)
Tax Revenue Bond	10.08	(5.27)	−0.04	(−6.16)	−7.34	(−2.78)
Tobacco Settlement Bond	−8.24	(−4.59)	−0.06	(−11.64)	−4.30	(−1.12)
School District Issuer	0.96	(1.36)	0.02	(5.44)	−10.65	(−9.66)
Health Care Issuer	20.52	(17.16)	0.12	(16.42)	4.75	(2.56)
Transportation Issuer	10.37	(9.27)	0.02	(4.87)	−9.96	(−6.01)
Utility Issuer	−2.13	(−2.17)	−0.01	(−2.35)	−5.65	(−3.61)
Mill's Ratio ($\rho\sigma$)	–	–	0.09	(10.41)	45.79	(17.97)
$\sqrt{\text{MSE}}$ (σ)	74.14		0.24		78.28	
R^2	48.1%		17.6%		54.0%	
Observations	80,684		80,684			

Table 11: Estimation Results for Mixture Model: Choice Equation

Table 11 summarizes estimation results for the coefficients in the switching equation. The dependent variable is the likelihood that the transaction is with an informed investor. The sample contains all dealer sales to customers during the first five days after issuance.

	Pr(*Informed*)	
	Coef.	t-Stat
Constant	0.12	(50.27)
$ln(Par)$	0.16	(96.59)
No. of Days since Issuance	−0.57	(−276.39)
Wrap-Fee Trade	1.43	(176.61)
When-Issued Trade	−0.05	(−4.62)
Fraction of Issue Sold	0.18	(21.68)
Issued at Premium	−0.39	(−59.05)
Issue Size	−0.05	(−16.83)
Coupon	0.16	(38.32)
Maturity	−0.05	(−96.82)
Callable Bond	0.01	(1.95)
Taxable Bond	−0.97	(−24.67)
Rating Available	−0.27	(−24.63)
Rating (1=AAA, 2=AA, etc.)	0.19	(55.05)
Competitive Offer	−0.04	(−3.70)
Deal Size	0.02	(5.34)
No. of Bond Issues	0.01	(17.40)
Development Revenue Bond	0.22	(7.03)
Pollution Revenue Bond	−0.10	(−3.79)
Certificate of Participation	0.11	(8.23)
Tax Revenue Bond	−0.37	(−21.23)
Tobacco Settlement Bond	−0.17	(−9.31)
School District Issuer	−0.15	(−23.56)
Health Care Issuer	−0.19	(−17.77)
Transportation Issuer	−0.33	(−32.27)
Utility Issuer	0.02	(2.28)
First-Time Issuer	0.31	(35.14)
Issue Frequency	0.08	(30.82)
Underwriter's Discount	0.26	(57.30)
R^2	76.3%	
Observations	80,684	

Table 12: Estimation Results for Mixture Model: Index-Adjusted Markups, Days 1-60

Table 12 summarizes estimation results for the coefficients in the mixture model for markups adjusted for returns on a broad-based maturity-matched municipal bond index. The first column reports OLS estimates from a pooled regression. The coefficients for the regime switching equation are reported in the second column of the body. The last two columns show the estimated coefficients in the markup equations under the *Informed* and the *Uninformed* regime. All conditioning variables are demeaned. The sample contains all dealer sales to customers between the issuance date and sixty trading days thereafter.

