Who Knows What When? -

The Information Content of Pre-IPO Market Prices✧

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Abstract

To resolve the IPO underpricing puzzle it is essential to analyze who knows what when during the issuing process. In Germany, broker-dealers make a market in IPOs that starts as soon as the offer range is published. We examine these pre-IPO prices and find that they are highly informative. They are closer to the first price subsequently established on the exchange than both the midpoint of the offer range and the offer price. The pre-IPO prices explain a large part of the underpricing left unexplained by other variables. The results imply that information asymmetries are much lower than the observed variance of underpricing suggests. They cast doubt on the informational role of bookbuilding and the relevance of the winner's curse problem.

JEL classification: G10, G14, G24

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1 Introduction

The underpricing of initial public offerings has been the subject of intensive theoretical and empirical research and yet still represents a puzzle. At the heart of the puzzle is the question of who knows what, and when. Do informed investors know more about the firm value than the issuer and the underwriter (as is assumed by, e.g., Rock, 1986; Benveniste and Spindt, 1989)? Does the underwriter know more than the issuer (as in the principal agent models of Baron and Holmström, 1980; Baron, 1982)? Does the issuer / underwriter have superior knowledge about the firm value but voluntarily chooses to underprice for signaling reasons (as in the models of Allen and Faulhaber, 1989; Grinblatt and Hwang, 1989; Welch, 1989) or to reduce litigation risk (as in Hughes and Thakor, 1992)? Is underpricing a means of creating excess demand, which can be desirable even if information is symmetric (as in the optimal ownership structure models of Brennan and Franks, 1997; Stoughton and Zechner, 1998)?

Finding answers to these questions is complicated by the fact that there is usually no price history before an IPO. In Germany, by contrast, broker-dealers offer OTC trading for investors who want to buy or sell IPO shares during the offer process. Bid and ask quotes from this pre-IPO market are publicly available. In the U.S., when-issued trading is common in conjunction with stock splits (see Angel et al. 1997), but, as in many other countries, it is illegal for IPOs. Consequently, there is little prior research on pre-IPO trading. Aussenegg et al. (2002) use German pre-IPO quotes to test for information production à la Benveniste and Spindt. Cornelli et al. (2003) develop a theoretical model to explore the impact of pre-IPO trading on bookbuilding. Dorn (2003) studies the behavior of retail investors in the German pre-IPO market.

We use data from the German pre-IPO market to examine the extent of information asymmetry during the bookbuilding process and the informational role of the bookbuilding procedure. Our

results can be summarized as follows. Pre-IPO prices are highly informative. They are closer to the prices subsequently established on the exchange than both the midpoint of the offer range and the offer price. Pre-IPO prices also appear to be largely unbiased estimates of the subsequent exchange prices. Finally, the difference between pre-IPO prices and the offer price explains a large part of the underpricing left unexplained by other variables like issue size, post-IPO volatility, and market momentum. The results are not driven by individual "hot" issues, or the hot issue market of 1998-2000 in general.

Each IPO we analyze is sold through bookbuilding. According to Benveniste and Spindt (1989), bookbuilding serves to elicit information from informed investors. The main implication of their theory is that underwriters partially adjust offer prices to new information in order to compensate investors for revealing this information. We use the pre-IPO market prices to test the theory and do not find evidence of partial adjustment. This casts doubt on the informational role of bookbuilding, and, in turn, supports the conclusion that pre-IPO markets can efficiently aggregate information. Note that our finding contrasts with Aussenegg et al. (2002) who also examine pre-IPO prices but do not find evidence in favor of partial adjustment in the German market. The difference is due to our use of a more general econometric specification. Like Aussenegg et al., we use a censored regression framework to analyze price revisions, and take into account that the offer price is not set above the upper end of the offer range in Germany. In addition, we also take into account that underwriters might avoid to price issues below the offer range.

Our work is related to previous research analyzing price formation for newly listed issues. Barry and Jennings (1992) and Schultz and Zaman (1994) report that the initial return is almost entirely reflected in the opening price on the first trading day. Aggarwal and Conroy (2000) analyze the quoting activity before the opening price on the first day of exchange trading is set and find that

learning takes place in the pre-opening period. Benveniste et al. (2000) analyze equity carve-outs. They find that the initial returns of the carved-out subsidiaries are related to the returns of the parent companies in the pre-IPO period. Due to the existence of pre-IPO trading in Germany, we can extend this line of research. We can analyze prices set during the entire offer process rather than only in the pre-trading period on the first day of exchange trading, and our analysis is not confined to the special case of carve-outs.

The remainder of the paper is organized as follows. Section 2 provides an overview of the German market for pre-IPO trading. In section 3 we present our data set and some descriptive statistics. Section 4 analyzes the accuracy of the pre-IPO prices and their relation to initial returns and price revisions. In Section 5 we summarize our findings and discuss their implications.

2 IPOs and pre-IPO markets in Germany

Up to the mid 1990s the German IPO market was rather inactive. Almost all IPOs were fixed price offerings. Since 1995, when it was first used, bookbuilding is the dominant selling procedure.[1] With the inception of the Neuer Markt, the (now defunct) growth segment of the exchange, and the hot IPO market of the late 1990s, both the number of IPOs and the level of underpricing reached unprecedented levels.

Two characteristics of the German IPO market are important in the context of our analysis.[2] In contrast to US bookbuilding practice, upward revisions of the offer range or offer prices above the offer range are very rare in Germany.[3] Downward revisions and offer prices below the offer

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1 See Biais and Faugeron-Crouzet (2002) for a comparison of different selling procedures.

2 See Ljungqvist and Wilhelm (2002) fur further institutional details of the German IPO market.

3 The only case of an upward revision was ISION Internet AG, where the range was increased from [53, 60] to [53, 69]; the offer price was set at 69 (prices in DM). Why upward revisions are avoided is a largely unexplored phenomenon. Ljungqvist et al. (2003) offer a discussion of possible explanations and consequences. Jenkinson et

range, on the other hand, do occur. Second, there is an active OTC market in which shares of companies that are in the process of being issued are already traded. This market, referred to as *pre-IPO trading*, is organized by several broker-dealers. These act as market makers and quote bid and ask prices. Pre-IPO trading covers most issues that are subsequently listed on the Frankfurt stock exchange. To avoid conflicts of interest, broker-dealers do not make a market in issues for which they act as underwriters.

