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IPO Pricing with Bookbuilding and a When-Issued Market

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Abstract

We study IPO pricing in Germany to determine whether when-issued trading provides information that is useful for setting IPO offer prices, and whether such trading supplants bookbuilding as a source of information. We find that when-issued trading reveals relevant information for pricing IPOs, and that, once when-issued trading has begun, bookbuilding is not a source of costly information for pricing. But bookbuilding does not appear to be fully supplanted as a source of pricing information. We find evidence consistent with bookbuilding being used to gather information prior to the onset of when-issued trading.

I. Introduction

In an initial public offering (IPO) of shares, the issuer sells securities for which there does not yet exist a secondary market price. The issuer must thus not only market and distribute the shares, but also determine a price at which the issue can be sold. Various types of mechanisms are used to do this. In auctions, investors submit bids, and then securities are priced and allocated according to explicit rules. In bookbuilt offerings, underwriters collect investors' indications of interest, and then exercise discretion in the pricing and allocation of the securities. Apart from this difference, both mechanisms have in common that pricing-relevant information is obtained directly from potential buyers in the primary market.

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Alternatively, information that is needed for setting primary market prices may be revealed through trading in related securities. For some securities, there may even be active forward trading *before* the securities are offered in the primary market. This is the case for auctions of U.S. Treasury securities, in which investors buy and sell the securities in a pre-auction, "when-issued" market. This when-issued market can allow the release of information that may affect investors' bidding strategies in the auction and thus the price(s) at which the securities are sold. In the U.S. there is no market for when-issued trading of IPO shares. Such trading is effectively prohibited by a U.S. securities regulation that restricts the covering of short sales.[1] The stated reason for the short sale restriction is that: "Such short sales could result in a lower offering price and reduce an issuer's proceeds."[2]

In contrast to the U.S., a number of countries in Europe do permit when-issued trading prior to an IPO. Germany, in particular, has a very active when-issued market for IPO shares that operates concurrently with bookbuilding. Benveniste and Spindt (1989) argue that information gathering through bookbuilding is costly: to obtain pricing-relevant information from investors, it may be necessary to pay them informational rents in the form of allocations of underpriced shares. When-issued trading, on the other hand, may provide pricing-relevant information for free because the when-issued prices are publicly observable. In fact, to quote one of the largest market makers in the German when-issued market, "By observing when-issued trading, the underwriter can gauge the market's interest in an IPO."[3] If when-issued trading reveals sufficient information for setting IPO offer prices, then bookbuilding may be used only as a means for distributing IPO shares, and not as a means for obtaining costly information.

The purpose of this paper is to determine whether when-issued trading provides information that is useful for IPO pricing, and whether such trading supplants bookbuilding as a source of information. To answer these questions, we study IPO pricing in Germany. We find that when-issued trading does reveal information that is relevant for setting the IPO offer price. We also find that, once when-issued trading has begun, bookbuilding is not a source of costly information. But we cannot conclude that bookbuilding is *fully* supplanted by when-issued trading as a source of costly information for IPO pricing. We instead find evidence consistent with bookbuilding being used to gather information *prior* to the onset of when-issued trading.

In our analysis we distinguish between bookbuilding activities that take place before and after the opening of when-issued trading. This is possible because when-issued trading begins only after the posting of an indicative range for the IPO offer price.[4] We can therefore analyze the role of bookbuilding after the

[1]Regulation M, Rule 105 prohibits the covering of short positions that were created within the last five days before the IPO, with allocations received in the IPO. In addition, there are restrictions on trading in unregistered shares.

[2]See Paragraph II.F. of the Securities Exchange Act Release No. 38067 (December 20, 1996) on Regulation M, found at the Website, http://www.sec.gov/rules/final/34-38067.txt. Regulation M became effective on March 4, 1997.

[3]This quote was taken from the Website of Schnigge AG, http://www.schnigge.de/info/service/pre-ipo-trading.html.

[4]This is true of all when-issued markets in Europe.

when-issued market opens by following Hanley (1993) and testing for a "partial adjustment phenomenon." Hanley (1993) finds that, for U.S. IPOs, there is a significant positive relation between IPO initial returns and the revision of IPO offer prices from price ranges set some time before IPO pricing. This phenomenon is consistent with informational rents being paid to investors who provide information after the range is set. The partial adjustment phenomenon is also documented more recently in the U.S. IPO market by Bradley and Jordan (2002), Loughran and Ritter (2002), and Lowry and Schwert (2002). In our study, however, we find no evidence of the partial adjustment phenomenon.

The lack of a partial adjustment phenomenon indicates that investors do not receive rents for information provided after the when-issued market opens. Either underwriters do not gather information after when-issued trading begins, or they obtain the information for free through the prices of when-issued trading. Before concluding, however, that when-issued trading *fully* supplants bookbuilding as a source of costly information, we test one more hypothesis: if underwriters can obtain all relevant information for free, then investors should not receive rents for any information. We reject this hypothesis. Our evidence suggests that, prior to the onset of when-issued trading, the underwriter collects information directly from investors in order to set the price range. This information cannot be obtained for free through the when-issued market since this market is not yet open when the range is set. After the market opens, the information is impounded into when-issued prices. We find that IPOs are underpriced relative to when-issued prices, consistent with the notion that investors receive informational rents for information provided prior to the opening of the when-issued market.

We thus provide evidence of the coexistence of two different sources of information for determining IPO offer prices. Underwriters gather information from potential investors *before* posting a price range. When-issued trading, which commences after the range has been posted, provides a further indication of how the IPO should be priced. There is no partial adjustment phenomenon, indicating that investors are not rewarded for providing information *after* when-issued trading commences. However, investors may be rewarded for providing information to underwriters prior to the onset of when-issued trading.

Our findings are directly relevant for European IPO markets in which when-issued trading takes place, but should also be of interest for any market that is considering allowing when-issued trading of IPOs. Our results are consistent with a recent study of European IPOs by Jenkinson and Jones (2004) who examine data from order books that were built after the posting of price ranges and find that while institutional bidders are favored in the allocation of IPO shares, this favorable treatment is not necessarily a reward for information contained in their orders. Jenkinson, Morrison, and Wilhelm (2004) discuss institutional details that are consistent with our evidence of information gathering prior to the range setting. Pichler and Stomper (2004) develop a model that shows how information gathering through bookbuilding can enable informative when-issued trading, and how the structure of bookbuilding is affected by when-issued trading.

Our paper extends the existing literature on IPO pricing, and underpricing, by investigating information gathering in a market with a different institutional framework than that in the U.S. Cornelli and Goldreich (2001) examine book-

building by a European investment bank and find that investors who post more informative bids earn higher average profits, since they receive more favorable allocations of IPO shares. Ljungqvist and Wilhelm (2003), who use data from Europe and the U.S., find a linkage between IPO allocations, price revisions, and underpricing that is consistent with the theory of Benveniste and Spindt (1989).

Our paper is also related to the literature on when-issued markets. Bikchandani and Huang (1993) describe the when-issued market for U.S. Treasury securities, and discuss the concern that traders who plan to bid in Treasury auctions will be loath to reveal positive information in when-issued trading. Bikchandani and Huang (1992) and Nyborg and Sundaresan (1996) provide evidence consistent with this concern, although Nyborg and Sundaresan show that this is less of a concern for uniform price auctions, as compared to discriminatory price auctions. Löffler, Panther, and Theissen (2002) examine the when-issued market for German IPOs and find that the final prices in this market are unbiased predictors of opening prices in the secondary market. Our study differs from theirs in that we focus on the pricing of IPOs and on the interaction of bookbuilding and when-issued trading.