	Pooled Transactions		Pr(*Informed*)		*Informed* Regime		*Uninformed* Regime	
	Coef.	t-Stat	Coef.	t-Stat	Coef.	t-Stat	Coef.	t-Stat
Constant	90.81	(372.57)	−4.09	(−3368.12)	18.74	(309.24)	107.77	(261.44)
1/Par	0.27	(53.51)	–	–	0.00	(2.52)	0.21	(33.65)
$ln(Par)$	–	–	0.15	(158.74)	–	–	–	–
No. of Days since Issuance	1.41	(46.65)	−0.47	(−3092.25)	2.33	(386.61)	0.74	(18.34)
Wrap-Fee Trade	−73.81	(−73.36)	0.56	(111.04)	−0.00	(−0.26)	−72.13	(−68.52)
When-Issued Trade	3.31	(4.25)	−0.24	(−60.36)	−0.04	(−5.33)	1.59	(1.64)
Fraction of Issue Sold	26.76	(30.93)	−0.43	(−98.04)	0.01	(0.95)	−0.03	(−0.02)
Issued at Premium	−9.84	(−13.87)	−0.16	(−44.30)	−0.23	(−55.11)	−13.48	(−17.59)
Issue Size	3.45	(10.82)	−0.01	(−6.60)	−0.02	(−11.81)	4.77	(13.49)
Coupon	−26.76	(−60.65)	0.16	(69.72)	−0.00	(−0.64)	−25.15	(−43.61)
Maturity	8.41	(147.41)	−0.02	(−85.30)	−0.00	(−0.52)	8.52	(124.64)
Callable Bond	−14.18	(−18.66)	−0.17	(−43.58)	0.03	(5.33)	−12.94	(−14.78)
Taxable Bond	71.55	(19.09)	−0.62	(−32.99)	0.08	(2.08)	61.27	(13.32)
Rating Available	17.57	(15.86)	−0.34	(−58.11)	−0.04	(−4.91)	1.17	(0.81)
Rating (1=AAA, 2=AA, etc.)	−6.05	(−16.59)	0.00	(0.26)	−0.03	(−10.55)	−5.66	(−11.83)
Competitive Offer	−22.52	(−28.52)	−0.08	(−14.77)	−0.03	(−4.25)	−32.58	(−37.75)
Deal Size	1.77	(4.86)	−0.21	(−111.13)	0.02	(7.28)	−2.38	(−5.73)
No. of Bond Issues	−0.45	(−10.66)	−0.01	(−37.63)	−0.00	(−4.47)	−0.71	(−14.37)
Development Revenue Bond	−26.61	(−8.69)	0.88	(57.77)	0.05	(3.56)	−13.81	(−4.29)
Pollution Revenue Bond	−6.53	(−2.47)	−1.01	(−76.16)	−9.36	(−607.68)	−16.20	(−5.53)
Certificate of Participation	−9.17	(−7.30)	0.26	(40.29)	0.02	(2.54)	−3.85	(−2.67)
Tax Revenue Bond	19.97	(11.33)	−0.24	(−26.79)	−0.02	(−2.53)	16.04	(7.97)
Tobacco Settlement Bond	−26.09	(−15.86)	0.26	(28.20)	−0.14	(−14.01)	−19.92	(−9.13)
School District Issuer	−1.24	(−1.83)	−0.01	(−2.08)	0.03	(7.08)	1.56	(2.06)
Health Care Issuer	36.81	(33.56)	0.30	(54.55)	0.15	(13.85)	45.66	(33.12)
Transportation Issuer	−1.33	(−1.27)	0.11	(21.25)	0.01	(1.60)	3.28	(2.40)
Utility Issuer	4.68	(4.97)	0.21	(42.48)	−0.01	(−2.04)	13.11	(11.43)
First-Time Issuer	–	–	0.11	(23.66)	–	–	–	–
Issue Frequency	–	–	−0.07	(−49.15)	–	–	–	–
Underwriter's Discount	–	–	0.03	(10.43)	–	–	–	–
Mill's Ratio	–	–	–	–	−0.01	(−0.47)	35.04	(28.42)
$\sqrt{\text{MSE}}$	91.00		0.45		0.28		95.03	
R^2	45.9%		99.4%		93.9%		45.3%	
Observations	139,411							

Table 13: Money Left on Table

Table 13 provides summary statistics for the money left on the table by uninformed investors. Money left on the table is defined in equation (18). Total profits to the underwriting syndicate are defined as the sum of the underwriter fees and the money left on the table.

			Quartiles			
	Mean	S.D.	1^{st}	2^{nd}	3^{rd}	Obs.
Days 1-5						
Money Left on Table:						
by Transaction (in Basis Points)	128.4	82.0	66.8	117.1	187.2	36,585
by Transaction (in thousand $)	1.0	7.2	0.1	0.3	0.6	36,585
by Issue (in thousand $)	3.0	33.2	0.0	0.0	1.0	12,421
by Deal (in thousand $)	36.8	152.6	1.6	9.9	28.6	1,000
by Deal (% of Total Par $*100$)	14.6	19.3	1.9	8.4	19.6	1,000
by Deal (% of Total Profit)	14.3	14.4	2.7	9.9	21.9	823
Days 1-60						
Money Left on Table:						
by Transaction (in Basis Points)	97.4	80.1	33.4	78.6	150.3	113,057
by Transaction (in thousand $)	0.9	7.9	0.1	0.2	0.4	113,057
by Issue (in thousand $)	7.9	67.4	0.0	0.2	2.2	12,421
by Deal (in thousand $)	97.9	340.7	4.0	18.6	66.2	1,000
by Deal (% of Total Par $*100$)	27.7	33.2	5.4	17.5	37.2	1,000
by Deal (% of Total Profit)	23.5	18.9	7.5	19.9	36.0	823
Underwriter's Discount:						
by Deal (% of Total Par $*100$)	88.8	73.6	53.4	71.0	100.0	823