Trades in the pre-IPO market are forward trades. All transactions are contingent on the IPO taking place ("if issued") and are settled on the first trading day of the stock in the secondary market ("when issued"). In case the IPO is cancelled the pre-IPO trades are undone. If the subscription period is extended by more than three days, or if the offer range is changed, all orders that have not yet been filled are cancelled.

The timing of pre-IPO trading is closely linked to the bookbuilding process (see Figure 1). Pre-IPO trading usually starts as soon as the offer range and the schedule for the issue are published.[4] This often happens one day before the subscription period begins. Consequently, there are many cases where there is pre-IPO trading prior to the subscription period (region A in Figure 1). Pre-IPO trading then continues throughout the subscription period (region B). The length of the subscription period differs across IPOs and lies between three days and two weeks. Pre-IPO trading lasts until the day before the first exchange listing. When (as is mostly the case in our sample)

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al. (2003) present a formal model relating to the European practice of not pricing IPOs outside the offer range. We asked a manager of ISION's underwriter and were told that the avoidance of upward revisions is due to the resistance of institutional investors.

[4] In principle, pre-IPO trading could commence prior to the publication of the offer range. However, this would increase the probability that pre-IPO trades have to be unwound because an issue is cancelled or delayed.

there is one working day between the end of the subscription period and the first day of exchange trading, there is pre-IPO trading after the end of the subscription period (region C).

Insert Figure 1 about here

Pre-IPO trading has been organized since the early 1980s. In the late 1990s it has developed into a transparent market that is easy to access. Bid and ask quotes from the pre-IPO market are available through information vendors (REUTERS, Bloomberg) and the internet. Daily newspapers (e.g. Frankfurter Allgemeine Zeitung, Börsenzeitung) often report pre-IPO prices when reporting about ongoing IPOs; Börsenzeitung also publishes summary information on the previous day's trading (daily high and low prices, trading volume and 4 p.m. bid and ask quotes).

Both retail and institutional investors can trade in the pre-IPO market. Banks usually do not offer retail investors the possibility to take short positions. This is not a peculiarity of the pre-IPO market as it also holds for short positions in listed shares. Since trading in the pre-IPO market can only occur if some investors take short positions, the restriction implies that institutional investors play an active role in the market.[5] Börsenzeitung (July 31, 2001) reported that the main sellers were pre-IPO shareholders wishing to reduce their share in the company and institutional investors who were confident of receiving share allocations and wished to lock in their profits.

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[5] Cornelli et al. (2003, p. 2) claim that the depth of the pre-IPO market is "usually not sufficient to interest large institutions". While this seems plausible when comparing the absolute trading volume in the pre-IPO market with the size of large mutual funds, one should not overlook that, first, there was a large number of small, specialized funds in period under analysis, and, second, IPO allocations to mutual funds are often small. Löffler (2003) analyzes fund transactions in newly issued shares and found many of them to be rather small. One of his sample funds (ADIG AS Aktiv Dynamik, a fund with assets under management of € 77 million by June 2000) traded in 160 new issues in a period of less than 20 months. The median trade size was 0.09% of the issue volume.

3 Data

We restrict the analysis to stocks that went public on the Frankfurt Stock Exchange. We obtained data on these IPOs (offer price, IPO volume, bookbuilding spread, first trading price, market segment) from the exchange. Data on secondary market prices and trading volumes are from Datastream.

Pre-IPO bid and ask quotes are from the broker Börsenmakler Schnigge AG, the broker with the largest share in the pre-IPO market.[6] Using quotation, rather than transaction, data is not an impediment to our analysis because our interest is in the information that can be inferred from the pre-IPO market. None of our analyses assumes that trades have actually taken place at these prices. The quotation data is from two sources. First, Schnigge maintains a historical data base that contains the closing bid and ask quotes from the last day of pre-IPO trading (i.e., the day before the stock is first traded on the exchange). The date base starts in 03/30/98; our analysis ends in 06/30/01. Out of the 400 IPOs that were sold during this period, Schnigge made a pre-IPO market in 357 issues.[7] We refer to this sample of 357 firms as the *full sample*. 306 of these companies chose to list on the growth segment Neuer Markt.

Second, Börsenzeitung started publishing daily (4.00 p.m.) Schnigge quotes in April 2000. From June 2000 onwards, Börsenzeitung also published daily volume data. We collected these data

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[6] Schnigge claims to have a market share of 80% (annual report 1999, p.14).

[7] Schnigge does not make a market if involved in the underwriting. It also appears that Schnigge refrained from making a market in issues with little investor interest. Consistent with this interpretation, issues not covered by Schnigge are smaller (the median issue volume is € 30.82 million vs. € 39.10 million for the full sample), less underpriced (22.25% vs. 42.71%), and very rarely listed on the growth segment Neuer Markt (1.8% vs. 85.7%).

from 04/17/00 through 06/30/2001. We refer to this sample as the *daily sample*. It covers 112 IPOs, for 86 of which we also have volume data.

Insert Table 1 about here

Table 1 presents descriptive statistics for the full sample, the full sample broken down by years, and the daily sample. The average issue size is € 117.6 million, the median is € 39.9 million. The underpricing in the sample period, measured by the return from the offer price to the first price established on the exchange, is substantial. The mean underpricing is 42.7%, the median is 13.3%. Only 10.1% of the issues are *over*priced. The hot IPO market from 1998 through 2000 is evidenced by the large number of IPOs and the high underpricing in these years and is consistent with findings for the US (see, e.g., Ljungqvist and Wilhelm, 2003). In 2001, both the number of IPOs and the average underpricing decreased significantly. The underpricing in the daily sample, 19.15%, is not significantly different from the 1960-95 average of 15.80% for German IPOs reported by Stehle and Ehrhardt (1999). Since we obtain similar results for the full and the daily sample, we are confident that our results are not driven by the 1998-2000 hot issue market.

For the IPOs for which we have information on daily pre-IPO market trading volume (86 IPOs from June 2000 onwards), the mean daily volume as a percentage of shares issued in the IPO is 0.48% (median 0.31%). For the same 86 stocks, we compute the mean secondary market volume – again as a percentage of shares issued – on the 30th day of exchange listing, which is 0.55%. The pre-IPO trading volume is thus of the same order of magnitude as the trading volume in the secondary market.

