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Price Discovery in Initial Public Offerings and the Role of the Lead Underwriter

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ABSTRACT

We examine the price discovery process of initial public offerings (IPOs) using a unique dataset. The first quote entered by the lead underwriter in the five-minute preopening window explains a large proportion of initial returns even for hot IPOs. Significant learning and price discovery continues to take place during these five minutes with hundreds of quotes being entered. The lead underwriter observes the quoting behavior of other market makers, particularly the wholesalers, and accordingly revises his own quotes. There is a strong positive relationship between initial returns and the time of day when trading starts in an IPO.

RESEARCHERS HAVE DOCUMENTED AND TRIED to explain why IPOs jump up in price initially but then perform poorly in the long run.[1] Schultz and Zaman (1994) and Barry and Jennings (1992) report that almost the entire initial return is reflected in the very first trade price. However, researchers have not examined how the price changes from the offer price to the price of the first trade. Our empirical analysis explains the learning process by which the price changes from the offer price to the first trade price. The offer price is typically set after the market closes on the day prior to the first day of trading. Yet, there is a large price runup by the next morning. For example, Amazon.com went public on May 15, 1997 at an offer price of $18 and the first trade occurred at 10:30 a.m. on May 16 at a price of $29.25. This research is also motivated by the concern of stock exchanges, regulators, and market participants about the initial price discovery and volatility of IPOs. Price discovery is particularly important and difficult for the opening of

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[1] See Aggarwal and Rivoli (1990) and Ritter (1991) for short-run and long-run performance.

IPOs because no trading history exists. Therefore, the initial trading and price discovery in these stocks can be very noisy and has become a cause for concern.

As Ellis, Michaely, and O'Hara (1999) discuss, the lead underwriter is always a market maker in Nasdaq IPOs. In its role as a market maker, the lead underwriter must initially decide at what price to start quoting and trading the stock. We use unique quote data with the identity of the market maker to examine the quoting behavior of the lead underwriter during the preopening period; the behavior of other market makers; the importance of the preopening period for learning and price discovery; and factors that determine the time of day when trading in an IPO starts. The paper analyzes how accurate the lead underwriter's starting quotes are and how he learns from the quoting behavior of other market makers and decides the price at which to buy/sell the stock.

IPOs have a preopening period that lasts for a maximum of five minutes before actual trading begins. During this five-minute preopening period, all market makers have the option to add, revise, or cancel quotes before trading actually begins.[2] Nasdaq is examining whether the five-minute preopening window should be lengthened for some stocks to achieve more efficient price formation and lower volatility. The argument for a longer time period is stated by market participants:

> The five-minute period wasn't nearly enough time to gauge the huge levels of demand that have built for most recent internet deals, and to determine where the stock would head once it opened. . . . [T]he new rules would allow Nasdaq traders more time to determine at what price an IPO is likely to open. . . (*The Asian Wall Street Journal*, February 3, 1999)

Quotes entered into the system during the preopening period are not binding. Therefore, it is possible that market makers do not show their true intention when entering these quotes. They face only the small costs of order placement and handling without the risk of execution. However, market makers may have incentives to produce price discovery even in the absence of binding commitments. The lead underwriter is certainly motivated to learn from the quote revision process in the preopening. All market makers may cooperate in the price discovery process because the opening of IPOs is a repeated game.

There can be a considerable amount of activity during this five-minute window. For example, there were 116 quote entries in the case of Amazon.com during the five-minute preopening period. We analyze whether these nonbinding quotes have any value and how the price discovery process works

[2] The preopening period is five minutes long during our sample period for all stocks. In January 1999, the duration of the preopening period was increased for selected stocks. The preopening period for non-IPO Nasdaq stocks is much longer and lasts for 90 minutes.

even though no trades take place during this time period. The price discovery process starts even before the preopening period begins. The lead underwriter decides when to start trading an IPO and sets the first quote during the five-minute preopening. This first quote explains a large portion of initial returns.

A limited number of recent studies have empirically examined how opening prices are determined on the Paris Bourse, the New York Stock Exchange (NYSE), and on Nasdaq for non-IPO stocks. Biais, Hillion, and Spatt (1999) find that significant learning and price discovery takes place during the 90-minute preopening on the computerized Paris Bourse. Cao, Ghysels, and Hathaway (2000) conclude that quotes during preopening result in significant price discovery for Nasdaq stocks. This limited evidence suggests that preopening is important, and we expect preopening to be even more important for IPOs.[3]

The lead underwriter has the flexibility to decide at what time during the day trading starts in an IPO and he informs Nasdaq of its decision. We find that most IPOs do not start trading at 9:30 a.m. when the Nasdaq market opens. For example, actual trading in Amazon started at 10:30 a.m. Almost half the IPOs in our sample start trading after 11:00 a.m. Underwriters have certain preferences as to when to start trading an IPO. The opening time is found to be later for IPOs that start trading much higher than the offer price.

The rest of the paper is organized as follows: Section I provides details of the quote-by-quote data along with the sources for other data used in the paper; Section II discusses the empirical findings; and a summary and conclusions are provided in Section III.

I. Data

We use the Securities Data Company's (SDC) New Issues database to identify all IPOs that took place during the period May to October, 1997 and started trading on the Nasdaq Stock Market. The analysis is limited to IPOs that start trading on Nasdaq because our objective is to examine the role of the lead underwriter as a market maker. Unit offerings and American Depositary Receipts are excluded. The sample consists of 188 IPOs. The SDC database is used to obtain information on offer price, offer date, offer size, number of shares issued, and underwriter compensation.

As discussed earlier, quoting in IPOs can start five minutes before trading. We use a proprietary quote database available at the SEC to obtain quote-by-quote data during the preopening and also after the market opens. Quote updates are sequential and include all market maker identifications.