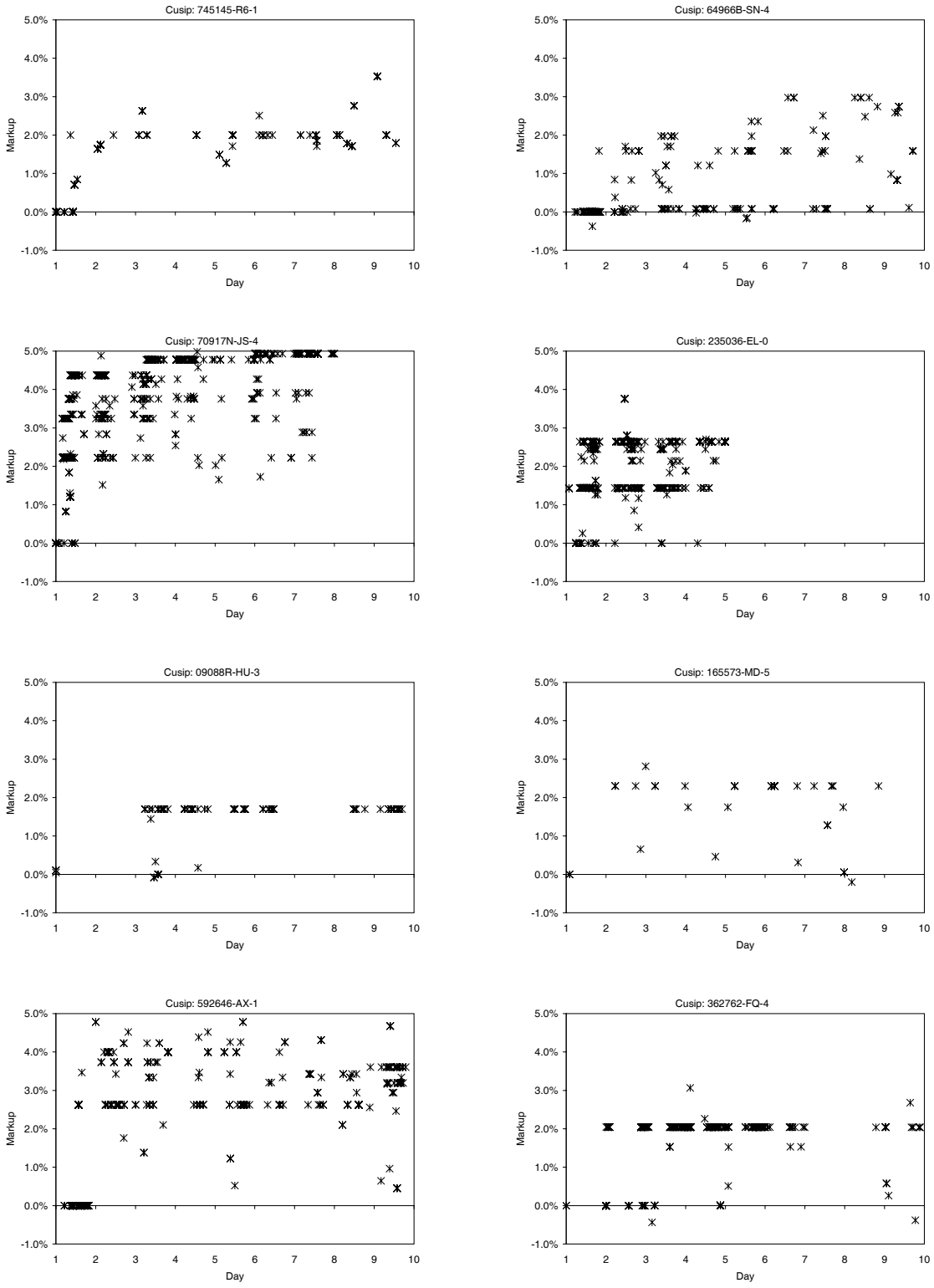
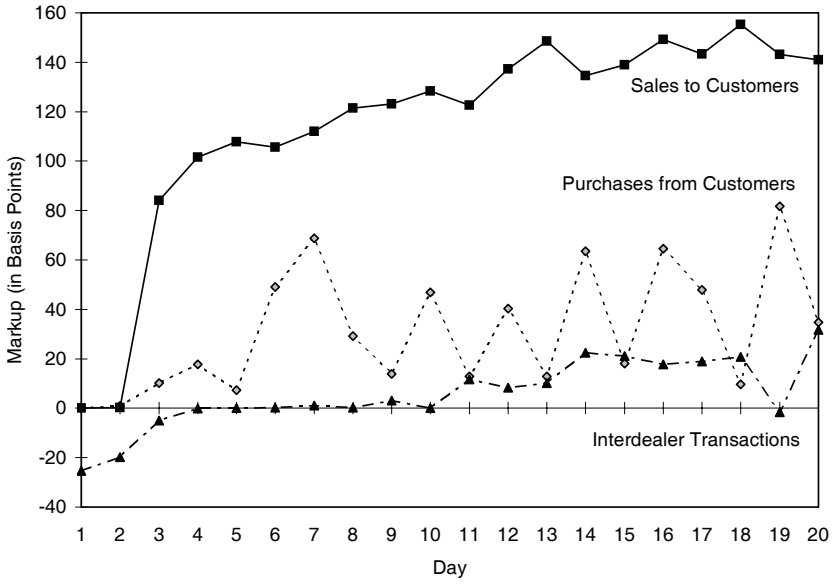