Figure 2 presents an example. It shows the evolution of the pre-IPO quotes for Linos AG, a company that went public on the Neuer Markt on September 1, 2000. The offer price range was €24 to € 27. The subscription period lasted from August 24 to August 30. Pre-IPO trading began on

August 23 (the day on which the offer range was announced) and lasted until August 31 (the day before the first listing on the exchange). The first pre-IPO bid prices were more than 30% above the upper end of the offer range. In the course of the offer process, the quotes rose steadily. The quotes on the last day of pre-IPO trading were above € 50. The daily average trading volume was 9,450 shares. This is equivalent to 0.68% of the issue volume. The offer price was set at the upper end of the offer range (€ 27). The first market price on September 1 was € 73. In this particular case, the pre-IPO quotes were thus considerably lower than the first market price, but they were also consistently closer to it than both the midpoint of the offer range and the offer price. In addition, the difference between the pre-IPO quotes and the subsequent first market price decreased in the course of the pre-IPO trading period. This is evidence of price discovery and information aggregation through pre-IPO trading. The next section will reveal whether this picture is representative.

Insert Figure 2 about here

4 Empirical Results

We present our empirical results in two subsections. The first contains a univariate analysis of the accuracy of the prices set in the pre-IPO market. The second subsection presents the results of a multivariate analysis aimed at shedding light on the information content of pre-IPO quotes and the informational role of the bookbuilding procedure.

4.1 Pricing Accuracy

A first indication of the accuracy of the pre-IPO prices is the frequency with which the first market price on the exchange falls within the last pre-IPO quotes. We find this to be the case for 52.9% of the IPOs in our sample. In contrast, only 26.9% of the first exchange prices are inside

the offer range, even though offer ranges are wider than the bid-ask spreads in the pre-IPO market (see Table 1).

To assess the accuracy of the pre-IPO quotes in more detail we examine the percentage difference between the prices set during pre-IPO trading and the first market price set on the exchange after completion of the IPO. We define the pre-IPO pricing error as:

$$\text{Pre-IPO pricing error} = \frac{P_i - p_{i,j}}{p_{i,j}} \tag{1}$$

where P_i is the first exchange price of stock i, and $p_{i,j}$ is a pre-IPO quote midpoint for stock i at stage j of the pre-IPO trading period.[8] For the full sample, we only have quotes from the last day before the IPO. For the daily sample, we calculate variants of the pre-IPO pricing error based upon prices quoted on the day before the subscription period, on the first and last day of the subscription period, halfway through the subscription period, and on the day before trading on the exchange starts.[9] In 30 cases, pre-IPO trading commenced only on the first day of the subscription period.[10] For the quotes from the day before the subscription period the number of observations thus reduces from 112 to 82.

In order to gauge the magnitude of the pre-IPO pricing errors we compare them to two benchmarks. The first is the "offer range error"

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[8] Alternatively, we also use logarithmic and market-adjusted pricing errors. The results are similar.

[9] If the subscription period extends over an even number of trading days, we take the midpoint to be the day that is closer to the beginning of the subscription period.

[10] These are the cases where there was no working day between the publication of the issue details and the start of the subscription period (i.e., the cases where there is no region A, see Figure 1). In 17 out of these 30 instances, the subscription period began on a Monday or on a day following a public holiday.

$$\text{Offer range error} = \frac{P_i - \text{Midpoint of offer range}}{\text{Midpoint of offer range}} \tag{2}$$

and the second is the "offer price error" which is identical to the underpricing defined above:

$$\text{Offer price error} = \frac{P_i - \text{offer price}}{\text{offer price}} \tag{3}$$

Insert Table 2 about here

Table 2 presents descriptive statistics for the pricing errors. The results for the full sample are shown in Panel A. The mean offer range error is 49.4%, and the mean offer price error is 42.7%. The first official price set on the exchange is thus more than 40% higher than both the midpoint of the offer range and the offer price. By contrast, the last pre-IPO price is, on average, almost equal to the first price on the exchange. The mean pre-IPO pricing error is only 0.6%, which is not significantly different from zero (t-value 0.76, z-value for a Wilcoxon test 1.58). The standard deviations show that the pre-IPO prices are not only less biased, but also more efficient estimates of the first market price than both the midpoint of the offer range and the offer price. The standard errors of the offer range error and the offer price error are 77.5% and 69.0%, respectively, more than four times as large as the corresponding figure for the pre-IPO pricing error (15.7%). In the light of this, the gain in accuracy that the offer price achieves relative to the offer range midpoint appears to be small. The results are not due to outliers. After winsorization—we replace the 5% largest and smallest observations with the 95% and 5% quantile of the distribution, respectively—the standard deviation of the offer price error is 55.40% whereas the corresponding value for the pre-IPO pricing error is only 11.23%. Viewed in isolation, the standard deviation of the pre-IPO pricing error may appear high, but it is similar to the volatility of post-IPO exchange

prices. The cross-sectional standard deviation of close-to-close returns from the first day of trading on the exchange to the second is 13.20%.

So far, we have described differences in accuracy without testing for their statistical significance. We conduct paired t-tests as well as Wilcoxon matched-pairs signed-rank tests to test the null hypothesis of no difference between absolute pre-IPO pricing errors on the one hand, and absolute offer range and offer price errors on the other hand (see Table 3). In each test, the null hypothesis is rejected at the 0.1% level or better. Taken together, the results indicate that, first, pre-IPO quotes are significantly more informative than the offer range and the offer price and, second, that pre-IPO quotes are good proxies for the prices set on the first trading day on the exchange.

Insert Table 3 about here

Moving on to the daily sample, a similar picture emerges. As for the full sample, Table 2 contains the descriptive statistics, while Table 3 presents tests for differences in absolute pricing errors. The pre-IPO pricing errors are, again, significantly smaller than both the offer range errors and the offer price error. Intriguingly, pre-IPO pricing errors calculated from pre-IPO quotes set on the day before the start of the subscription period are significantly smaller than the offer range errors, and are smaller (though not significantly so) than the offer price errors.[11] The pricing accuracy steadily increases towards the IPO date, indicating that the quality of the information

[11] It may seem surprising that quotes from the day before the subscription period are closer to the first market prices than pre-IPO prices from subsequent days. Note, however, that the standard deviation of the pricing error is higher at the beginning. Further, the number of observations is reduced from 112 to 82 because, in 30 cases, the first day of pre-IPO trading coincided with the first day of the subscription period (no region A, see Figure 1). Consequently, there are no pre-IPO quotes from the day before the subscription period for these 30 issues. Restricting the analysis to those 82 IPOs where pre-IPO trading commenced on the day before the subscription period began shows no significant differences between the days before and during the subscription period.

available to market participants rises over time. Further tests (not reported in Table 3) show that the absolute pre-IPO pricing errors from the last day of pre-IPO trading are significantly lower than the ones from the first day of the subscription period. This increase in accuracy may be due to the arrival of public information, or to the gradual incorporation of private information into pre-IPO prices.