[3] Other papers examine the role of stabilization by underwriters (see Aggarwal (2000a, 2000b), Ellis, Michaely, and O'Hara (2000), Benveniste, Busaba, and Wilhelm (1996), Chowdhry and Nanda (1996), Hanley, Kumar, and Seguin (1993), Logue et al. (2000), Ruud (1993), Schultz and Zaman (1994), and Prabhala and Puri (1998)).

Table I

Descriptive Statistics on Nasdaq IPOs

The sample consists of 188 Nasdaq IPOs during the period from May to October, 1997. The table provides mean and median statistics; *N* is the number of observations; offer-to-open return is the percentage difference between the opening price on day 1 and the offer price; offer-to-close return is the percentage difference between the closing price on day 1 and the offer. The mean and median number of comanagers and syndicate members is also reported along with the number of different market makers who quote in the preopening.

	Mean	Median
Offer price ($)	12.33	12.00
Issue size (millions of $)	46.93	34.38
Offer to open return (%)	17.66	13.76
Offer to close return (%)	19.47	14.17
Number of comanagers	2.34	2.00
Size of the syndicate	16.85	17.00
Number of market makers entering quotes in the preopening	6.71	7.00

Therefore, we can examine the quoting activity of the lead underwriter, the comanager, and other market makers. We use this data to create a time series of best bids and asks because Nasdaq does not report these during the preopening period. During the preopening, the inside bid and ask are noted as zero by Nasdaq. Once trading starts, the Nasdaq quote files include an inside bid and ask. Under normal conditions, the best bid is lower than the best ask and the difference is the market maker's spread. However, sometimes the quotes are crossed or locked. A crossed quote is one when the best bid is higher than the best ask. Similarly, a locked quote is one when the best bid and best ask are equal. We keep track of locked and crossed quotes.

II. Empirical Results

Table I provides descriptive statistics for the sample of 188 IPOs on Nasdaq during the period from May to October, 1997. The mean and median offer prices are $12.33 and $12.00, respectively. On average the first transaction is at a price that is 17.66 percent higher than the offer price (median is 13.76 percent). There is only a small change from the open price to the close price on the first day of trading. The mean offer-to-close return is 19.47 percent (median of 14.17 percent). This result is consistent with the conclusions of Barry and Jennings (1992) and Schultz and Zaman (1994) that the opening price captures almost all of the initial return.

The mean and median number of comanagers are 2.34 and 2.00, respectively. The mean and median size of the syndicate is 16.85 and 17, respectively. During the five-minute preopening, on average 6.71 different market makers enter quotes for each IPO. The maximum number of market makers quoting for any IPO in the preopening is 14 for our sample. Most syndicate members do not quote in the preopening; many of them do not even become

a market maker in the stock. Consistent with the findings of Ellis, Michaely, and O'Hara (2000), the role of the syndicate in the aftermarket is quite limited. On average, the mean number of market makers entering quotes for each IPO is 12.08 on day 1, 9.97 on day 2, 7.14 on day 10, and 7.72 on day 20. There are a number of market makers called wholesalers who are not part of the syndicate but they actively quote in the preopening. Their role is discussed below.

A. Price Discovery in the Preopening Period

The lead underwriter informs Nasdaq when it plans to open trading in an IPO. Before trading commences in a stock, there is a preopening period in which market makers can enter their quotes. This preopening period can be a maximum of five minutes and a minimum of zero seconds. Nasdaq informs market participants about the start and end of the preopening period via its News Frame. The lead underwriter sometimes gives advance notice (30–45 minutes) about when it wants to start trading, but sometimes it may inform Nasdaq only a few minutes before the open.

A.1. An Example of a Preopening: Amazon.com

We use the Amazon.com (Amazon) IPO as an example to illustrate the preopening process in Figure 1. Amazon went public on May 15, 1997 at an offer price of $18. The lead manager for the offering was Deutsche Morgan Grenfell, who started the preopening with a bid at $22.50 and ask at $23.50. This first preopening quote occurred at 10:25:20 a.m. and the last quote at 10:29:58 a.m. During this four-minute-and-38-second window, 116 quotes were entered for Amazon by eight different market makers. These preopening quotes are not binding, so the question is whether they help in price discovery. We find that the quotes continuously changed with prices moving upwards during this preopening window. During the few seconds just before the end of the preopening period, the best bid was at $29.75 and the best ask at $30. Quotes gradually moved from the $22 to $23 range to the $29 to $30 range. The first transaction occurred at 10:30:02 a.m. at a price of $29.25. This example illustrates that the lead underwriter's first quote in the preopening is quite informative and that price discovery also continues to occur during the five-minute preopening window.

A.2. The Lead Underwriter's First Quote

The lead underwriter always enters the first quote during the preopening. Figure 2 plots offer-to-open and offer-to-first-preopening quote (bid) returns. The IPOs in the figure are arranged sequentially by initial returns. For example, the largest price runup in our sample is almost 140 percent, of which 105 percent is explained by the lead underwriter's first quote during the preopening. The lead underwriter uses the offer price as a benchmark