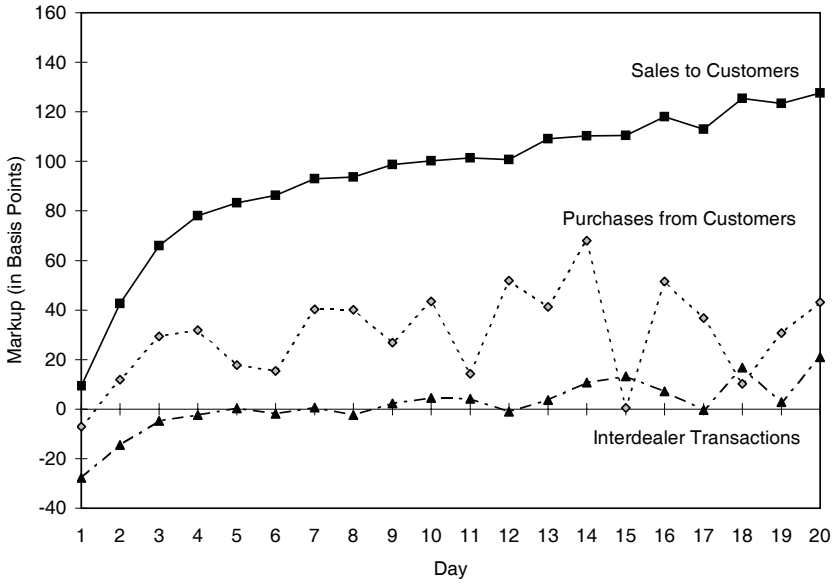