The paper is organized as follows. Section II provides a description of key institutional aspects of the German IPO market and of when-issued trading in other countries. In Section III, we describe our data. In Section IV, we develop a number of hypotheses on IPO pricing in the presence of bookbuilding and when-issued trading. In Section V, we present, through the use of summary statistics, an overview of IPO pricing relative to price ranges and when-issued trading prices. In Section VI, we develop and test a model of IPO pricing with a when-issued market. In Section VII, we analyze initial returns and also present our methodology for testing for a partial adjustment phenomenon in the presence of binding price ranges. Section VIII concludes.

II. Institutional Characteristics of the German IPO Market

The Frankfurt Stock Exchange (FSE) is by far the largest stock exchange in Germany. Most German IPOs have been listed on one of the FSE market segments: the Official Market (Amtlicher Handel, or first segment), the Regulated Market (Geregelter Freiverkehr, or second segment), or the Neuer Markt (German for "new market"). Table 1 presents the number of IPOs in each of these market segments from the beginning of 1999 through the end of 2004. During 1999 and 2000, the Neuer Markt accounted for more than 80% of all German IPOs. The FSE recently closed the Neuer Markt in a reorganization of its market segments, but this does not affect the relevance of our study.[5] As described below, the German IPO market continues to be characterized by bookbuilding and when-issued trading.

IPO Pricing through Bookbuilding. As in the U.S., most companies in Germany are taken public using a bookbuilding procedure. All but 10 of the IPOs listed in

[5]The Neuer Markt officially closed on June 5, 2003. Firms previously listed on the Neuer Markt are now part of the Official or the Regulated Market.

TABLE 1

Number of IPOs on the FSE and When-Issued Trading by Schnigge AG

The Frankfurt Stock Exchange (FSE) main market segments are: i) the Official Market (Amtlicher Handel), ii) the Regulated Market (Geregelter Markt), and iii) the Neuer Markt (New Market). The number of IPOs that were priced and sold using bookbuilding are given in parentheses. The number of IPOs traded in the when-issued market (and listed on the FSE thereafter) by Schnigge AG, the major broker in the German when-issued market, are given in brackets.

Year		Official Market	Regulated Market	Neuer Markt	Total
1999	All	27	9	131	167
	(bookbuilt)	(27)	(8)	(131)	(166)
	[when-issued trading by Schnigge]	[20]	[5]	[129]	[154]
2000	All	14	6	133	153
	(bookbuilt)	(14)	(5)	(132)	(151)
	[when-issued trading by Schnigge]	[12]	[5]	[132]	[149]
2001	All	5	5	11	21
	(bookbuilt)	(3)	(4)	(11)	(18)
	[when-issued trading by Schnigge]	[4]	[4]	[11]	[19]
2002	All	1	4	1	6
	(bookbuilt)	(0)	(1)	(1)	(2)
	[when-issued trading by Schnigge]	[1]	[2]	[1]	[4]
2003	All	0	0	0	0
2004	All	3	2	0	5
	(bookbuilt)	(3)	(2)	(0)	(5)
	[when-issued trading by Schnigge]	[3]	[2]	[0]	[5]
Total	All	50	26	276	352
	(bookbuilt)	(47)	(20)	(275)	(342)
	[when-issued trading by Schnigge]	[40]	[18]	[273]	[331]

Sources: Factbooks of the Deutsche Börse AG and home page of Schnigge AG (http://www.schnigge.de/).

Table 1 were priced and marketed using bookbuilding methods. The remaining 10 were fixed price offerings.

The German bookbuilding procedure is similar to that used in the U.S., but with some differences: i) In both countries, a preliminary price range is posted some time before the final pricing of the IPO shares. In the U.S., there is considerable variation in the time between the posting of the initial range and the pricing of the IPO. In Germany, there is very little variation; the initial range for a German IPO is typically set about one week prior to IPO pricing. ii) Underwriters may conduct discussions with prospective investors before setting the price range. Thus, the kind of information gathering that happens through U.S.-style bookbuilding may already begin prior to the filing of the price range.[6] iii) Bookbuilding officially begins in Germany only after the filing of the price range. This "official" bookbuilding period is also referred to as the "subscription period." During this period, investors submit binding orders for IPO shares.[7] iv) In Germany, underwriters almost never amend price ranges, whereas in the U.S. range amendments are quite common. v) U.S. issues are frequently priced outside the final price ranges, but this is very rare for German IPOs. During 1999 and 2000, some Neuer Markt issues were priced below the range, but none were priced above. This characteristic of IPO pricing in Germany is discussed further in Section V.

[6]Jenkinson, Morrison, and Wilhelm (2004) argue that this constitutes a difference between IPO pricing in Europe and the U.S. In the U.S., the 1933 Securities Act discourages underwriters from contacting investors prior to the filing of a registration statement.

[7]Orders are binding only after the end of the subscription period; investors can amend their orders during this period.

When-Issued (Grey Market) Trading. In Germany, when-issued trading of IPOs started in the early 1980s. The when-issued market is a forward market for IPO shares that is commonly referred to as the "grey market." Prior to 1998, this market operated as an interbank market via telephone; since then online trading platforms have been implemented, leading to increased participation of retail investors in trading. However, when-issued trading remains over-the-counter trading that takes place off exchange.

All transactions in the grey market are contingent on whether an IPO takes place. Traders' grey market positions are declared void if an IPO is withdrawn or postponed by more than seven days. Otherwise, transactions are concluded by physical delivery of IPO shares one or two days after the first day of secondary market trading.

Grey market trading is organized by independent brokers, whose quotes are disseminated via various channels, including Reuters and the brokers' own Web pages, but binding quotes can only be obtained directly from the brokers. The first quotes are typically set by the brokers after consulting other market participants. Thereafter, quotes are usually posted continuously every day from 8:00AM to 11:00PM. During 1999 and 2000, three brokers handled most of the trading: Börsenmakler Schnigge AG, Lang & Schwarz Wertpapierhandel AG, and Berliner Freiverkehr AG. These brokers are so-called "securities trading firms" with a license from the German Federal Banking Supervisory Office.

Both retail and institutional traders participate in the grey market. Members of an IPO's underwriting committee are precluded from trading since they are regarded as "insiders" according to paragraph 14 of the German Securities Trading Act. Retail traders are also typically precluded from taking short positions, which implies that the institutional traders must be net short in aggregate.[8] Indeed, Schnigge AG reports on their Website that short-sellers are typically institutional investors who can count on receiving share allocations in the primary market.[9]

Trading in the grey market begins only after the filing of the price range, and ends on the day before the start of secondary market trading of IPO shares. During this period, trading volume typically increases as the offer date approaches, reaching a level roughly comparable to that of secondary market trading. Table 1 compares the number of IPOs listed on the Frankfurt Stock Exchange with those for which Schnigge AG acted as a market maker in the grey market. The table shows that there was a when-issued market for virtually all IPOs on the Neuer Markt. In addition, when-issued trading of IPOs in Germany has continued beyond the closure of the Neuer Markt.

When-Issued Trading in Other IPO Markets. Other European countries besides Germany also have when-issued markets for IPO shares. These markets bear a striking similarity in the timing of market opening. Across these markets, when-issued trading opens only after underwriters announce preliminary price ranges, giving the traders an indication of how IPO shares will be priced in the primary

[8]See Dorn (2003) for evidence that retail investors are long in the grey market.

[9]This indicates that at least some of the sellers in this market are not really going short, in so far as they expect to cover their sales with IPO allocations.

market.[10] As discussed below, this institutional feature of when-issued trading is central to the interpretation of our empirical findings.