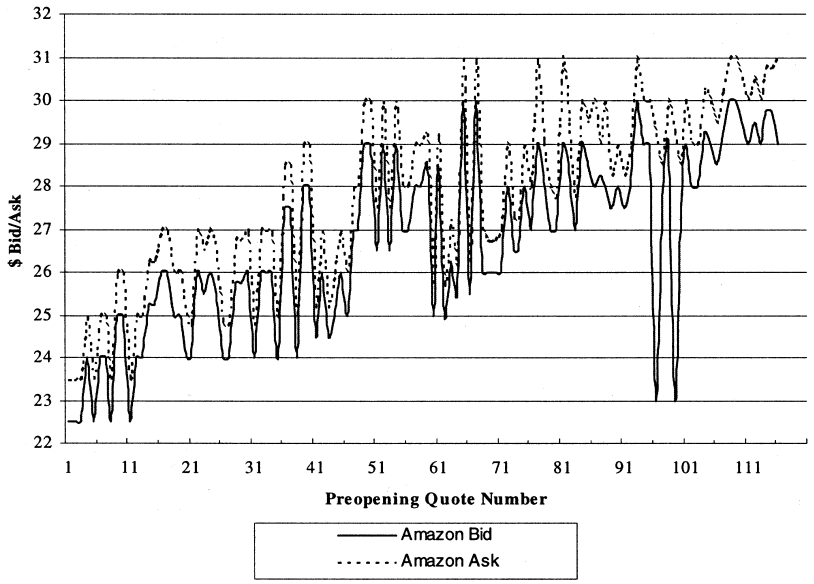

Figure 1. Preopening process for Amazon.com. Amazon.com went public on May 15, 1997, at an offer price of $18. The lead underwriter was Deutsche Morgan Grenfell, who started the preopening at 10:25:20 a.m. with a bid at $22.50 and ask at $23.50. During the five-minute preopening window, 116 quotes were entered by eight different market makers. At the end of the preopening period, the best bid and ask were $29.75 and $30.00, respectively. The first transaction in the stock occurred at a price of $29.25. The two spikes (toward the end of preopening) in the bid at a price of $23 are quotes by the lead underwriter.

and based on his information starts quoting above the offer price for hot IPOs. However, the lead underwriter has no incentive to overshoot by quoting above the equilibrium price. Instead, he revises his own quotes after observing what other market makers are quoting.

As can be seen in the Figure 2, a large proportion of the offer-to-open returns is captured in the very first quote entered by the lead underwriter. Barry and Jennings (1992) and Schultz and Zaman (1994) document that the first trade price captures most of the initial returns. We find that even before the open of trading, significant price discovery has already taken place. These results suggest that even for IPOs with big price runups, the lead underwriter has good information and is appropriately able to set quotes. The lead underwriter enters a bid equal to the offer price for weak IPOs, and these weak IPOs open at the offer price due to the price support provided by the lead underwriter, as seen in Figure 2. This is consistent with Aggarwal's (2000a) stabilization explanation for weak offerings. She finds that underwriters have a large short position in weak IPOs and this short position is covered in the aftermarket to help provide price support.

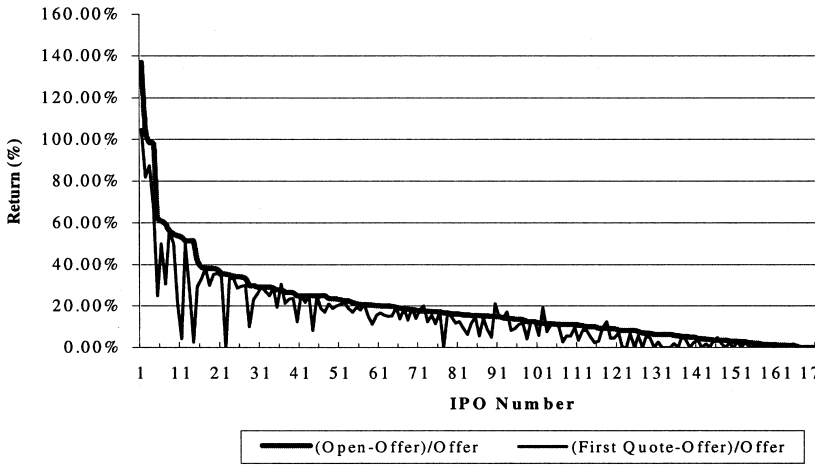

Figure 2. Price discovery in the first preopening quote. Each IPO in our sample is sorted by offer-to-open return and plotted. The two lines correspond to open-to-offer return (%) and first quote during the preopening-to-offer return (%). The IPO with the largest increase from offer price jumped almost 140 percent (open-to-offer). For this IPO, the first quote during the five-minute preopening window entered by the lead underwriter (acting as a market maker) is almost 105 percent higher than the offer price. Price discovery takes place even before the preopening quoting starts. For weak IPOs, the first trade occurs at the offer price and the first bid quote during preopening is also at offer price.

A.3. Quotes During Preopening

The maximum length of the preopening window can be five minutes and the minimum can be zero seconds. Eighty-three IPOs of 188 in the sample, have a preopening that lasts for three minutes or more; 86 stocks have a preopening that lasts for three minutes or less; and there are no preopening quotes for 19 stocks. The maximum number of quotes in the preopening period is 191 for Rambus, which was taken public by Morgan Stanley on May 14, 1997. IPOs that use most of the five-minute preopening window are those whose opening price is much higher than the offer price. Offerings with low offer-to-open returns utilize only a small portion of the five-minute window. Therefore, we find that the 14 IPOs whose quoting starts with at least 4:30 minutes remaining in the preopening window have an initial average return of almost 45 percent.

In Table II, the five-minute preopening period is divided into ten 30-second intervals. The interval 0:30-0:00 refers to the 30 seconds just before trading starts. Fourteen IPOs have a preopening of 4:30 minutes or longer; 14 stocks have a preopening of 30 seconds or less; and 19 stocks have no preopening quotes. The average number of quotes per IPO in the 30-second window just before trading starts for the 14 stocks with the longest preopening is 6.79. During the 30-second window when preopening just starts, the average number of quotes for each stock is only 1.14. Three patterns emerge from this analysis. First, quote-entering activity increases substantially just

Table II

Number of Quotes in the Preopening

Out of a total of 188 IPOs in the sample, 169 have one or more quote updates in the preopening five-minute window. Fourteen IPOs have the first quote entered with at least 4:30 minutes left in the preopening period. On average for these 14 IPOs, there are only 1.14 quotes entered per stock in the first 30-second period, but during the 30-second window just before trading starts, there is an average of 6.79 quotes entered per stock.