Figure 1: Examples of Price Trajectories on Sales Transactions.

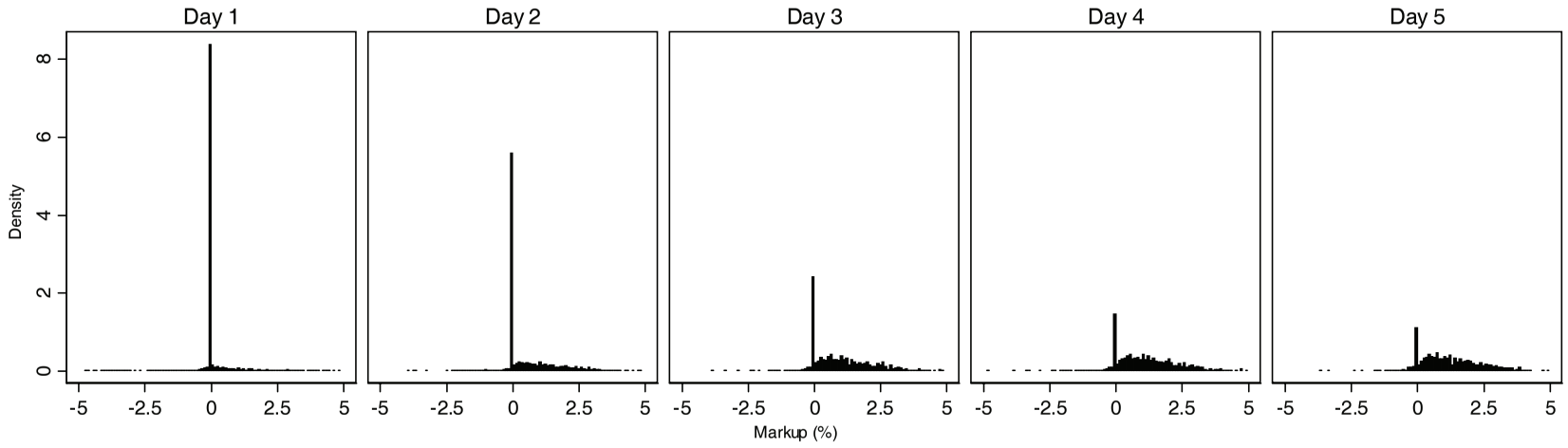


(a) Median Markups in Pooled Cross-Section.

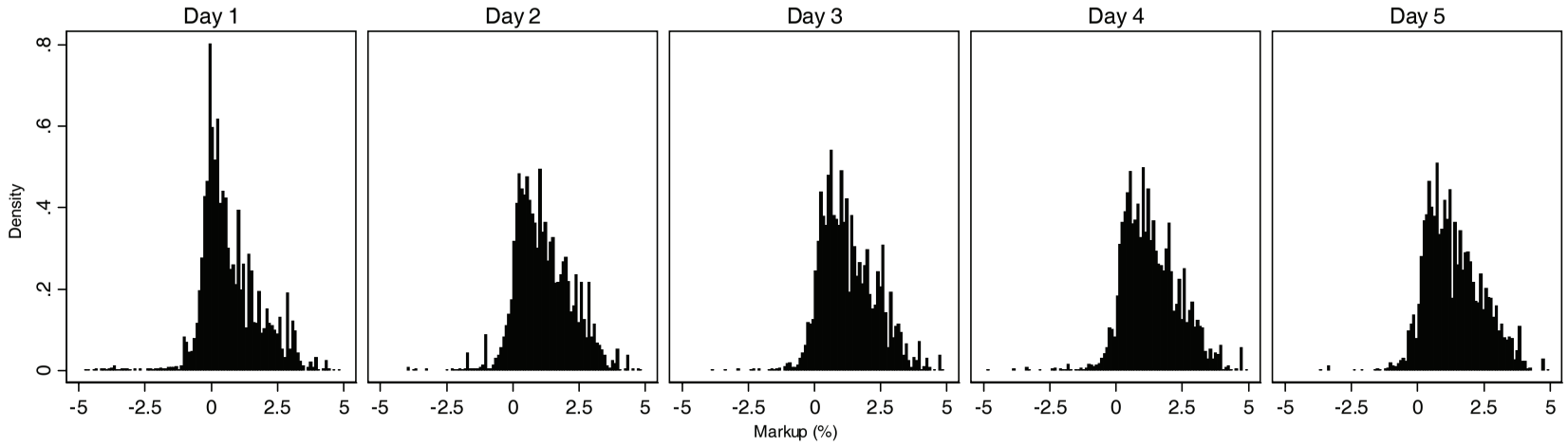


(b) Cross-sectional Average of Mean Markups per Issue and Day.

Figure 2: Markups over Reoffering Price by Transaction Type and Day since Issuance. The figure plots gross markups for different days since issuance and by transaction types. The solid line represents sales to customers, the dotted line purchases from customers, and the dash-dotted line interdealer transactions. The first panel reports median markups in the pooled cross-section by day since issuance. The bottom panel reports cross-sectional averages per day of mean markups per bond issue and day. The trajectory of the cross-sectional median of mean markups is very similar but about fifteen basis points lower. The cross-sectional moments of median markups are very similar to those of mean markups and therefore omitted.