Pre-IPO quotes set during the subscription period are significantly higher than the first market price. Thus, investors buying shares in the pre-IPO market and selling them on the first day of exchange trading would have lost money on average. In an analysis of individual investor trades, Dorn (2003) documents such losses, which he ascribes to over-optimistic sentiment. Although one cannot rule out this possibility, there is an alternative explanation related to a sort of peso problem. When making their trading decisions, investors may have assigned a positive probability to a revival of the hot issue market, which then did not occur. Since the daily sample contains several issues with underpricing above 100%, such expectations are not necessarily irrational.

The analysis of the pre-IPO pricing errors can be complemented by a Mincer-Zarnowitz test for unbiasedness. We run the following regression:[12]

$$P_i = \alpha_j + \beta_j p_{i,j} + \varepsilon_{i,j} \tag{4}$$

Here, we interpret the pre-IPO prices $p_{i,j}$ as estimates of the "true" price which, in turn, is proxied by the first price set on the exchange, P_i.[13] We estimate similar regressions using the midpoint of the offer range and the offer price, respectively, as independent variables. Unbiased-

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[12] To reduce the impact of heteroscedasticity, we exclude one observation (the IPO of Deutsche Börse AG) because prices were much larger than those of the other IPOs. Including Deutsche Börse AG in the sample does not change any of the results.

[13] See, among others, Rock (1986) for a justification of this assumption.

ness implies $\alpha_j = 0$ and $\beta_j = 1$. Given the descriptive statistics presented above we expect only the pre-IPO quotes to be unbiased estimators of the true price.

Insert Table 4 about here

The results are shown in Table 4. The final pre-IPO quotes are unbiased estimators of the true price (i.e., the joint null hypothesis $\alpha_j = 0$ and $\beta_j = 1$ is not rejected) whereas the midpoint of the offer range and the offer price are not. In the daily sample (Panel B), unbiasedness is rejected, however, for pre-IPO quotes established until the midpoint of the subscription period.

4.2 Pre-IPO Quotes and Underpricing: Multivariate Analysis

Most underpricing theories argue that underpricing is a rational answer to informational asymmetries. They also predict that the magnitude of underpricing varies cross-sectionally. Several empirical papers have uncovered variables that help to explain this variation (see Wasserfallen and Wittleder, 1994; and Ljungqvist, 1997 for research on the German IPO market). When comparing the pre-IPO pricing errors to the offer price errors (which, as noted above, are identical to our measure of underpricing), we should take into account the fact that a portion of the underpricing is predictable. Specifically, we wish to analyze whether the pre-IPO quotes contain information that is not already contained in those variables that have proven to have explanatory power for the magnitude of the underpricing. We use the following variables:

- the natural logarithm of the issue volume. In previous research (e.g. Ljungqvist, 1997) it has been documented that underpricing is negatively related to the size of the issue.

- the standard deviation of daily returns in the 20 trading days after completion of the IPO as a proxy for the uncertainty about the true value of the stock.[14]

- the return of an appropriate stock index in the 60 days prior to the subscription period. We include this variable because a strong positive relation between underpricing and the market return prior to the issue has been documented for Germany by Ljungqvist (1997). For firms that went public on the Neuer Markt we use the NEMAX All Share index, for firms listed on other segments of the Frankfurt Stock Exchange we use the CDAX index. Both indices are broad, value-weighted performance indices published by the exchange.

- the index return during the subscription period. We include this variable because the German practice of not adjusting the offer range limits the ability of underwriters to adjust the offer price to general market movements during the subscription period.

- a dummy variable for IPOs placed on the Neuer Markt. As shown by Kukies (2000), firms going public on the Neuer Markt are primarily small, young firms, where informational asymmetries are likely to be relatively high.[15]

- a dummy variable marking offerings that were managed or co-managed by a US investment bank (or a European affiliate thereof). This is motivated by Ljungqvist et al. (2003) who document lower underpricing for international IPOs led by a US bank.

- the price revision, which we define as the percentage difference between the offer price and the offer range midpoint. If underwriters partially adjust to new information as predicted by Benveniste and Spindt (1989), initial returns are positively related to price revisions.[16]

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[14] Using the percentage offer range as an alternative measure of the uncertainty leaves the conclusions unchanged.

[15] In the full sample [daily sample] 85.7% [83.0%] of the IPOs went public on the Neuer Markt.

The results for the full sample are shown in columns (1a, 1b) of Table 5. The coefficient of the issue volume has the expected negative sign but is insignificant. The coefficient on the secondary market volatility is positive and significant at the 1% level. The underpricing is strongly positively related to the index returns prior to, and during, the subscription period. Issues sold on the Neuer Markt exhibit higher underpricing, while choosing a US underwriter does not affect initial returns. Finally, initial returns are positively related to price revisions. Together, the independent variables explain 34% of the variation in underpricing. The standard error of the regression is 56.2%, which is still more than three times as large as the standard deviation of the pre-IPO pricing errors (15.74%, see Panel A of Table 2). This indicates that the pre-IPO prices contain information beyond that contained in the variables included in the underpricing regressions.

Insert Table 5 about here

This conclusion is strongly confirmed when we add the pre-IPO return as an additional explanatory variable. For the full sample it is defined as[17]

$$\frac{\text{Midpoint of last pre - IPO quotes}}{\text{offer price}} - 1 \qquad (5)$$

If, for whatever reasons, underwriters do not fully adapt offer prices to the market's assessment of the firm value (as represented by the pre-IPO quotes), the pre-IPO return should have explanatory power for the observed underpricing. Consistent with this argument, inclusion of the pre-IPO return changes the regression results dramatically. The R^2 jumps from 0.34 to 0.82. Except for the secondary market volatility, the other independent variables lose significance. The coefficient

[16] To capture potential asymmetries, we also included an additional variable defined as price revision times a dummy variable that is equal to one if the price revision is positive. Conclusions do not change.

of the pre-IPO return is close to one, the value one would expect if pre-IPO quotes were unbiased. Including *only* the pre-IPO return on the right-hand side yields an R^2 of 0.81 (not reported).