Time Left to Open	Start of Preopening									
	5:00–4:30	4:30–4:00	4:00–3:30	3:30–3:00	3:00–2:30	2:30–2:00	2:00–1:30	1:30–1:00	1:00–0:30	0:30–0:00
0:00–0:30	6.79	3.06	5.86	6.81	2.42	2.67	4.27	3.13	7.11	2.14
0:30–1:00	6.00	2.09	4.95	4.44	1.32	2.90	3.20	2.50	2.22	
1:00–1:30	6.64	2.13	5.24	5.38	1.84	2.48	2.00	1.38		
1:30–2:00	6.29	1.84	5.33	3.31	2.32	2.10	1.53			
2:00–2:30	5.50	2.00	4.86	2.50	1.63	1.57				
2:30–3:00	6.00	2.06	4.48	2.00	1.21					
3:00–3:30	6.71	2.28	2.95	1.69						
3:30–4:00	4.93	1.69	1.43							
4:00–4:30	2.00	1.09								
4:30–5:00	1.14									
Number of IPOs	14	32	21	16	19	21	15	8	9	14

before the market opens; IPOs that have a longer preopening period also have more quoting activity; and, third, IPOs that have a large increase in price are the ones that have longer preopening periods.

Next, we examine which market makers are quoting in the preopening. There are a total of 3,252 quotes during preopening for our sample of IPOs. Quotes can be entered (or revised) by the lead underwriter, comanagers, wholesalers, or other market makers. Wholesalers are a category of firms that make a market in thousands of Nasdaq stocks. Smith, Selway, and McCormick (1998) discuss how market making in Nasdaq stocks is the primary business of wholesalers. Wholesalers typically have payment for order-flow arrangements. They pay a rebate to order-entry firms to get the right to execute the firm's order flow. The payment for order flow does not have to be in cash but can take other forms. Knight, Herzog, and Troster all trade 5,000 or more Nasdaq stocks.[4]

The top five wholesalers have increased their market share from 21 percent of Nasdaq's trading volume in 1995 to 33 percent in 1998. The economies of scale in trading along with payment for order flow to discount brokerage firms has made it possible for them to grow at a very fast pace. Knight alone accounts for 17 percent of Nasdaq/OTC market share in June 1998. Often the wholesalers are either owned by or have a formal affiliation with order-entry firms. These firms specialize in retail orders that are automatically executed at the inside quotes. For example, Battalio, Jennings, and Selway (1999) find the average trade size at the largest wholesaler, Knight Securities, to be 377 shares with a 10 percent market share in Nasdaq stocks. Knight is a consortium of 25 retail brokerage firms including E*Trade, Waterhouse, Ameritrade, and Discover. Knight pays consortium and nonconsortium members for order flow that is routed to it. In 1998 Knight made a market in 6,700 securities and averaged 75,000 trades per day.

Table III shows that out of the total of 3,252 quotes, 13.28 percent are entered by the lead underwriter, 14.33 percent by comanagers, 49.05 percent by wholesalers, and 23.34 percent by all other market makers. The wholesalers not only enter the largest percentage of quotes but are also aggressive in improving the bid and ask. There are a total of 196 quotes that improve the bid and 236 quotes that improve the ask. The number of quotes improving the bid and ask are relatively few. The lead underwriter improves 22.96 percent of the bid quotes, the comanagers 14.29 percent, the wholesalers 50.51 percent, and all other market makers 12.24 percent. It is clear that the wholesalers are actively quoting. They have a large order flow that must be filled and their incentive is to open trading at the equilibrium price.

The wholesalers are even more active in improving quotes on the ask side and account for 84.75 percent of all ask improvements. The lead underwriter is responsible for only 4.66 percent of ask quote improvements. The lead

[4] The largest wholesalers are Knight Securities, Mayer and Schweitzer, Herzog Heine, and Geduld, Troster Singer, Sherwood, and Nash Weiss.

Table III

Quoting Behavior of the Lead Underwriter and Other Market Makers

This table provides information on which market makers are quoting during the preopening. The market maker may be the lead underwriter who always starts out with the first preopening quote. The proportion of quoting by other comanagers is reported separately. Wholesalers are market makers whose primary business is to make a market in thousands of Nasdaq stocks. All other market makers (besides the lead underwriter, comanagers, and wholesalers) are grouped together. The sample is also split by initial returns (offer-to-open).

	Total		Bid Improvements		Ask Improvements	
	N	%	*N*	%	*N*	%
Panel A: Full Sample (N = 3,252 quotes)						
Quotes entered by the lead underwriter	432	13.28	45	22.96	11	4.66
Quotes entered by other comanagers	466	14.33	28	14.29	7	2.97
Quotes entered by wholesalers	1595	49.05	99	50.51	200	84.75
Quotes entered by other market makers	759	23.34	24	12.24	18	7.63
	3252	100.00	196	100.00	236	100.00
Panel B: Initial Returns ≤ 10% (N = 677 quotes)						
Quotes entered by the lead underwriter	98	14.48	3	17.60	3	2.94
Quotes entered by other comanagers	85	12.56	4	23.50	4	3.92
Quotes entered by wholesalers	343	50.66	9	52.90	86	84.31
Quotes entered by other market makers	151	22.30	1	5.90	9	8.82
	677	100.00	17	100.0	102	100.00
Panel C: 10% < Initial Returns ≤ 20% (N = 754 quotes)						
Quotes entered by the lead underwriter	108	14.32	15	38.46	5	6.85
Quotes entered by other comanagers	127	16.84	5	12.82	0	0.00
Quotes entered by wholesalers	340	45.09	12	30.77	64	87.67
Quotes entered by other market makers	179	23.74	7	17.95	4	5.48
	754	100.00	39	100.00	73	100.00
Panel D: Initial Returns > 20% (N = 1,821 quotes)						
Quotes entered by the lead underwriter	226	12.41	27	19.29	3	4.92
Quotes entered by other comanagers	254	13.95	19	13.57	3	4.92
Quotes entered by wholesalers	912	50.08	78	55.71	50	81.97
Quotes entered by other market makers	429	23.56	16	11.43	5	8.20
	1821	100.00	140	100.00	61	100.00