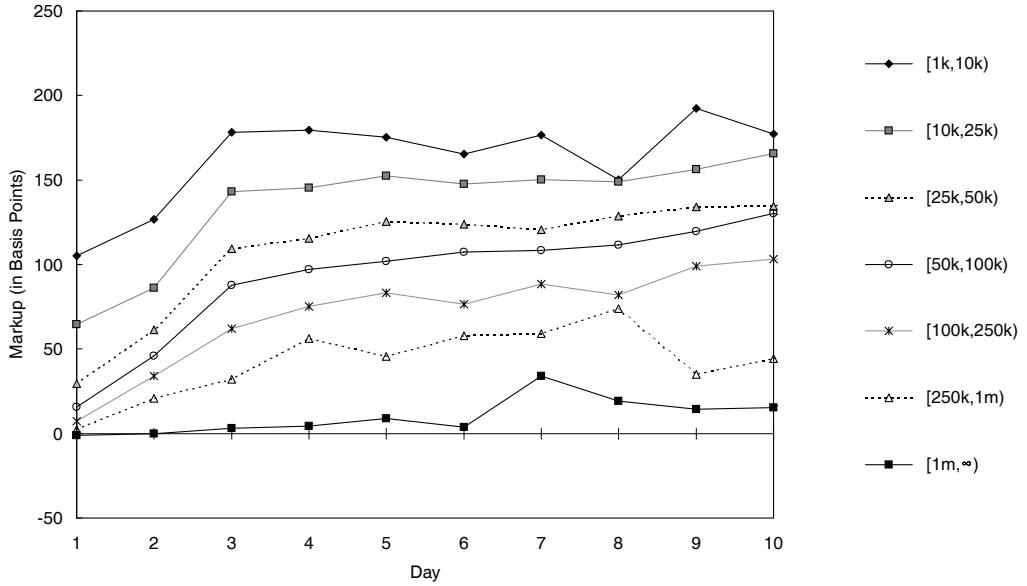


(a) Distribution of Markups on All Sales to Customers.

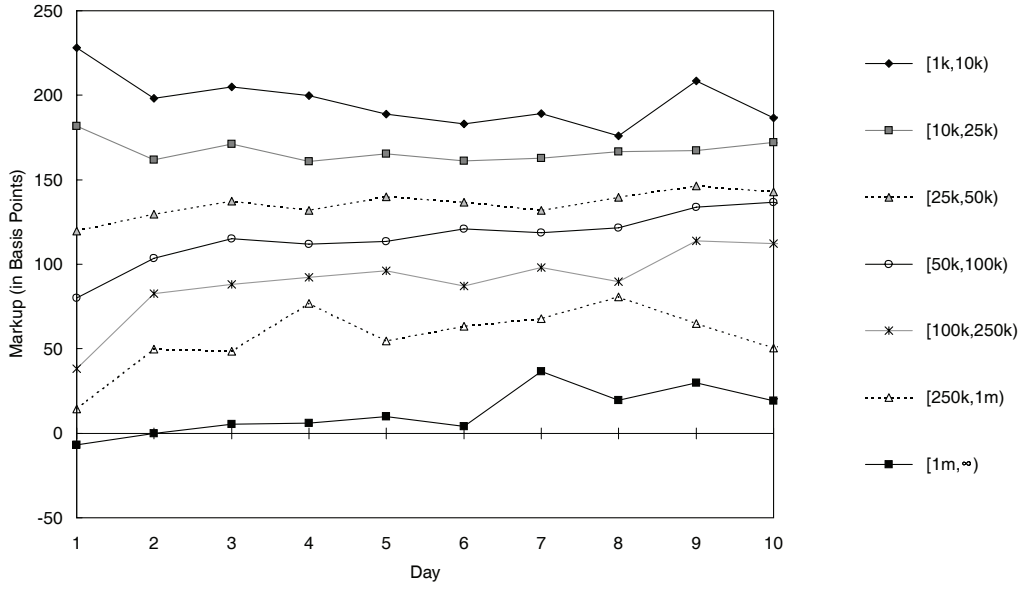


(b) Distribution of Markups on Sales to Customers without Transactions at the Reoffering Price.

Figure 3: Distribution of Markups over Reoffering Price on Sales to Customers by Day since Issuance.
The figure plots the cross-sectional distribution of gross markups on sales from dealers to customers. The sample is split by day since issuance. The gross markup is defined as the transaction price on the sales transaction minus the reoffering price and then divided by the reoffering price. The data is winsorized at the .5% and 99.5% levels. The first panel reports the actual distribution of markups. The second panel reports the conditional distribution without transactions at the reoffering price.