The results presented so far may be driven by the fact that in Germany offer prices are de facto bounded above by the upper end of the offer range. To check the robustness of our results, we excluded all IPOs where the offer price was equal to the upper end of the range. Coefficient estimates for the resulting sub-sample (116 observations) are shown in columns (2a, 2b) of Table 5. When only the "traditional" variables are included, the regression has no explanatory power, as evidenced by a negative adjusted R^2. Including the pre-IPO return increases the R^2 to 0.61. The pre-IPO return alone explains 60.7% of the cross-sectional variation in underpricing. Thus, the results are not solely driven by hot IPOs priced at the upper end of the offer range.

The results for the daily sample, which represents a much “colder” IPO market, are summarized in columns (3a) and (3b). They are consistent with those for the full sample, showing that the informativeness of the pre-IPO return is not limited to the hot IPO period.

So far, the regressions explored the information content of the last available pre-IPO quotes. These are quoted after the offer price is set. To identify the information that was available before the pricing decision, column (3c) uses the daily sample to analyze whether the pre-IPO return from the offer range midpoint to the pre-IPO midquotes from the *first* day of the subscription period helps to explain the amount of underpricing. The answer is a definite yes. Again, the R^2 increases substantially upon inclusion of the pre-IPO return, from 0.15 to 0.44. The documented information content of pre-IPO quotes can thus not be attributed solely to information that was disseminated in the course of the pricing process.

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[17] This pre-IPO return is only observed after the offer price is set; using the daily sample, we will also examine the informativeness of quotes that are set before the offer price (see below).

The results indicate that pre-IPO quotes contain information related to the value of the IPO firm. The information content of pre-IPO quotes by far exceeds the information that is inferred from (publicly observable) control variables. Put differently, valuation uncertainty during the offer process is much lower than the variation in underpricing suggests. This does not necessarily imply that the bookbuilding procedure fulfils no informational role. The information acquisition theory states that the underwriter adjusts offer prices only partially to new information because they need to cede informational rents to informed investors. The theory is traditionally applied to information revealed during bookbuilding. In an IPO market such as Germany, where price rigidity limits the informational role of bookbuilding, information production could concentrate on the pre-subscription period (Ausseneggg et al. 2002; Jenkinson and Jones, 2004; Jenkinson et al. 2003). This conjecture is consistent with the observations made so far: underwriters do not adjust offer prices to fully reflect the information contained in pre-IPO quotes because this information has been revealed to them before, with the implicit understanding that offer prices are only partially adjusted. Otherwise, investors would not have any incentive to reveal their information.

The partial adjustment hypothesis can be tested using censored regression analysis. Specifically, we test whether prices would fully adjust if they were not constrained by the offer range. As above, we define the price revision Δp as (offer price / midpoint of offer range – 1) and regress it on the independent variables included in the underpricing regressions from above. The crucial coefficient is the one on the pre-IPO return, for the calculation of which we use the pre-IPO quotes from the last day of the subscription period. It is thus defined as (midpoint of pre-IPO quotes from last day of the subscription period / midpoint of offer range – 1). This specification

ensures that underwriters could observe the pre-IPO returns before setting the offer price. It also implies that the analysis can only be conducted for the daily sample. The regression model is

$$\Delta p = \alpha + \sum_{i=1}^{n} \beta_i x_i + \gamma \,\text{pre-IPO-return} \tag{6}$$

where the x_i denote the set of independent variables introduced earlier. We test whether the coefficient γ is significantly different from one. If it is not, we cannot reject the hypothesis that underwriters fully adjust to available information. We use a generalized tobit specification which assumes that the price revision can be both right and left censored, and that censoring values are observation-specific.[18] Observations are treated as uncensored if the offer price lies within the offer range, or outside of it. An observation is right-censored if the offer price is equal to the upper end of the offer range.[19] Left-censoring occurs if the offer price is equal to the lower end of the offer range. To determine censoring, we use the final offer range, after any adjustments that occurred during the subscription period; to compute price revisions and pre-IPO returns, we use the initial offer range.

One may wonder why setting the offer price at the lower end of the range is an instance of censoring when downward adjustments are not ruled out. There are several possible reasons for avoiding downward adjustments: costs of negotiating and communicating the adjustment; reputational costs[20] (if the market views adjustments as evidence of unsuccessful offers); protection against collusion among institutional investors. The data confirms the conjecture that the lower

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[18] Estimation is done using the INTREG command in STATA.

[19] Note that a offer price equal to the upper end of the offer range is the most frequent case in our sample (see **Table 6** for details). Therefore, the number of right-censored observations is quite high, amounting to 50% of the total number of observations. This should be taken into account when interpreting the results.

end of the offer range constitutes a threshold that may be crossed, but usually is not. As shown in Table 6, prices cluster at the lower end of the range. In the daily sample, prices are more often set at the lower end of the offer range than within the range. The picture does not change if one removes the five cases in which the offer range was adjusted.

Insert Table 6 about here

Table 7 presents the regression results. The estimated coefficient γ is 0.94. It is not statistically different from one ($p = 0.61$). We thus cannot reject the hypothesis that underwriters would fully adjust offer prices to pre-IPO-quotes if they were unconstrained. To check robustness, we allow the coefficient γ to vary with the sign of the pre-IPO return, or drop the other independent variables (specifications (2) and (3)). The conclusion does not change.

Insert Table 7 about here

Aussenegg et al. (2002, Table 7) conduct a similar analysis for Neuer Markt IPOs of the years 1999-2000 and obtain an opposite result. In their regression, the coefficient γ is 0.771, significantly different from one. However, they do not model left-censoring. If we use our data and estimate γ in the way Aussenegg et al. do, we obtain an estimate of 0.743, significantly different from one (p-value=0.0001). The differences between our study and theirs thus appear to be due to the econometric modeling of the pricing behavior. We favor our approach because the clustering at the lower end of the offer range strongly points to censoring, and because our modeling of censoring is more general. It does not require that the lower end influences the underwriter's choice of the offer price; it just allows for cases in which it does. The analysis of Aussenegg et al., on

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[20] Nanda and Yun (1997) analyze the relation between underpricing and the market value of the investment bank. They find that overpriced issues are associated with a decrease in the market value of the lead underwriter.

the other hand, assumes that the lower end of the offer range never restricts the underwriter's choice.

5 Summary and conclusions

In this paper we exploit a special feature of the German equity market, namely the existence of an active pre-IPO market to examine IPO underpricing in Germany. We demonstrate that pre-IPO prices are highly informative. They are, on average, very close to the prices subsequently established on the exchange, much closer than both the midpoint of the offer range and the offer price. In addition, the pre-IPO return (defined as the "return" between the midpoint of the offer range and the midpoint of the IPO quotes on the day prior to the first trading day on the exchange) explains a large part of the underpricing that is left unexplained by market momentum and other variables.