underwriter does not revise his quotes often. He watches the quoting behavior of other market makers, particularly the wholesalers, and then revises his own quotes. The quotes entered by the wholesalers and to some extent the comanagers play an important role in the price discovery process. The role of all other market makers is quite limited. We do not report results classified by syndicate members because the rest of the syndicate (besides the lead underwriter and comanagers) does not play a significant role. Ellis, Michaely, and O'Hara (2000) find the market share of comanagers is quite small in transactions done during the first few days after an IPO, but we find their role is significant during preopening.

We also split the sample based on initial IPO returns (offer-to-open) in Panels B, C, and D of Table III. As expected, weak IPOs (initial return less than or equal to 10 percent) have very few bid improvements and relatively more improvements in the ask quotes. The reverse pattern emerges for hot IPOs (initial return greater than 20 percent). These have 140 bid improvements and 61 ask improvements. The wholesalers account for 55.71 percent of the bid improvements and 81.97 percent of the ask improvements.

Table IV reports the results of regressions with percentage change in the lead underwriter's bid quote as the dependent variable. Every quote change by the lead underwriter is a new observation. The first quote after the preopening is also an observation. The independent variables are

$$\text{CDIFF} = \frac{(\text{comanagers' average bid quote} - \text{lead underwriter's ending bid quote})}{\text{lead underwriter's ending bid quote}} \times 100,$$

WDIFF and ODIFF are defined similarly using quotes by the wholesalers and other market makers, respectively. Also included as independent variables are the percentage of quotes that are locked and crossed during this period (LCQUOTES) and the total number of quotes (TQUOTES).

Locked quotes occur when the bid equals the ask and crossed quotes occur when the bid is greater than the ask. We find that it is the wholesalers whose quotes result in locking/crossing the market. Fourteen IPOs in our sample end the preopening period locked/crossed.[5] These are hot IPOs that get locked/crossed early during preopening and they remain in this state until the market opens. A wholesaler may have a large volume of retail buy orders before the market opens but the best ask is for fewer shares than what he needs. In this case the wholesaler may enter a bid higher than the best ask in the hope of getting other market makers to adjust their quotes. Some also contend that wholesalers increase the prices during the preopening and then short the stock once trading begins. If their retail buy order

[5] According to *Traders*, May 1999, Nasdaq averaged 104 daily locked or crossed markets of one minute or more in January 1999, 51 locked/crossed markets in August 1998, and only 22 locked/crossed markets in January 1999.

Table IV

The Lead Underwriter's Learning Process

The dependent variable in all three models is the percentage change in the lead underwriter's bid price quote. The independent variables are

$$\text{CODIFF} = \frac{(\text{comanagers' average bid quote} - \text{lead underwriter's ending bid quote})}{\text{lead underwriter's ending bid quote}} * 100;$$

WDIFF and ODIFF are defined similarly for wholesalers and other market makers, respectively. The average quote is for the period in which the lead underwriter revises his quote. Also included are the percentage of quotes that are locked and crossed (LCQUOTES) and total number of quotes (TQUOTES) during this same time period. *N* is the number of observations. Model 1 uses the full sample of 169 IPOs with preopening quotes; Model 2 uses the 83 IPOs whose preopening lasts for three minutes or more; and Model 3 uses the 86 IPOs whose preopening lasts for less than three minutes. *t*-statistics are in parenthesis.

	Model 1		Model 2		Model 3	
Constant	0.01	0.01	0.01	0.01	0.01	0.01
	(8.64)*	(4.22)*	(8.92)	(4.25)*	(1.41)	(1.94)**
CODIFF	0.05	0.06	0.06	0.07	−0.05	−0.05
	(1.30)	(1.54)	(1.48)	(1.63)	(−0.48)	(−0.40)
WDIFF	0.23	0.20	0.20	0.18	0.26	0.26
	(6.26)*	(5.04)*	(4.96)*	(3.91)*	(2.68)*	(2.72)*
ODIFF	−0.06	−0.05	−0.02	−0.02	−0.15	−0.16
	(−1.18)	(−1.05)	(−0.41)	(−0.31)	(−1.68)**	(−1.78)**
LCQUOTES	—	0.00	—	0.00	—	−0.00
		(1.19)		(0.98)		(−0.34)
TQUOTES	—	0.00	—	0.00	—	−0.00
		(1.15)		(0.89)		(−1.30)
Adjusted R^2 (%)	19.16	19.04	18.97	18.80	7.57	7.30
F-statistic	21.76	13.37	17.08	10.54	2.53	1.88
N	263	263	206	206	57	57

* and ** significant at the 5 percent level and at the 10 percent level.

flow is large, then they have to take a short position to satisfy their customer demand and would benefit from a high opening price. However, we do not analyze this issue.

Model 1 in Table IV consists of all 263 bid quote changes by the lead underwriter, Model 2 consists of 206 quote changes for 83 IPOs whose preopening lasted for more than three minutes, and Model 3 consists of 57 observations for 86 IPOs whose preopening lasted for three minutes or less. In each case the model is with and without the independent variables LCQUOTES and TQUOTES. The coefficient on the WDIFF variable is positive and statistically significant in all six models. The CODIFF variable is not statistically significant in any model. These results again suggest that the lead underwriter finds quote changes provided by the wholesalers informative and accordingly revises his own quotes.