Other European when-issued markets differ from the German market in the nature of the contracts traded. In Germany, when-issued trading is typically in forward contracts that specify physical delivery. In the U.K. when-issued market, it is common to buy IPO shares at a specified markup over the (as of yet unknown) offer price, with cash settlement instead of physical delivery. The German IPO market also stands out in that almost all IPOs are traded on a when-issued basis. In other countries, this is not the case. According to Cornelli, Goldreich, and Ljungqvist (2004), the second most active when-issued market for IPOs is that of Italy, where only 46% of the IPOs between November 1995 and December 2002 were traded. In France (October 1997–December 2001) and the U.K. (June 1997–July 2002), when-issued trading took place for only 4% of the IPOs.

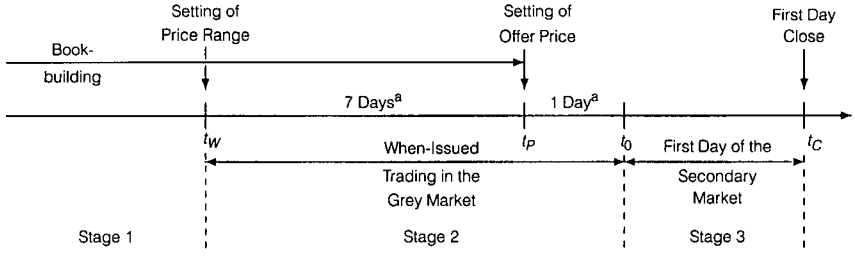
As discussed in the Introduction, when-issued trading of IPO shares is not permitted in the U.S. It is possible, however, to bet on the outcome of an IPO. For example, the Iowa Electronic Market (IEM) offered betting contracts on the market capitalization at the end of the first trading day of Google's IPO in 2004. These contracts differed from trading in the German grey market in that they called for cash settlement, in contrast to the requirement of physical delivery in the grey market. One day prior to Google's first trading day the contract price on IEM predicted a first day closing price of $100 for Google shares; the shares closed on the first day at $100.30. Thus, the IEM betting market was a very good predictor of Google's secondary market price.

Timeline. We present in Figure 1 a timeline that will be referred to in the remainder of the paper. In Stage 1, underwriters gather information to use in setting the price ranges prior to the opening of when-issued trading at time t_W. In Stage 2, after time t_W, grey market trading takes place. This trading starts *after* price ranges are posted, and continues beyond time t_P, which is when the underwriter sets the IPO offer price. The grey market closes on the evening before the first secondary market trading day. The opening of the secondary market at time t_0 marks the beginning of Stage 3. The closing price of the first day of secondary market trading is realized at time t_C.

In Germany, the term bookbuilding is used to refer specifically to the process of underwriters collecting investors' orders during the subscription period. By this definition, bookbuilding does not start until after time t_W. Throughout this article, we use the term bookbuilding more as a generic term for how underwriters gather information directly from investors, even if this information gathering happens before time t_W. In our analysis, we differentiate between bookbuilding that occurs prior to the opening of the grey market and bookbuilding that occurs concurrently with grey market trading.

[10] We thank Gary Beechener of Tullett & Tokyo Liberty (securities) Ltd., one of the largest brokers in when-issued markets for European IPOs, for providing this information.

FIGURE 1
The German IPO Pricing Process



[a]Median number of trading days during the years 1999 and 2000.

III. Data

We collect data for all IPOs that began trading on the Neuer Markt between January 1999 and December 2000. As shown in Table 1, these are the two years in which the Neuer Markt IPO market was most active: 131 firms went public on the Neuer Markt in 1999 and 133 in 2000. The years 1999 and 2000 are regarded as a hot market period for IPOs. Ljungqvist and Wilhelm (2003) and Loughran and Ritter (2004) find that even after controlling for many firm-specific characteristics, such as firm age and whether the firm is in a high-technology industry, initial returns are significantly positively related to whether a firm went public during the 1999–2000 period. While some of our quantitative results may be affected by this relation, we do not expect that it affects our qualitative results regarding the roles of bookbuilding and grey market trading in IPO pricing.

Exclusions. We drop from our sample one IPO that was a fixed price offering and six IPOs that took place simultaneously on the Neuer Markt and another exchange. We exclude the latter six observations because the pricing of these IPOs may involve information gathering in markets for which we have no data. In addition, the three IPOs in January 1999 are excluded from our regressions since the data for these IPOs are used to measure primary market conditions prior to February 1999. We thus obtain a final sample of 254 IPOs, all of which feature when-issued trading of IPO shares.

Data Sources. Data are obtained from Deutsche Börse AG (primary market data), Reuters, Thomson Financial-Datastream, and Karlsruher Kapitalmarktdatenbank (secondary market data), as well as from one of the most important market makers in the grey market, Schnigge AG (prices of grey market trading). In the regressions involving data on when-issued trading, we use the price of the last *transaction* before the pricing date t_P of each IPO. To obtain these data, we asked Schnigge AG to search their archive of transaction records. For 14 IPOs, we could not obtain such price data. For these IPOs, we use the last mid-quotes (mean of the bid and ask quotes) posted before the pricing date.

To our knowledge, our data set is the only one with prices of actual transactions in the German grey market just before IPO pricing for such a large sample of IPOs. We lack corresponding volume data that would enable us to to detect price

effects of large transactions. However, we can check whether there is a systematic difference between the grey market prices and the prices at which trading opens in the secondary market. To this end, we regress these opening prices on the grey market prices. We find that the latter prices are unbiased predictors of the former prices.[11]

For the industry classification of Neuer Markt IPOs, we draw on the industry description in the prospectus and on the NEMAX (Neuer-Markt-Index) industry classifications. We split our sample into groups of IPOs by high technology and non-high technology issuers, as well as Internet and non-Internet issuers. Each IPO is assigned to two groups. For example, IPOs of Internet retailers are classified both as non-high technology and as Internet issuers. To identify high technology issuers, we use the high technology industry description in Appendix 4 of Loughran and Ritter (2004). High technology issuers are in the businesses of computer hardware, communications equipment, electronics, navigation equipment, measuring and controlling devices, medical instruments, telephone equipment, communications services, and software. IPOs are classified as Internet IPOs if the NEMAX industry classification is "Internet."

Descriptive Statistics on the Size of Issues and Issuers. As shown in Table 2, 71% (181 out of 254) of the IPO firms on the Neuer Markt during 1999 and 2000 were in high technology industries. These firms account for about 68% of the IPO Euro volume. Twenty-one percent (54 out of 254) of IPO firms were Internet firms; they account for about 34% of the Euro volume. During the same time period, about 60% of the IPO firms on the Nasdaq market were high technology firms (51% by dollar volume), and about one-half were Internet firms (49% by dollar volume).[12]

Table 2 also presents statistics on the fraction of issuers' stock sold at the IPO. Firms listing on the Neuer Markt sell, on average, about 28% of their shares at the IPO. In comparison, during the same period Nasdaq IPO firms sold about 22% of their shares. The markets are similar in that, in both markets, Internet firms sell a somewhat smaller fraction of their equity than do non-Internet firms (24.6% versus 29.1% on the Neuer Markt, 19.7% versus 24.2% on Nasdaq).

IV. IPO Pricing in the Presence of When-Issued Trading: Economic Arguments and Hypotheses

In this section, we discuss the theoretical basis for our empirical analysis. Subsection A presents the motivation for our research questions. Our strategy for analyzing these questions is illustrated by means of a numerical example in subsection B. In subsection C, we present three hypotheses that will be tested in Sections VI and VII.

[11]The results of this regression may be obtained from the authors.