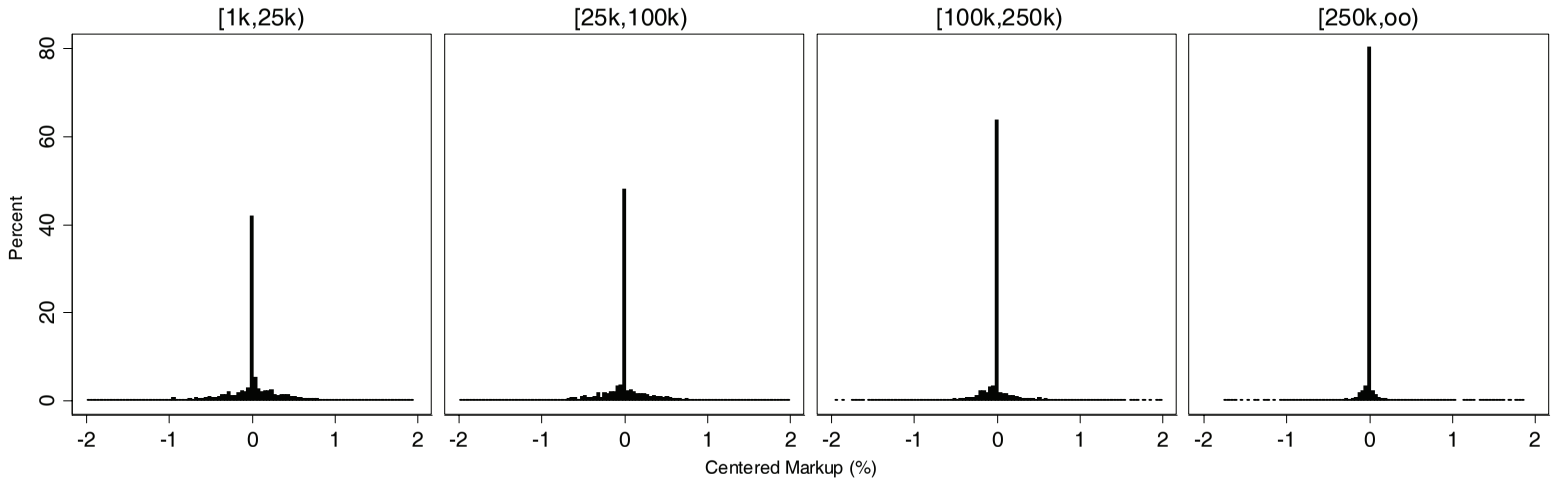


(a) Markups on Sales to Customers.

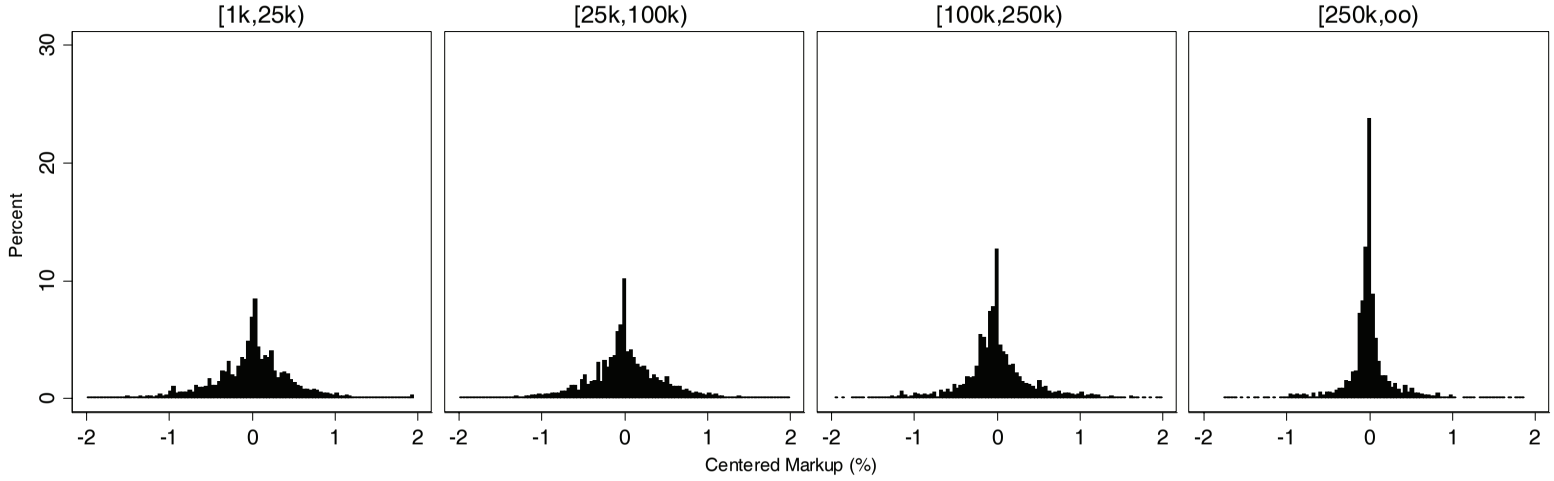


(b) Markups on Sales to Customers without Transactions at the Reoffering Price.