A.4. Price Discovery Model

We test the three hypotheses proposed by Biais, Hillion, and Spatt (1999) about price discovery in the preopening period and follow their approach. The "pure noise" hypothesis postulates that market makers do not post informative quotes during the preopening, whereas the "pure learning" hypothesis states that preopening quotes are informative and the quote is equal to the conditional expectation of the value of the asset. The "noisy learning" hypothesis states that because of countervailing incentives, the opening price should reflect a combination of the martingale (from pure learning) and the noise (from pure noise).

The following regression model is estimated:

$$\text{Open} - \text{Offer} = \alpha + \beta_t\,(\text{Price}_t - \text{Offer}) + \epsilon_t, \tag{1}$$

where Price_t is the indicative price during the preopening period at time t, and the opening price on the first trading day of an IPO is used as a proxy for the new equilibrium price and the IPO offer price as a proxy for the old equilibrium price.

We estimate empirically the cross-sectional regression in equation (1) for each 30-second period of the five-minute preopening window. As seen in the Amazon example, prices vary as time elapses during the preopening because learning takes place. If the indicative price (Price_t) is the conditional expectation of the value of the stock (pure learning), then innovations in the preopening price are entirely informative about the value of the asset, and the slope coefficient in equation (1) should be equal to one. We estimate equation (1) separately for each 30-second interval. Figure 3 plots the slope coefficient using bid quotes for each 30-second interval along with the 95 percent confidence bands. The slope coefficient is not significantly different from one, suggesting that significant learning occurs from the preopening quotes. The lead underwriter does not change quotes too often during preopening, but seems to watch and learn from the quoting behavior of other market makers. The confidence interval is quite wide initially but it narrows substantially as opening time approaches.

B. Opening of Trading

Interviews with investment bankers indicate that most of them wait for their Nasdaq trading desk to open trading in other stocks before they begin trading an IPO. Therefore, it is not surprising that most IPOs do not start trading at 9:30 a.m. There is considerable uncertainty with respect to pricing an IPO at the open. Trading in IPOs starts with market makers posting quotes; therefore, market makers need to decide where to quote. Market makers seem to wait to see where the overall market opens before they enter quotes in an IPO. The lead underwriter decides when trading starts and informs the stock market of its decision.

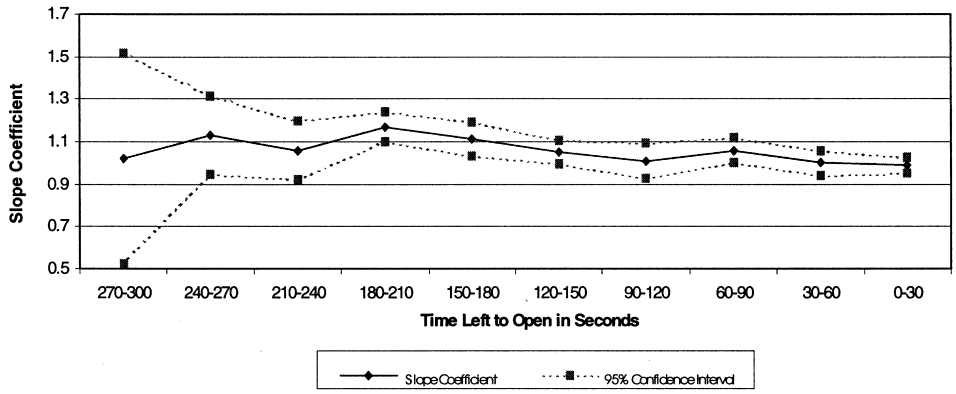

Figure 3. Price Discovery in the Preopening Period. The price discovery process is examined using the method proposed by Biais, Hillion, and Spatt (1999). The following regression is estimated:

$$\text{Open} - \text{Offer} = \alpha + \beta_t\,(\text{Price}_t - \text{Offer}) + \epsilon_t,$$

where the true value of the stock is proxied by the opening price on day 1, the offer price is the proxy for the previous equilibrium price, and the indicative price at time t is Price_t. The indicative price at time t is taken as the average of the bid quotes and the average of the ask quotes during the 30-second interval. If the preopening is efficient, then the slope coefficient β_t should be equal to one. The figure presents the slope coefficients and the 95 percent confidence interval.

Besides waiting to get an indication of where the overall market opens, the market maker is also trying to gather information on what kind of trading to expect in the IPO. The delayed opening allows him to gather information about buyers and sellers in the market. It is more difficult to open trading in IPOs that jump up in price because there is an order imbalance.

B.1. First Trade in an IPO

For the full sample of 188 IPOs, 16 start trading between 9:30 and 10:00 a.m., 40 between 10:00 and 10:30 a.m., and 40 between 10:30 and 11:00 a.m., as seen in Table V. The start time is the time when the first transaction takes place in the secondary market. There are 92 IPOs that start trading after 11:00 a.m. compared with 96 that start trading before 11:00 a.m. The median size of offerings that start trading earlier is lower than that of those that start trading later. IPOs that start trading during the first half-hour after the market opens (9:30 to 10:00 a.m.) have a median size of $29.1 million. The median size is $42.1 million for IPOs that start trading between 12:00 and 12:30 p.m. By 12:30 p.m., most IPOs have started trading.

It is also interesting to note that IPOs that start trading during the first hour have a median initial return of 4.56 percent. These returns increase almost monotonically with the opening time until noon, as seen in Table V.

Table V

Opening Time of Nasdaq IPOs

The sample consists of 188 IPOs during the period May to October, 1997. The table provides information on when the first trade occurs in each IPO. Start time is the half-hour time interval in which the first trade occurs; *N* is the number of IPOs that start trading during the particular half-hour period; mean and median are offering size (proceeds) in dollars; mean and median return are the returns in percent for an investor who buys at the offer price and sells at the open price.