[12]Nasdaq high technology issuers are identified using the SIC codes as described in Appendix 4 of Loughran and Ritter (2004). To identify Internet IPOs, we use the list of Internet IPOs provided by Jay Ritter, http://bear.cba.ufl.edu/ritter/ipodata.htm. The average value of one Euro during the years 1999 and 2000 was U.S.$1.012.

TABLE 2

Issue Size and Fraction Sold

Summary statistics for IPOs on the Neuer Markt from February 1999 through December 2000. High tech firms satisfy the high tech industry description in Appendix 4 of Loughran and Ritter (2004). IPOs are defined as Internet firms if the NEMAX industry classification is Internet. Issue size is the offer price times the number of shares sold at the IPO, not including the greenshoe option. Fraction sold is 100% × the number of shares sold at the IPO divided by the number of shares outstanding, not including any shares issued under the greenshoe option.

	Total	High Tech	Non-High Tech	Internet	Non-Internet
Issue Size (million Euros)					
Mean	69.8	66.3	78.7	112.9	58.2
Std. Dev.	171.4	186.1	127.0	342.3	73.1
Median	39.0	39.9	36.7	45.4	37.9
Minimum	8.0	8.0	9.5	9.5	8.0
Maximum	2,489.4	2,489.4	790.5	2,489.4	790.5
Total	17,741	11,992	5,749	6,096	11,645
	100.0 %	67.6 %	32.4 %	34.4 %	65.6 %
Fraction Sold (%)					
Mean	28.1	28.6	26.9	24.6	29.1
Std. Dev.	8.0	8.0	7.7	5.0	8.4
Median	26.5	26.6	26.5	24.2	27.9
Minimum	6.1	9.2	6.1	9.2	6.1
Maximum	66.7	66.7	46.0	35.9	66.7
No. of IPOs	254	181	73	54	200

A. The Research Questions

In bookbuilding, underwriters gather information directly from investors. As described in the Introduction, doing so may require the issuer to pay rents for the information. If, however, investors trade in the grey market, then their information can be publicly revealed through the prices in this market. Grey market trading therefore represents a potentially valuable source of free information for IPO pricing. But, this does not necessarily imply that the trading can supplant bookbuilding as an indicator of how IPOs should be priced. For a number of reasons, grey market trading may not be able to open on its own. First, prospective sellers may stay out of the market because of the possibility of a "squeeze." In the when-issued market for Treasury securities, a squeeze can occur if short-sellers in the when-issued market are not awarded securities in the auction (see Bikhchandani and Huang (1993), Nyborg and Sundaresan (1996), and Chatterjea and Jarrow (1998)). If bookbuilding precedes grey market trading, however, then some investors may already be confident that they will be allocated IPO shares, thus lessening the fear of squeezes.

A second reason for when-issued trading to fail is adverse selection risk. Glosten and Milgrom (1985) show that informational asymmetries across traders can induce market makers to quote spreads so wide that no trading occurs. The posting of the price range at time t_W, however, may mitigate this problem. The price range can reveal information that decreases informational asymmetries and, hence, enables the when-issued market to open.[13] Thus, it is possible that bookbuilding is an important source of information for IPO pricing, even if grey mar-

[13]This view is consistent with the fact that when-issued trading commences only after the range has been posted. Pichler and Stomper (2004) demonstrate how engaging in direct information gathering, prior to when-issued trading, can enable informative when-issued trading as a positive externality of bookbuilding.

ket prices subsequently reveal all of the information that can be obtained through bookbuilding. Whether grey market trading does reveal such information, and whether such trading supplants bookbuilding as a source of such information, are empirical questions that we address in this paper.

B. Numerical Example

We present a very simple numerical example in order to motivate the methodology of our empirical analysis. In this example, there are two IPOs, each of which has a prior expected value of 10 per share (the units do not matter). To price the IPOs, information is obtained directly from an informed investor. This investor's information set includes that of the underwriter (the prior), as well as additional private information. For the first IPO, the investor expects a value of 18 per share; for the second IPO, the investor expects a value of 14 per share. The pricing of the IPOs also depends on publicly observable information, such as market factors, that is realized just before the offer price is set. It is, of course, only *new* public information that will further affect the IPO offer price, that is, information that is uncorrelated with the informed investor's report. For each IPO in the example, this new information happens to add a value of 2 per share, so that the first IPO is worth 20 per share and the second is worth 16 per share. We assume that these values are equal to the prices at which the IPO shares will trade in the secondary market.

Consistent with Benveniste and Spindt (1989), we assume that in order to induce truthful reporting on the part of the informed investor, the underwriter commits to allocate underpriced shares to the investor if she reports positive private information. We will assume that the underwriter leaves 1/4 of the value of the informed investor's information on the table, and that the offer price fully takes into account all other information, i.e., the realizations of the market factors.[14] Thus, the first IPO is underpriced by 2 (=(18 − 10)/4) and the second by 1 (=(14−10)/4), which results in offer prices of 18 (=20−2) and 15 (=16−1) for the first and the second IPO, respectively. The following table summarizes this information. The initial return is defined as the secondary market price (value, given all relevant information) minus the offer price. (Note that in our empirical anlaysis we define the initial return as a percent of the offer price. In this example, we present only absolute returns.)

	Value of IPO Shares Given:				
IPO	Underwriter's Prior	Underwriter's Prior & Information from Informed Investor	All Relevant Information	Offer Price	Initial Return
1	10	18	20	18	2
2	10	14	16	15	1

[14]It has been documented that there is also a partial adjustment to public information. We control for this in our empirical work, but ignore it here in the interest of brevity. As long as the new information is uncorrelated with the investor's report, then our example is unaffected by this simplification.

Regardless of whether the underwriter polls the informed investor before or after setting the price range, we assume that the price range is set with the center of the range equal to the expected offer price. Thus, if the underwriter sets the range before obtaining the investor's information, then the center of the price range equals the underwriter's prior expected value of the IPO shares. The following table summarizes the IPO pricing process in this case. The price revision is defined as the difference between the offer price and the center of the price range. The table exhibits the commonly observed "partial adjustment phenomenon"—the higher the price revision, the higher the initial return.

IPO	Range Center	Offer Price	Price Revision	Initial Return
1	10	18	8	2
2	10	15	5	1

If, instead, the underwriter obtains the investor's private information prior to setting the range, then the center of the range is equal to the expected offer price, given the underwriter's prior and the information reported by the informed investor. The range center of the first IPO equals 16 since the underwriter expects a share value of 18 and the shares are to be underpriced by 2. For the second IPO, the range center equals 13 since the expected value of the IPO shares is 14 and the shares are underpriced by 1. In this case, the price revision equals 2 for both IPOs, determined by the realizations of the market factors. We observe no partial adjustment phenomenon, as it is defined above.

IPO	Range Center	Offer Price	Price Revision	Initial Return
1	16	18	2	2
2	13	15	2	1

The above example demonstrates that testing for a partial adjustment phenomenon, as in Hanley (1993), is a valid method to look for evidence that costly private information is gathered *after* ranges have been posted. If costly private information is gathered only prior to posting the ranges, then we should not find a partial adjustment phenomenon of the sort defined by Hanley. This is despite the fact that the offer price is, even in this case, only partially adjusted relative to private information that the underwriter obtains directly from the informed investor.

In our study, we can test for partial adjustment to information, *regardless* of when the information was obtained by the underwriter. This is because the grey market prices can reveal information that the underwriter obtains from investors, regardless of whether the information is obtained before or after the price range is posted. For the two IPOs in the above examples, this implies closing grey market prices of 20 and 16, respectively. As a consequence, there will be a partial adjustment of the IPO offer prices with respect to prices in the grey market, irrespective of how the price ranges are set.