Figure 4: Markups over Reoffering Price on Sales to Customers by Par Range and Day since Issuance.
The figure reports cross-sectional averages of mean markups per issue and day since issuance. The sample is split by the par amount of the transaction. The top panel includes all transactions constituting sales to customers. The bottom panel excludes all sales transactions at the reoffering price.



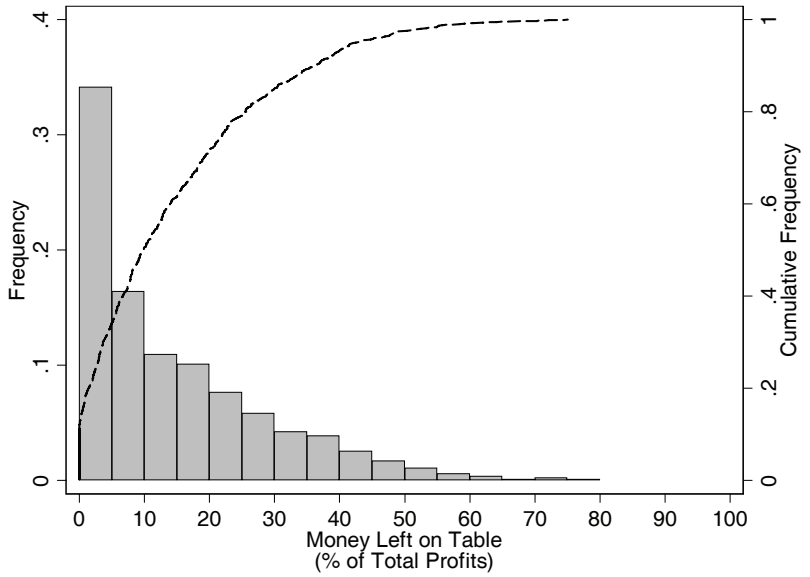
(a) All bond issues on days with multiple transactions of the given size.



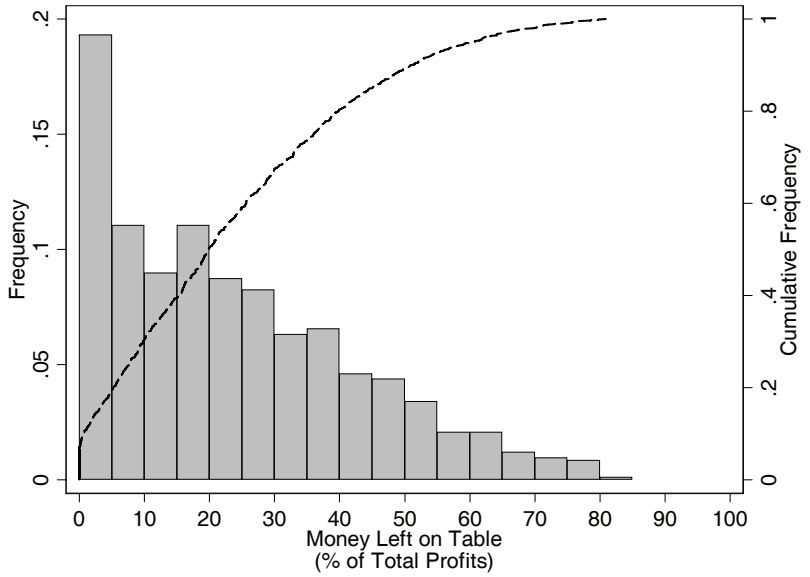
(b) All bond issues on days on which not all transactions occur at the same price.

Figure 5: Intraday Price Dispersion

The figure illustrates the intraday dispersion of markups on customer transactions. Markups are centered on the intraday within-group mean for each bond issue and transaction size range. Each plot shows the histogram of centered markups for a given transaction size range over the first sixty days.



(a) Money Left on Table in Deals by Uninformed Investors on Days 1-5.



(b) Money Left on Table in Deals by Uninformed Investors on Days 1-60.

Figure 6: Money Left on Table by Uninformed Investors

The figure plots the distribution of the money left on the table by uninformed investors across bond deals as a fraction of the total profits to the underwriting syndicate during the first five days (top panel) and first sixty days (bottom panel) of trading. The dashed line represents the cumulative frequency distribution. Money left on the table is defined in equation (18). Total profits are the sum of the underwriter fees and the money left on the table.