These results imply that information asymmetries are likely to be much lower than the observed variance of underpricing suggests. Any informational disadvantage of uninformed investors, for instance, is largely reduced because they can monitor the pre-IPO prices and condition their subscription decision on that information. They can thereby alleviate the winner's curse problem. In the presence of a pre-IPO market that efficiently aggregates private information, the winner's curse is therefore unlikely to be a valid explanation for high levels of underpricing.

In information acquisition models (Benveniste and Spindt, 1989), underpricing rewards informed investors for revealing their information during the bookbuilding process. Previous empirical studies (e.g. Hanley, 1993; Ljungqvist and Wilhelm, 2002; and Cornelli and Goldreich, 2001) provide support for this hypothesis. However, they do not quantify the extent to which the underpricing can be explained through the Benveniste-Spindt argument. We find that pre-IPO prices on the day before the subscription period are already as informative as the offer price. This result

leaves little role for information production *during* the subscription period. Some researchers have argued that information production in Europe, and particularly in Germany, takes place *prior to* the subscription period (e.g. Aussenegg et al. 2002; Jenkinson and Jones, 2004; Jenkinson et al. 2003). In this case, underwriters would not fully incorporate the information contained in pre-IPO quotes because they have to cede rents to investors who revealed this very information before bookbuilding started. Within a censored regression framework we cannot reject the hypothesis that underwriters fully adjust to the information contained in pre-IPO quotes. This is, again, inconsistent with information acquisition models.

In some theories, underpricing serves as means to create excess demand, either to achieve a preferred ownership structure (Brennan and Franks, 1997; Stoughton and Zechner, 1998) or to serve the underwriters' interests (Loughran and Ritter, 2002). Such explanations are not built on information asymmetries and are thus consistent with our findings.

Taken together our results cast a shadow of doubt on the dominant role that is often ascribed to information asymmetries in explaining the underpricing of IPOs. In this sense, our paper supports the conjecture of Ritter and Welch (2002) that asymmetric information cannot explain the recently observed high levels of underpricing, and that underpricing research should concentrate on agency conflicts and allocation issues.

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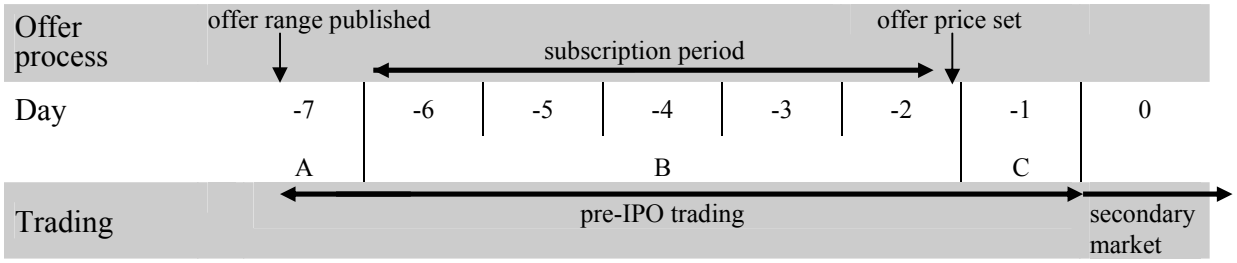

Figure 1: Timeline for offer process and pre-issue trading.

The figure shows the timing of events for a typical IPO. Day 0 is the first day of trading on the exchange. Pre-IPO trading starts as soon as the offer range is published. In the majority of cases this happens one day before the subscription period begins. If this is the case, pre-IPO trading thus starts before the subscription period begins (region A). The length of the subscription period varies from 3 days to two weeks. The 5-day period shown in the figure represents the median value in our sample. The last day of pre-IPO trading is the day before trading on the exchange starts. Since in many IPOs there is one day between the end of the subscription period and the first trading day on the exchange, there is often pre-IPO trading after the end of the subscription period (region C).

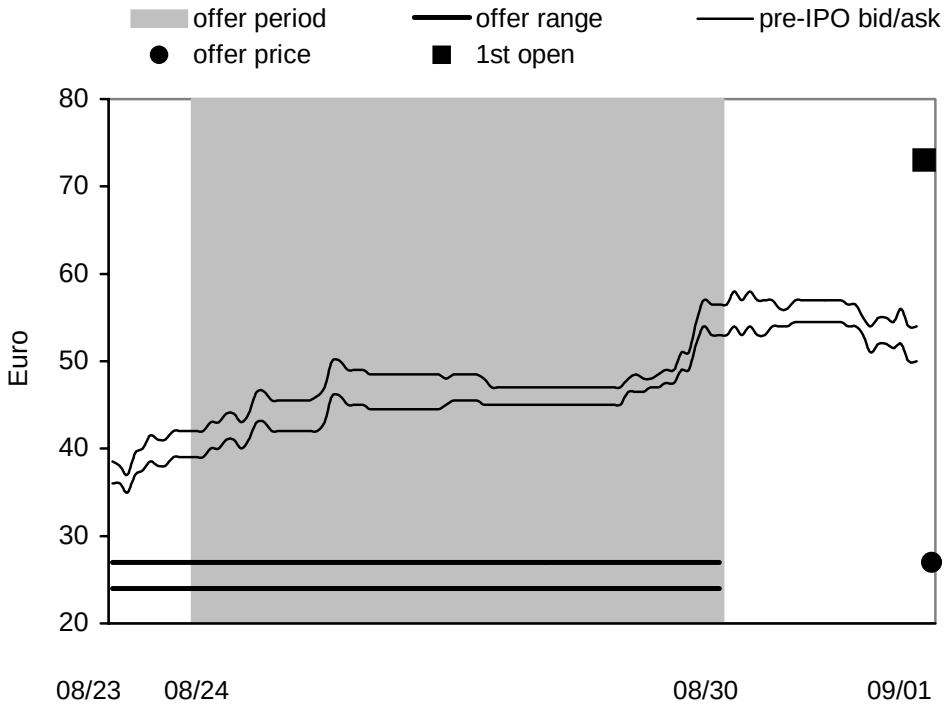

Figure 2: An example: Pre-IPO trading of LINOS AG.

Linos AG went public on September 1, 2000 at an offer price of € 27. The first price established on the exchange was € 73. The offer range was € 24 to € 27, the subscription period lasted from August 24 to August 30. Pre-IPO trading began on the day of the announcement of the offer range (August 23) and lasted until August 31. The shown pre-IPO bid and ask quotes were recorded at full hours from the website of the broker-dealer Schnigge.