In our analysis, we employ two different methods to search for evidence that underwriters gather information from investors in exchange for informational rents. i) We test for a partial adjustment phenomenon, as in Hanley (1993), in

order to look for evidence of such information gathering after the ranges are set. ii) We test for a partial price adjustment relative to the prices in the grey market in order to look for evidence that underwriters gather costly information at any time prior to setting the offer price.[15]

C. Hypotheses

Our hypotheses follow from the above discussion. In this section, we present the hypotheses in a general form. In Sections VI and VII, where we present our econometric analysis and results, we refine the hypotheses in order to address specific characteristics of the data.

The first hypothesis concerns the question of whether underwriters gather costly information from investors *after* setting price ranges, and thus after the onset of when-issued trading. As illustrated in the numerical example, such information gathering should result in a partial adjustment phenomenon. We should thus reject the null hypothesis that there is full adjustment of IPO pricing for any information that underwriters receive after setting price ranges:

H_{REV}. After controlling for public information, the IPO offer price revision from the price range has a coefficient of zero in a regression explaining the initial return.

Following Hanley (1993), initial returns are defined as the percent difference between the first day secondary market closing price and the IPO offer price; the IPO offer price revision is the percent difference between the IPO offer price and the center of the price range. We control for public information, such as recent returns on various market indices, so that our results will not be driven by a partial adjustment of IPO prices with respect to such information.

If bookbuilding plays an informational role after the opening of grey market trading, then we should reject hypothesis H_{REV} in favor of the alternative hypothesis that the coefficient is greater than zero. We should point out that this hypothesis is really a joint hypothesis as rejection of the null hypothesis depends on both i) whether underwriters receive information from investors who participate in bookbuilding after time t_W, and ii) whether the investors receive informational rents. It is possible that underwriters receive informative orders from investors after time t_W, but informational rents need not be paid since the information is simultaneously revealed through grey market trading.[16]

As the numerical example illustrates, even if we cannot reject hypothesis H_{REV} this does not mean that investors are not rewarded for providing the underwriter with information. It may simply be that such information is gathered by the underwriter before the price range is set (and before grey market trading opens). To test this hypothesis, we proceed in two steps. We first check whether grey market trading reveals information of relevance for IPO pricing. If it does, then we should be able to reject the following null hypothesis:

[15]The price ranges are the first publicly available information released during the IPO pricing process. Some studies use nonpublic bookbuilding data from the *official* bookbuilding period, i.e., the subscription period in which investors submit bids. In Germany, this occurs *after* the range has been posted. As a consequence, these studies do not test for informational rents being paid for information that underwriters obtain from investors before setting the price ranges.

[16]We thank Michel Habib for pointing this out.

H^{Inf}_{GREY}. After controlling for other public information, the grey market return (defined below) has a coefficient of zero in a regression explaining the IPO offer price revision from the price range.

The grey market return is defined as the percent difference between the price of the last transaction in the grey market before the IPO offer price is set and the center of the price range. We again control for public information other than the grey market return. We do this in order to test whether grey market trading reveals information beyond what is otherwise publicly available. If so, then we should reject the null hypothesis in favor of the alternative that the coefficient is greater than zero. If we reject the hypothesis H^{Inf}_{GREY}, then we can test whether IPO offer prices are fully adjusted with respect to this information. Our next hypothesis is thus:

H^{Adj}_{GREY}. After controlling for other public information, the grey market return has a coefficient of one in a regression explaining the IPO offer price revision from the price range.

The alternative to this hypothesis is that the coefficient is less than one, i.e., the IPO offer price is underrevised with respect to information revealed through grey market trading.[17] If so, then buyers in the primary market earn returns that can be interpreted as informational rents. Rejection of hypothesis H^{Adj}_{GREY} is thus consistent with underwriters gathering costly information from investors at *some* time prior to pricing the issue. This result alone would not tell us whether underwriters gather such information before or after posting price ranges. However, if hypothesis H^{Adj}_{GREY} is rejected and hypothesis H_{REV} is not (i.e., informational rents are paid for information gathered at some time prior to pricing the issue, and no partial adjustment can be observed after the range is set), this would be consistent with underwriters gathering costly information only prior to setting price ranges.

V. Patterns of IPO Pricing Relative to Price Ranges and Grey Market Prices

In this section, we discuss patterns in the pricing of IPOs relative to price ranges and the prices at which IPO shares are traded in the grey market. Table 3 presents data on the distribution of the IPO offer prices and the last grey market prices before the offer price is set, relative to the price ranges. The mean value of the range center (midpoint between the range minimum and maximum) is Euro 22.10 and the standard deviation is Euro 11.60. The mean value of the range width, as a percent of the range center, is 17.4%, with a standard deviation of only 5.5%.[18]

Table 3 shows a striking pattern in IPO pricing: no IPO in our sample is priced above the range maximum and 70% have an offer price equal to the maximum. Thus, the price ranges appear to be effectively binding at the upper end.

[17] We use the term "underrevision" in order to distinguish this phenomenon from "partial adjustment," as defined above.

[18] Most Nasdaq IPOs during 1999 and 2000 had initial price ranges of $10 to $12. U.S. firms often undergo stock splits prior to going public, so as to manage the stock price.

TABLE 3

Offer Prices and Grey Market Prices Relative to Ranges

Table 3 shows the distribution of IPO offer prices (offer) and the last grey market prices before the offer price is set (grey) relative to the price ranges. The price ranges are characterized by the range maximum (max) and minimum (min).

	Number of IPOs (percent of subsample)				
	offer < min	offer = min	min < offer < max	offer = max	Total
grey < min	7 (50.0%)	5 (35.7%)	2 (14.3%)	0 (0%)	14 (100%)
min ≤ grey < max	2 (3.8%)	18 (34.0%)	30 (56.6%)	3 (5.7%)	53 (100%)
grey ≥ max	0 (0%)	2 (1.1%)	11 (5.9%)	174 (93.0%)	187 (100%)
Total	9	25	43	177	254
Percent of sample	3.5%	9.8%	16.9%	69.7%	100%

Moreover, the ranges seem to define focal points for IPO pricing. About a quarter of the IPOs that are priced strictly within the range have an offer price equal to the range center; 10% of the IPOs are priced exactly at the lower end of the range. Unlike the upper end of the range, however, the lower end does not constrain IPO pricing as there are IPOs for which the offer price is strictly below the range.

Of the IPOs that traded in the grey market above the price range just before IPO pricing (grey ≥ max in Table 3), 93% had an offer price exactly equal to the range maximum. Similarly, the majority of IPOs that traded within the range were priced within the range at the offer, and most (86%) of the IPOs that traded strictly below the range minimum were priced at or below this minimum. Thus, it appears that the grey market provides an indication of how IPOs should be priced in the primary market. The use of this information, however, is limited by the constraint that IPOs are never priced above the range maximum.

The practice of not pricing IPOs above the range maximum appears to be the result of an implicit commitment on the part of the underwriters, rather than an explicit commitment. We find no case of an explicit contractual or legal requirement that prevents underwriters from pricing IPOs strictly above the price range. However, we have been told by underwriters that investors in the German IPO market expect their orders to be binding only if the IPO offer price is set below (or equal to) the range maximum. As described in Section II, investors submit orders to purchase IPO shares during the subscription period, after the price range has been published in the prospectus. Many of these orders are market orders, i.e., they do not contain explicit limit prices. However, investors expect that these market orders will not be filled at prices above the ranges, and underwriters are thus concerned that doing so will expose them to legal actions.[19] Underwriters are not as concerned about pricing an IPO below the range minimum, because investors would find it difficult to argue in court that their orders were meant to be filled only at sufficiently high prices. Underwriters could avoid potential legal problems by obtaining new confirmations of all investors' orders before setting an offer price above the range. This, however, is perceived as too costly, and thus a ceiling is effectively placed on the IPO offer price.[20] This feature of the German

[19]The wording of the issue prospectus in Germany is also somewhat different than in the U.S. While not definitively commiting to not price above the range, the wording implies that investors can expect the offer price to be within the range.