Start Time	*N*	Mean Size	Median Size	Mean Return (%) (Open − Offer)/Offer	Median Return (%) (Open − Offer)/Offer
9:30–10:00	16	$ 53,015,406	$29,150,000	5.78	4.56
10:00–10:30	40	$ 40,792,097	$29,083,331	10.63	5.59
10:30–11:00	40	$ 43,478,933	$33,125,000	17.07	13.89
11:00–11:30	29	$ 45,003,500	$35,000,000	16.10	15.34
11:30–12:00	28	$ 50,139,261	$38,500,000	34.60	23.75
12:00–12:30	14	$ 40,010,714	$42,125,000	20.41	12.03
12:30–1:00	7	$ 37,082,143	$32,000,000	26.34	25.00
1:00–1:30	4	$ 56,275,000	$45,650,000	9.58	14.30
1:30–2:00	6	$105,231,059	$51,875,000	20.27	15.78
2:00–2:30	4	$ 54,815,532	$11,925,500	13.61	12.22

Those offerings that start trading between 11:30 and 12:00 have an initial return of 23.75 percent, between 12:00 and 12:30 the initial return is 12.03 percent, and between 12:30 and 1:00 it is 25.00 percent. After 12:30, very few IPOs start trading and the sample size is limited. IPOs with large price run-ups start trading later than IPOs whose price does not increase much. The mean open-to-offer returns of the 96 IPOs that start trading by 11:00 a.m. is 11.16 percent and 24.36 percent for the 78 IPOs that start trading between 11:00 a.m. and 1:00 p.m. The difference in the means of the two groups is statistically different. After 1:00 p.m. only 14 IPOs start trading.

B.2. Lead Underwriter's Preferences for First Trade Time

Nineteen investment banks served as the lead manager for four or more offerings during our sample period. These 19 banks account for 116 of the 188 offerings in the sample. Some of these firms are counted twice because of mergers during the period. For example, Montgomery Securities lead managed 13 IPOs, the largest number of offerings before the merger, and also lead managed another six after the merger as Nations Banc-Montgomery. Another example is Alex Brown, which managed seven before the merger and four more after the merger as BT-Alex Brown.

Our interviews with investment bankers reveal that Wall Street expects certain underwriters to open at a certain time. For example, they mention that Prudential opens their IPOs at 10:00 a.m., whereas Alex Brown normally starts around 1:00 p.m. This is exactly what we find. The starting time for all lead underwriters who did four or more offerings during the

sample period is reported in Table VI. The median starting time for the four offerings done by Prudential is 10:02 a.m. and the median starting time for Alex Brown is 1:00 p.m. for the seven offerings lead managed by them. After their merger, BT-Alex Brown did four more offerings with a median starting time of 1:47 p.m. Investment bankers told us that they like market participants to know when to expect trading to start. For example, if Prudential is known to start at 10:00 a.m. they try to keep it as such.

The range between the earliest time and the latest time when a particular lead manager starts trading certain IPOs can be quite large. For example, the median starting time for Alex Brown is 1:00 p.m., but the earliest trading in an IPO in which Alex Brown is the lead underwriter is 11:30 a.m. and the latest is 1:50 p.m. This raises the question as to why the same underwriter starts trading certain IPOs early and others later. Besides the preference of the lead underwriter, characteristics of the individual offering also determine the opening time. Therefore, we examine whether initial returns (offer-to-open) are different for IPOs done early versus those that are done later.

For each investment bank that lead managed four or more IPOs, the difference in initial returns of the two offerings done latest versus the two done earliest are reported in Table VI. This difference is positive for 15 lead underwriters and negative for only four. As an example, Goldman Sachs lead managed 10 IPOs during the sample period. The two that opened earliest had an average initial return of 8.63 percent, whereas the two that opened last had an average initial return of 61.72 percent, resulting in a difference of 53.09 percent. For all 19 lead managers, the average difference in returns between the two latest and two earliest IPOs is 10.01 percent. Even though the lead underwriter has time preferences, it opens IPOs that jump up a lot in price later.

B.3. Initial IPO Returns

We analyze other characteristics besides the preference of the lead underwriter that explain initial IPO returns. Our model uses explanatory variables that have not traditionally been used in the literature. The regression model is estimated with initial returns measured as (open-offer)/offer in percentage as the dependent variable for all 169 IPOs that have preopening quotes. The independent variables are: log of proceeds in millions (SIZE), number of quotes in the preopening five-minute window (PQUOTES), the opening time of trading in seconds past midnight (CLOCK), and a dummy variable equal to zero if the start time is before the mean start for the underwriter (DTIME), as reported in Table VI. The DTIME variable is included to control for underwriter preferences for the start time of trading.

The number of quotes in the five-minute preopening window is significant in explaining initial returns as shown in Table VII. This is consistent with our earlier finding that IPOs with large price runups use the full five-minute preopening window and also have a larger number of quotes. The

Table VI

Lead Underwriter's Preferences for Trade Starting Time

The table provides information on trading preferences of 19 lead underwriters who did four or more IPOs. The table is sorted by mean starting time. The name of the lead underwriter, the number of IPOs done by them (N), the mean and median starting time for the IPOs, the earliest and latest time at which the first trade takes place; and the difference in initial returns are presented. Difference in initial returns is the difference in offer-to-open returns between the two IPOs done last and the two IPOs done first by that particular lead underwriter.