Table 1: Descriptive statistics for the sample IPOs

		IPO volume (million €)	Underpricing (%)	Width of initial offer range (%)	Width of last pre-IPO bid-ask spread (%)
full sample NOB=357	mean	117.57	42.68	17.63	10.45
	median	39.90	13.33	16.95	10.00
	std. dev.	465.90	69.01	5.31	4.24
1998 NOB=39	mean	40.65	72.35	15.45	11.19
	median	27.92	38.78	14.43	11.11
	std. dev.	41.06	75.12	3.95	3.62
1999 NOB=152	mean	82.27	38.55	17.24	10.50
	median	37.65	8.88	16.47	10.00
	std. dev.	185.80	65.81	4.73	4.36
2000 NOB=149	mean	170.96	43.14	18.17	10.33
	median	46.20	14.29	17.39	9.52
	std. dev.	686.11	71.66	5.78	4.10
2001 NOB=17	mean	141.73	7.48	21.45	9.33
	median	21.60	1.14	20.69	8.00
	std. dev.	303.46	23.56	6.24	5.61
daily sample NOB=112	mean	127.74	19.15	19.32	9.76
	median	34.75	5.00	18.18	9.19
	std. dev.	565.80	36.95	6.39	4.03

Notes. The table presents descriptive statistics for the full sample, the full sample broken down by years, and the daily sample. Underpricing is defined as (first price on the exchange / offer price – 1). The width of the offer range is defined as 2 × (upper bound – lower bound) / (upper bound + lower bound). Similarly, the width of the pre-IPO bid-ask spread is defined as 2 × (ask – bid) / (ask + bid). NOB denotes number of observations.

Table 2: How accurate are pre-IPO quotes? - An analysis of pricing errors

	Mean (percent)	t-value	Std. dev. (percent)	Std. dev. (after winsorization, percent)	Quantiles (percent) 25%	50%	75%
Panel A: Full Sample (NOB=357)							
Offer range error	49.44	12.05	77.52	64.21	0.00	20.69	73.68
Offer price error	42.71	11.70	69.00	55.40	1.09	13.33	60.26
Pre-IPO pricing error (Last pre-IPO quotes)	0.64	0.76	15.74	11.23	-6.47	-1.58	4.58
Panel B: Daily Sample (NOB=112)							
Offer range error	19.34	4.46	45.90	39.08	-10.28	10.73	32.8
Offer price error	19.15	5.48	36.95	30.23	0.00	5.00	22.7
Pre-IPO pricing error based on quotes from the:							
day before subscription period	-5.13	-1.67	27.83	23.25	-23.50	-8.25	5.2
first day of subscription period	-9.48	-4.06	24.72	20.38	-24.42	-12.41	0.3
midpoint of subscription period	-7.80	-4.06	20.37	18.46	-20.00	-8.10	1.5
Last day of subscription period	-4.26	-2.50	18.07	14.78	-15.18	-5.15	1.1
Last day of pre-IPO trading	0.47	0.36	13.66	8.82	-5.80	-2.66	3.61

Notes. The pre-IPO pricing error is defined as

$$\text{Pre-IPO pricing error} = \frac{P_i - p_{i,j}}{p_{i,j}}$$

where P_i is the first trading price and $p_{i,j}$ is the midpoint of pre-IPO quotes. The offer range error and the offer price error are defined similarly as

$$\text{Offer range error} = \frac{P_i - \text{Midpoint of offer range}}{\text{Midpoint of offer range}} \text{ and } \text{Offer price error} = \frac{P_i - \text{final offer price}}{\text{final offer price}},$$

respectively. Means, standard deviations and the quantiles are reported in percent. The t-values in the third column are for a test of the null hypothesis of a zero mean. In the winsorization, extreme observations are pulled to the variable's 5% and 95% quantiles, respectively. For the quotes from the last day before the subscription period the number of observations (NOB) reduces to 82 as trading did not commence at this stage in some cases. For this sample of 82 IPOs, the standard deviation of the offer range error and the offer price error is 48.3% and 39.9%, respectively.

Table 3: Testing differences between absolute pricing errors

	Offer range error		Offer price error	
	t-statistic and p-value	z-statistic (Wilcoxon test) and p-value	t-statistic and p-value	z-statistic (Wilcoxon test) and p-value
Panel A: Full Sample (NOB=357)				
Pre-IPO pricing error (Last pre-IPO quotes)	12.39 (0.000)	14.91 (0.000)	10.44 (0.000)	10.85 (0.000)
Panel B: Daily Sample (NOB=112)				
Pre-IPO pricing error based on quotes from the:				
day before subscription period	3.57 (0.001)	2.42 (0.016)	1.03 (0.306)	0.51 (0.613)
first day of subscription period	3.51 (0.001)	2.09 (0.037)	0.66 (0.512)	0.98 (0.326)
midpoint of subscription period	4.78 (0.000)	3.62 (0.000)	1.87 (0.064)	0.09 (0.938)
last day of subscription period	5.94 (0.000)	6.18 (0.000)	3.15 (0.002)	1.50 (0.133)
last day of pre-IPO trading	8.09 (0.000)	8.69 (0.000)	5.28 (0.000)	5.10 (0.000)

Notes. Using paired t-tests and Wilcoxon matched-pairs signed-rank test, we test the significance of mean differences between the absolute pre-IPO pricing errors on the one hand and the absolute offer range errors and absolute offer price errors on the other hand. The variables are as defined in the legend to Table 2, except that absolute values are taken. Table entries are test statistics for the null hypothesis of zero difference between the absolute pricing errors of the prices defined in the column and row headers, respectively. p-values are in parentheses. For the quotes from the day before the subscription period the number of observations (NOB) reduces to 82.