[20]Due to the expectations discussed above, underwriters feel compelled, before pricing above the range, to give retail investors an opportunity to change their orders. Doing so could result in a post-

IPO market is in sharp contrast to the U.S. IPO market where IPOs are frequently priced strictly above the range, and so investors cannot reasonably expect an IPO to be priced within the range.

The constrained nature of IPO pricing causes our data set of IPO offer prices to be "right-censored." For a large number of our IPOs (174 out of 254), the grey market price is at least as high as the top of the range and the offer price is exactly equal to the top of the range. For these IPOs, we know only that if there were no constraint on the pricing, the offer price would be somewhere in the interval [range maximum, ∞). To take this into account in our empirical analysis, we have to employ suitable econometric techniques as described below. In the remainder of the paper, we refer to these 174 IPOs as "constrained" IPOs; the remaining 80 IPOs are referred to as "unconstrained."

Panel A of Table 4 presents statistics on the percentage by which underwriters deviate in IPO pricing from the last grey market price prior to the pricing date. On average, IPO shares are offered at prices about 22% below the grey market. This is not very surprising, given the underwriters' policy of not pricing above the price ranges. Yet, on average, even unconstrained IPOs are priced significantly (4.5%) below the grey market. Panel B of Table 4 provides statistics on the initial returns of our sample of IPOs, defined as the percent difference between the first day secondary market closing price and the IPO offer price. Across all IPOs in our sample, the mean initial return is 46.5%; the median is 19.5%. In comparison, Loughran and Ritter (2004) report for the years 1999 and 2000 a mean (median) initial return of 65.0% (32.3%) for IPOs in the U.S. For the subsample of IPOs with constrained offer prices, the average initial return is 67.1%. For IPOs with unconstrained offer prices, the average initial return is only 1.7%.

TABLE 4

IPO Underpricing and Pricing Relative to Grey Market Prices

IPO pricing relative to grey market prices (Panel A) is the percent difference between the offer price and the last grey market price prior to the pricing date. Initial returns (Panel B) are the percent difference between the secondary market closing price on the first day of trading and the offer price. Constrained IPOs satisfy two criteria: i) the offer price is equal to the upper bound of the price range, and ii) a price at least as high as this was paid for shares in the grey market just prior to the pricing date. All other IPOs are unconstrained.

	Total	Unconstrained IPOs	Constrained IPOs
Panel A. IPO Pricing Relative to Grey Market Prices			
Mean	−21.82	−4.51	−29.78
Std. Dev.	21.40	9.69	20.61
Median	−16.23	−2.63	−25.95
Minimum	−79.84	−29.27	−79.84
Maximum	26.32	26.32	0.00
Panel B. Initial Returns			
Mean	46.48	1.68	67.07
Std. Dev.	71.70	14.75	77.88
Median	19.46	0.38	38.01
Minimum	−30.00	−30.00	−13.00
Maximum	444.44	63.00	444.44
No. of IPOs	254	80	174

ponement of the IPO, with a consequent loss to the underwriter's reputation. We thank Alexandra Wolfram from Merrill Lynch's office in Frankfurt for the opportunity to discuss this with practitioners.

VI. Regression Analysis: IPO Pricing

In our regression analysis, we first model the IPO pricing process and test hypotheses H^{Inf}_{GREY} and H^{Adj}_{GREY}. Next, in Section VII, we model the underpricing and test the hypothesis H_{REV}. We follow this order because the results of the pricing analysis will be used as inputs for the initial returns analysis.

A. Econometric Model of IPO Pricing

Before testing hypotheses H^{Inf}_{GREY} and H^{Adj}_{GREY}, we need to develop a model of IPO pricing as a function of publicly available information other than the grey market prices. We then expand the model in order to test hypothesis H^{Inf}_{GREY}. If we reject this hypothesis, indicating that grey market prices reveal additional information for IPO pricing, then we can test whether IPO offer prices are fully adjusted to such information, as specified in hypothesis H^{Adj}_{GREY}. Rejection of this hypothesis is consistent with investors receiving informational rents for information provided at some time prior to pricing the issue, as illustrated by the example in Section IV.

In developing our basic model of IPO pricing, we build on prior theoretical and empirical research. Much of this research refers to IPO underpricing, rather than pricing, but it provides us with inspiration for developing a model of IPO pricing based on publicly available information. Our set of explanatory variables includes proxies for market conditions prior to each IPO, as well as signals of issuers' own information about the value of IPO shares. For the latter, we focus on two signals that are commonly mentioned in the literature: the fraction of an issuer's outstanding shares sold at the IPO and the choice of underwriter. The first of these variables is motivated by Leland and Pyle (1977) who suggest that issuers can signal that they are of higher quality through self-financing. The second is inspired by Titman and Trueman (1986) who argue that an underwriter with a better reputation is better able to certify the quality of an issue. Thus, underpricing should be lower with a more reputable underwriter.[21] Translating this to a pricing model, we would expect the price adjustment to be larger.

As a proxy for underwriter reputation, we use the share of total IPO volume (in Euros) for which an underwriter acts as lead manager. We deviate from the common practice with U.S. data of using rankings, such as those developed by Carter and Manaster (1990), because no such rankings are available for many of the underwriters on the Neuer Markt. The idea behind the market share measure is that a high market share commits underwriters to honor implicit contracts between themselves and investors. To measure underwriters' market shares, we construct the variable *UMSHARE* as described in Appendix A.

We also control for effects of market conditions on IPO pricing, consistent with the findings of prior studies that initial returns are positively related to both the recent secondary market performance and the average initial returns of recent IPOs (see, e.g., Bradley and Jordan (2002), Loughran and Ritter (2002), and

[21] The empirical evidence regarding the effect of underwriter choice on IPO underpricing, however, is mixed. Carter and Manaster (1990), Booth and Chua (1996), and Lowry and Schwert (2002) all find that initial returns are negatively related to proxies for underwriter reputation. Using only data from the 1990s, Beatty and Welch (1996) and Habib and Ljungqvist (2001) find a positive relation.

Lowry and Schwert (2002)). To measure secondary market conditions, we use the return of the Neuer Markt All Share Index during the period between setting the price range (at t_W) and setting the offer price (at t_P); this variable is denoted as $IX_{t_W \to t_P}$. To obtain indices for primary market conditions, we compute for each IPO in our sample the average initial returns of "similar" IPOs on the Neuer Markt (NM) and Nasdaq (NQ) that occurred during the period $t_W \to t_P$ and during the two-month period before the range is set, denoted as $t_W - 2m$. IPOs are regarded as similar if they have the same industry classification (e.g., high tech *and* Internet). The resulting indices are denoted as IR^{market}_{period}, where $period \in \{t_W \to t_P, t_W - 2m\}$ and $market \in \{NM, NQ\}$. The construction of these indices is further described in Appendix B. We also include two measures for IPO activity: $N^{NM}_{t_W \to t_P}$ ($N^{NM}_{t_W - 2m}$) denotes the number of similar IPOs on the Neuer Markt during the period $t_W \to t_P$ ($t_W - 2m$).[22] Finally, we include industry indicator variables in order to control for differences in the pricing of IPOs across different industries.