Lead Underwriter	N	Mean Starting	Median Starting	Earliest	Latest	Difference in Initial Returns (%)
Salomon	4	9:58 a.m.	10:00 a.m.	9:44 a.m.	10:08 a.m.	24.59
Lehman	7	10:01 a.m.	10:00 a.m.	9:36 a.m.	10:30 a.m.	7.59
Oppenheimer	4	10:12 a.m.	10:07 a.m.	10:03 a.m.	10:30 a.m.	6.60
DLJ	4	10:17 a.m.	10:12 a.m.	9:30 a.m.	11:13 a.m.	4.83
Bear-Stearns	4	10:20 a.m.	10:17 a.m.	10:15 a.m.	10:30 a.m.	11.78
Prudential	5	10:22 a.m.	10:02 a.m.	10:00 a.m.	12:00 p.m.	3.91
A.G. Edwards	6	10:27 a.m.	10:10 a.m.	9:45 a.m.	11:58 a.m.	7.29
Smith Barney	7	10:29 a.m.	10:30 a.m.	10:15 a.m.	11:04 a.m.	23.86
Raymond James	4	10:34 a.m.	10:10 a.m.	10:00 a.m.	11:57 a.m.	13.55
Friedman, Billings	4	11:08 a.m.	11:00 a.m.	10:30 a.m.	12:00 p.m.	0.00
Montgomery Securities	13	11:11 a.m.	11:10 a.m.	10:10 a.m.	12:35 p.m.	33.58
Nations Banc-Montgomery	6	11:30 a.m.	11:33 a.m.	10:45 a.m.	12:14 p.m.	−4.37
Goldman Sachs	10	11:31 a.m.	11:42 a.m.	10:25 a.m.	12:15 p.m.	53.09
Hambrecht & Quist	8	11:34 a.m.	11:37 a.m.	11:05 a.m.	11:58 a.m.	3.04
Robertson Stephens	7	11:44 a.m.	11:35 a.m.	10:41 a.m.	12:46 p.m.	1.01
Morgan Stanley	7	11:51 a.m.	11:45 a.m.	11:15 a.m.	1:00 p.m.	−4.07
Cruttenden	5	12:08 p.m.	12:20 p.m.	10:30 a.m.	2:02 p.m.	−0.94
Alex Brown	7	1:00 p.m.	1:00 p.m.	11:30 a.m.	1:50 p.m.	10.13
BT-Alex Brown	4	1:50 p.m.	1:47 p.m.	1:45 p.m.	2:00 p.m.	−5.30

Table VII
Regression Results for Opening Time

The dependent variable is the open-to-offer return (%). Dollar proceeds of the offering in millions (SIZE), time of day in seconds after midnight when trading starts (CLOCK), the number of quote entries in the five-minute preopening window (PQUOTES), a dummy variable (DTIME) equal to one if the first trade is before the mean time for the lead underwriter, as reported in Table V, and zero otherwise are the independent variables. One hundred sixty nine observations that had preopening quotes are used in the model. *t*-statistics are in parenthesis.

Constant	−0.62
	(−1.86)*
SIZE	0.03
	(1.46)
CLOCK	0.06×10^{-4}
	(1.81)**
PQUOTES	0.01
	(10.68)*
DTIME	0.02
	(0.65)
Adjusted R^2	45.50%
F-statistic	36.06
N	169

* and ** significant at the 5 percent level and at the 10 percent level.

time of day when trading starts (CLOCK) is also significant at the 10 percent level. The dummy variable, DTIME, which is equal to zero if the opening time is before the underwriter's mean opening time is not significant. The analysis is also repeated using the traditional measure of initial returns (close-to-offer), and the results are similar.

III. Summary and Conclusions

We analyze several issues in the initial price discovery process of IPOs. The initial trading of IPOs is quite different from the opening of trading in a regular stock that already trades in the secondary market. First, IPOs only have an offer price to serve as a benchmark and no other trading history exists. Second, the lead underwriter, who takes the company public, plays an important role as a market maker in the aftermarket. Third, trading in IPOs can start at any time during the day at the discretion of the lead underwriter.

Trading in IPOs is preceded by a five-minute preopening period instead of the typical 90-minute period for non-IPO stocks. The lead underwriter starts the process by entering the first quote in the five-minute preopening window. These preopening quotes are not binding. We find that this first quote is very informative and can explain a large proportion of initial returns even for hot IPOs. Our analysis also shows that significant learning and price discovery continue during the five-minute window. Hundreds of quotes are

entered during this period for IPOs that have large price runups. The quotes are gradually revised upwards reaching the equilibrium trading price for hot IPOs. The number of quotes entered also increases as time to open trading approaches.

The group of market makers referred to as wholesalers enters the largest proportion of quotes during the preopening. These market makers are not part of the syndicate but they make a market in thousands of Nasdaq stocks and this is their primary business. They make payment for order flow and therefore receive a large amount of the retail order flow. The wholesalers do not just enter quotes actively but are also the ones who most often improve the best bid and best ask, sometimes causing the market to lock/cross. In a locked market the best bid is equal to the best ask and in a crossed market the best bid is greater than the best ask. Hot IPOs get locked/crossed early during preopening and remain in this state even at the end of the preopening period. The wholesalers lock/cross the market in the hope that other market makers will change their quotes and therefore the order flow received by the wholesalers can be executed at the equilibrium price. The lead underwriter learns a great deal from the quoting pattern of the wholesalers and to some extent from the comanagers. The rest of the syndicate does not play a significant role.

IPOs often start trading much after the market opens. Investment bankers have preferred times when they like to open trading in IPOs. Most IPOs do not start trading at 9:30 a.m. Underwriters like to get trading of other Nasdaq stocks started before turning to IPOs. They also prefer to observe the market opening before entering quotes in IPOs. IPOs that have higher initial price runups open later. This finding is consistent with the statements of underwriters and market makers that IPOs need a period of time for price discovery. The time of day when trading in an IPO starts is an important variable in explaining initial returns even after controlling for investment bank preferences.

The lead underwriter has flexibility in deciding when to start trading in an IPO. Price discovery starts with the very first quote entered by the lead underwriter and it continues during the five-minute preopening window. The frequency of quotes increases as time to open trading approaches. Because IPOs are not required to start trading when the market opens, it is not clear that a longer preopening period helps in the price discovery process. We expect that if the preopening period is lengthened, most of the activity will still take place in the few minutes prior to the opening of trading.

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