Table 4: Are pre-IPO quotes unbiased estimates of the true price? – Results from Mincer-Zarnowitz regressions

Dependent variable: First market price

	α_j	β_j	R^2	p-value for H_0: $\alpha_j = 0; \beta_j = 1$
Panel A: Full Sample (NOB=356)				
midpoint of offer range	-8.679 (-1.82)	1.956 (8.86)	0.669	0.000
offer price	-8.843 (-2.28)	1.878 (10.52)	0.695	0.000
last pre-IPO price	-0.756 (-0.93)	1.034 (39.09)	0.964	0.366
Panel B: Daily Sample (NOB=111)				
midpoint of offer range	-2.376 (-1.12)	1.377 (9.60)	0.654	0.000
offer price	-2.129 (-1.41)	1.355 (12.28)	0.727	0.000
Pre-IPO quotes from				
Day before subscription period	-3.781 (-2.09)	1.159 (11.87)	0.809	0.064
First day of subscription period	-1.395 (-0.87)	0.992 (11.70)	0.783	0.009
Midpoint of subscription period	-1.715 (-1.32)	1.023 (14.33)	0.853	0.003
Last day of subscription period	-0.660 (-0.66)	1.001 (17.23)	0.881	0.160
Last day of pre-IPO trading	-1.203 (-1.38)	1.080 (20.80)	0.934	0.289

Notes. The Table shows the results of the regression

$$P_i = \alpha_j + \beta_j p_{i,j} + \varepsilon_{i,j}$$

where P_i is the first price set on the exchange and p_{ij} is as defined in the first column. t-statistics (in parentheses) are calculated using heteroscedasticity-consistent standard errors. The last column shows the p-value for a Wald test of the joint null hypothesis $\alpha_j = 0; \beta_j = 1$.

In both panels one observation (the IPO of Deutsche Börse AG) has been excluded. The prices were much larger than those of the other IPOs. For the quotes from the last day before the subscription period the number of observations (NOB) is reduced to 81 as trading in some IPOs did not commence at this early stage.

Table 5: Do pre-IPO quotes explain cross- sectional variation in initial returns?

Dependent variable: Initial return

	Full sample		Full sample *and* offer price < upper limit		Daily sample		
Independent variable	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(3c)
Constant	0.122	0.017	-0.027	-0.042	0.032	-0.036	0.039
	(0.99)	(0.28)	(-0.52)	(-1.37)	(0.24)	(-0.45)	(0.36)
log(volume)	-0.037	-0.021	0.004	0.005	0.015	0.008	-0.028
	(-1.34)	(-1.45)	(0.42)	(0.91)	(0.42)	(0.45)	(-1.07)
secondary market	3.792	0.923	0.890	0.107	2.470	0.145	1.165
Volatility	(4.12)	(2.06)	(1.99)	(0.40)	(1.81)	(0.21)	(0.99)
index return	0.991	-0.045	-0.054	-0.116	0.184	-0.229	-0.231
(prior to subscription period)	(5.65)	(-0.54)	(-0.63)	(-1.64)	(0.56)	(-1.44)	(-0.98)
index return	2.228	0.445	0.256	0.076	1.133	0.555	1.263
(during subscription period)	(4.55)	(1.35)	(1.40)	(0.63)	(1.83)	(1.37)	(2.23)
Neuer Markt IPO	0.192	0.038	-0.010	-0.017	0.062	-0.012	-0.010
	(3.49)	(1.32)	(-0.39)	(-0.98)	(0.92)	(-0.37)	(-0.16)
US underwriter	0.065	0.005	0.018	-0.016	-0.092	-0.049	0.036
	(0.71)	(0.08)	(0.61)	(-0.86)	(-0.98)	(-0.95)	(0.37)
Price revision	0.602	0.026	-0.057	-0.062	0.800	0.107	0.254
	(2.83)	(0.25)	(-0.32)	(-0.62)	(3.51)	(0.64)	(1.15)
pre-IPO return		0.997		0.972		1.116	
(last day of subscr. period)		(15.65)		(11.43)		(7.51)	
pre-IPO return							0.712
(1st day of subscription period)							(4.91)
Number of observations	357	357	116	116	112	112	112
Adj. R^2	0.336	0.820	-0.002	0.606	0.147	0.742	0.444
Std. error of regression	0.562	0.293	0.113	0.071	0.341	0.188	0.276

Notes. The Table shows the results of regressing initial returns on variables that, based on previous research, are considered to explain the level of underpricing: the natural logarithm of the issue volume, the secondary market volatility in the 20 days following the IPO, the return on an appropriate stock index, computed separately for the 60 days prior to the subscription period and for the subscription period, and dummy variables for firms that went public on the growth segment Neuer Markt, and for those underwritten by US banks. We also include the pre-IPO return, defined as (midpoint of pre-IPO quotes / offer price – 1) when using the last available quotes or as (midpoint of pre-IPO quotes / offer range midpoint – 1) when using the quotes from the first day of the subscription period. t-statistics (in parentheses) are calculated using heteroscedasticity-consistent standard errors.

Table 6: Location of offer prices relative to the final offer range

< range	at lower end	lower end < < range midpoint	at range midpoint	range midpoint< < upper end	at upper end	> range
Panel A: Full sample (NOB=357)						
11	44	32	10	19	241	–
Panel B: Daily sample (NOB=112)						
8	25	13	4	6	56	–

Table 7: Are offer prices fully adjusted to information contained in pre-IPO quotes?

Dependent variable: Price revision

Independent variable	(1)	(2)	(3)
constant	-0.353	-0.349	-0.117
	(-5.61)	(-5.08)	(-6.98)
log(volume)	0.044	0.044	
	(4.91)	(4.73)	
secondary market volatility	-0.184	-0.173	
	(-0.33)	(-0.32)	
index return (prior to subscription period)	0.184	0.176	
	(1.4)	(1.31)	
index return (during subscription period)	-0.009	-0.014	
	(-0.04)	(-0.06)	
Neuer Markt IPO	0.139	0.138	
	(3.2)	(3.18)	
US underwriter	-0.003	-0.004	
	(-0.06)	(-0.08)	
pre-IPO return (last day of subscription period)	0.938	0.921	1.120
	(7.67)	(5.47)	(8.00)
pre-IPO return × $I_{\text{pre-IPO return} < 0}$		0.056	
		(0.17)	
p(coeff. pre-IPO return = 1)	0.612	0.638	0.390
Number of observations	112	112	112

Notes. With a censored regression we analyze the determinants of price revisions (= offer price / midpoint of offer range – 1). An observation is right-censored if the offer price is equal to the upper end of the offer range. Left-censoring occurs if the offer price is equal to the lower end of the offer range. To determine censoring, we use the final offer range, after any adjustments that occurred during the subscription period; revisions and pre-IPO returns are computed based on the initial range. To test the adjustment of offer prices to information contained in pre-IPO quotes, we examine the coefficient of the pre-IPO return, defined as (midpoint of pre-IPO quotes / midpoint of offer range – 1). t-statistics (in parentheses) are calculated using heteroscedasticity-consistent standard errors