We estimate the following basic model of the price revision from the range to the offer price,

$$(1) \qquad PREV = f(UMSHARE,\ FSOLD,\ I_{industry},\ primary\ \&\ secondary\ market\ conditions) + \varepsilon_1.$$

The dependent variable, *PREV* (price revision), is defined as 100% × (offer price − range center)/range center. Table 5 presents the exact definitions of all of the explanatory variables.

TABLE 5

Variables for IPO Pricing Model

UMSHARE	Underwriter market share (%) (see details in Appendix A)
FSOLD	Fraction of issuer's stock sold at the IPO = 100% × (# of shares sold)/(# of shares outstanding after the IPO, excluding greenshoe)
$I_{INTERNET}$	Dummy variable indicating Internet IPOs
$I_{HIGHTECH}$	Dummy variable indicating high tech IPOs
Primary and Secondary Market Conditions (see details in Appendix B):	
$IX_{t_W \to t_P}$	Return on the Neuer Markt All Share Index after posting of the range and before t_P
$IR^{NM}_{t_W \to t_P}$	Average initial return of Neuer Markt IPOs after posting of the range and before t_P
$IR^{NQ}_{t_W \to t_P}$	Average initial return of Nasdaq IPOs after posting of the range and before t_P
$IR^{NM}_{t_W - 2m}$	Average initial return of Neuer Markt IPOs during the two months before posting of the range
$IR^{NQ}_{t_W - 2m}$	Average initial return of Nasdaq IPOs during the two months before posting of the range
$N^{NM}_{t_W \to t_P}$	Number of Neuer Markt IPOs after posting of the range and before t_P
$N^{NM}_{t_W - 2m}$	Number of Neuer Markt IPOs during the two months before posting of the range
Grey Market Return:	
GREYMKT	100% × (last grey market price before t_P − range center)/range center

In order to test hypotheses H^{Inf}_{GREY} and H^{Adj}_{GREY}, we expand the basic model of equation (1) to include the grey market return,

[22] Booth and Chua (1996) and Benveniste, Ljungqvist, Wilhelm, and Yu (2003) find that initial returns are negatively related to the number of recent IPOs in the same industry.

$$(2) \quad PREV = g(UMSHARE,\ FSOLD,\ I_{industry},\ primary\ \&\ secondary\ market\ conditions,\ GREYMKT) + \varepsilon_2,$$

where *GREYMKT* is the percent difference between the price of the last transaction in the grey market before the pricing of IPOs and the center of the price range.

B. IPO Pricing: Unconstrained IPOs

As discussed in Section V, the IPO offer price is never set above the range maximum. For the IPOs that are constrained by this pricing convention, we cannot directly observe the price that would have been set if the constraint did not exist. Since somewhat complicated econometric modeling is required to deal with this problem, we first present the results of estimating equations (1) and (2) only for the subsample of unconstrained IPOs. In subsection C, we estimate these equations for the full sample of IPOs.

In Table 6, we report ordinary least squares (OLS) estimates of the pricing models for the subset of unconstrained IPOs. Column (1) of Table 6 reports OLS estimates for equation (1), the basic model without the grey market return. Neither the underwriter market share nor the fraction sold at the IPO have significant coefficients. Price revisions, however, are significantly positively related to recent primary market returns, both on the Neuer Markt and on Nasdaq. The results suggest that there are informational spillovers between the German and U.S. IPO markets. For the period between the time of setting the range and setting the offer price ($t_W \rightarrow t_P$), the average initial return of Nasdaq IPOs is significant while that of Neuer Markt IPOs is not.[23] Price revisions are significantly positively related to the average returns of Neuer Markt IPOs during the two-month period prior to the time of range setting ($t_W - 2m$).

Testing Hypotheses H^{Inf}_{GREY} and H^{Adj}_{GREY}. Column (2) of Table 6 reports the estimates for equation (2), the pricing model with the grey market return. We reject hypothesis H^{Inf}_{GREY} as the price revision is significantly positively related to the grey market return (*GREYMKT*). Indeed, the explanatory power of our model substantially increases when we include the grey market return. Thus, when-issued trading does reveal information of relevance for IPO pricing. In fact, the information content of the grey market return seems to swamp that of some of our proxies for primary market conditions.

We also reject hypothesis H^{Adj}_{GREY}. The relation between the grey market return and the price revision is not one-to-one. As indicated by the p-value stated at the bottom of column (2), the coefficient of the variable *GREYMKT* is significantly smaller than one. In column (3), we confirm that this finding is not due to any interaction between this variable and other explanatory variables. Underwriters do not fully revise the pricing of IPO shares relative to information revealed through grey market trading. This underrevision is consistent with both parts of

[23] This may be due to the fact that the Neuer Markt IPO market is sparser than that of Nasdaq.

TABLE 6

Price Range to Offer Price Revision for Unconstrained IPOs

OLS estimates, where the dependent variable *PREV* (price revision) is the percentage revision of the offer price from the center of the price range. The independent variables are as defined in Table 5. Variables with the superscript "+" equal the variables without this superscript whenever these variables take values exceeding their 50th percentile, and equal zero otherwise. The *t*-statistics for robust standard errors are reported in parentheses.

Dependent Variable: $PREV = 100(\%) \times (OFFER - RCENTER)/RCENTER$

	(1)	(2)	(3)
Intercept	−14.033**	−10.660**	−6.087***
	(−2.31)	(−2.48)	(−8.10)
GREYMKT (%)		0.394***	0.385***
		(6.76)	(6.46)
UMSHARE (%)	−0.320	−0.196	
	(−1.22)	(−1.08)	
FSOLD (%)	0.045	0.158	
	(0.30)	(1.55)	
$I_{INTERNET}$	3.772	−6.601*	
	(0.78)	(−1.86)	
$I_{HIGHTECH}$	−2.790	−2.345	
	(−0.88)	(−0.84)	
$I_{HIGHTECH} \times I_{INTERNET}$	−5.965	4.256	
	(−1.06)	(0.98)	
Secondary Market Index:			
$IX_{t_W \to t_P}$ (%)	0.367	0.258	
	(1.48)	(1.37)	
$IX^{+}_{t_W \to t_P}$ (%)	−0.745	−0.634	
	(−1.31)	(−1.46)	
Primary Market Conditions:			
$I\bar{R}^{NM}_{t_W \to t_P}$ (%)	0.007	−0.040	
	(0.08)	(−0.50)	
$I\bar{R}^{NM+}_{t_W \to t_P}$ (%)	−0.024	−0.008	
	(−0.31)	(−0.12)	
$I\bar{R}^{NQ}_{t_W \to t_P}$ (%)	0.167**	0.013	
	(2.30)	(0.17)	
$I\bar{R}^{NQ+}_{t_W \to t_P}$ (%)	−0.110	−0.017	
	(−1.63)	(−0.24)	
$I\bar{R}^{NM}_{t_W - 2m}$ (%)	0.110***	0.098***	
	(2.86)	(3.07)	
$I\bar{R}^{NQ}_{t_W - 2m}$ (%)	0.043	0.009	
	(0.66)	(0.19)	
$N^{NM}_{t_W \to t_P}$	−1.443	−0.723	
	(−1.64)	(−1.12)	
$N^{NM}_{t_W - 2m}$	0.486*	0.176	
	(1.91)	(0.89)	
p: zero coeff. of $IX_{t_W \to t_P} + IX^{+}_{t_W \to t_P}$	0.378	0.251	
p: zero coeff. of $I\bar{R}^{NQ}_{t_W \to t_P} + I\bar{R}^{NQ+}_{t_W \to t_P}$	0.051	0.186	
p: zero coeff. of primary market indices	0.006	0.024	
p: coeff. of *GREYMKT* equals 1		0.000	0.000
F	2.08	8.29	41.76
R^2	28%	58%	41%
No. of observations	80	80	80

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

the example of Section IV: in the first part, issuers leave money on the table in order to pay for information that is obtained after ranges are set (*after* grey market trading begins); in the second part, issuers leave money on the table in order to pay for information that is obtained before ranges are set (*before* grey market trading begins). Thus, we find evidence that is consistent with investors receiving rents for information provided at *some* time prior to IPO pricing. In Section VII, we test for a partial adjustment phenomenon in order to discriminate between rents paid for information obtained before or after when-issued trading commences.

While the results in Table 6 are very clear-cut, we are concerned about a possible selection bias since these results are based on a non-randomly selected subsample.[24] For example, an IPO will be in the unconstrained subsample for one of two reasons: either the information learned after setting the range is not very positive, or the information learned is positive, but the underwriter does not respond to it in setting the offer price. We will discuss this further in the following subsection after we present the empirical analysis of our full sample of IPOs.

C. IPO Pricing: The Full Sample of IPOs

In estimating equations (1) and (2) for the full sample of IPOs, we must take into account the feature that no IPO is priced above the upper bound of its price range. As a further complication, the sizes of the price ranges vary somewhat across IPOs. Thus, the price revision is a right-censored variable, with censoring occurring at different values across the IPOs. We therefore estimate equations (1) and (2) using a generalized TOBIT model that allows for variation in the extent to which prices can be revised. In this analysis, the dependent variable is the *latent* price revision, $PREV^*$, that would be realized if the price ranges did not constrain IPO pricing. For each constrained IPO, we cannot directly observe this variable; instead, we know only that the latent price revision is in the interval $[MAXREV, \infty)$, where $MAXREV$ is the highest possible price revision (from the range center to the upper bound of the price range).

The estimates are reported in Table 7.[25] Column (1) reports estimates for equation (1), the basic model without the grey market return; column (2) reports estimates for equation (2), the model with the grey market return. In Table 7, we also allow for heteroskedasticity conditional on the year of the IPO. Such heteroskedasticity may be due to time variation in the extent of underwriters' information gathering for IPO pricing. (This heteroskedasticity was not present in the unconstrained subsample.)

[24]The unconstrained subsample of IPOs is very similar to the full sample in terms of industry affiliation and the year of the IPO. The two samples differ in that all 47 of the IPOs that experienced negative grey market returns (grey market prices equal to or below the midpoint of the price range) are (by definition) in the unconstrained subsample.

[25]The estimates are obtained using a routine for "interval regressions" (INTREG from the Stata Corporation) that handles both "point" and "interval" data. The point data are the price revisions of the unconstrained IPOs, for which the latent price revision is equal to the actual revision, $PREV^* = PREV$. For constrained IPOs, we only have interval data: $PREV^* \in [MAXREV, \infty)$. Both kinds of data are combined to obtain estimates based on the maximization of a log-likelihood function that is a sum of logs of probabilities of censoring (for constrained IPOs) and logs of densities (for unconstrained IPOs).

TABLE 7

Price Range to Offer Price Revision for All IPOs

Generalized TOBIT regressions, where the dependent variable *PREV** (latent price revision) is the percentage latent revision of the offer price from the center of the price range. For each IPO, the variable is censored at a different point, given by the upper bound of the respective price range. The independent variables are defined in Table 5. Variables with the superscript "+" equal the variables without this superscript whenever these variables take values exceeding their 50th percentile and equal zero otherwise. In estimating these models, we assume multiplicative heteroskedasticity conditional on the year of issue. The *z*-statistics for robust standard errors are reported in parentheses.

Dependent Variable: $PREV^* = 100(\%) \times (OFFER^* - RCENTER)/RCENTER$

	(1)	(2)	(3)
Intercept	−8.523	−11.610***	−0.854
	(−1.21)	(−3.21)	(−1.55)
GREYMKT (%)		0.801***	0.821***
		(14.78)	(16.05)
UMSHARE (%)	0.556	0.083	
	(1.63)	(0.53)	
FSOLD (%)	−0.085	0.169**	
	(−0.44)	(2.12)	
$I_{INTERNET}$	−0.936	−1.887	
	(−0.12)	(−0.50)	
$I_{HIGHTECH}$	−11.143**	−0.282	
	(−2.39)	(−0.13)	
$I_{HIGHTECH} \times I_{INTERNET}$	−5.307	−0.278	
	(−0.61)	(−0.07)	
Secondary Market Index:			
$IX_{t_W \to t_P}$ (%)	1.035**	−0.016	
	(2.47)	(−0.07)	
$IX^+_{t_W \to t_P}$ (%)	−0.849	−0.172	
	(−0.96)	(−0.42)	
Primary Market Conditions:			
$I\bar{R}^{NM}_{t_W \to t_P}$ (%)	0.112	−0.060	
	(1.08)	(−1.50)	
$I\bar{R}^{NM+}_{t_W \to t_P}$ (%)	−0.020	0.071*	
	(−0.23)	(1.74)	
$I\bar{R}^{NO}_{t_W \to t_P}$ (%)	0.138**	0.056*	
	(2.08)	(1.85)	
$I\bar{R}^{NO+}_{t_W \to t_P}$ (%)	−0.038	−0.037	
	(−0.65)	(−1.22)	
$I\bar{R}^{NM}_{t_W - 2m}$ (%)	0.147***	0.046**	
	(3.95)	(1.97)	
$I\bar{R}^{NO}_{t_W - 2m}$ (%)	0.245***	0.064**	
	(3.51)	(2.08)	
$N^{NM}_{t_W \to t_P}$	1.531	−0.431	
	(1.15)	(−0.76)	
$N^{NM}_{t_W - 2m}$	0.427	0.112	
	(1.36)	(0.84)	
Estimation of log(dist. var.)			
Intercept	2.890***	2.501***	2.514***
$I_{YEAR=99}$	−0.255	−1.188***	−1.065***
p: zero coeff. of $IX_{t_W \to t_P} + IX^+_{t_W \to t_P}$	0.760	0.408	
p: zero coeff. of $I\bar{R}^{NO}_{t_W \to t_P} + I\bar{R}^{NO+}_{t_W \to t_P}$	0.010	0.257	
p: zero coeff. of primary market indices	0.000	0.020	
p: coeff. of *GREYMKT* equals 1		0.000	0.000
Wald χ^2	95.12	561.24	257.62
No. of observations	254	254	254

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Testing Hypotheses H^{Inf}_{GREY} and H^{Adj}_{GREY}. The estimates in Table 7 yield the same qualitative results as those in Table 6. As in the last subsection, we reject hypothesis H^{Inf}_{GREY}. The latent price revision $PREV^*$ is significantly related to the price of the last trade in the grey market prior to the pricing date t_P. We also reject hypothesis H^{Adj}_{GREY}. The relation between the grey market return and the price revision is not one-to-one. As indicated by the p-value stated at the bottom of column (2), the coefficient of the variable *GREYMKT* is significantly *smaller* than one. In column (3), we confirm that this finding is not due to any interaction between this variable and other explanatory variables. Overall, the estimates in Tables 6 and 7 support the same qualitative conclusion: when-issued trading of IPOs reveals information of relevance for IPO pricing, but the offer price is not fully adjusted relative to this information.

The most striking difference between the results in Tables 6 and 7 is that the coefficient on the grey market return is much larger with the full sample of IPOs than with the unconstrained subset. As discussed above, there is likely a selection bias in the unconstrained sample. To check how this affects our results, we repeat the regressions of columns (2) and (3) of Tables 6 and 7, allowing for different coefficients for positive and negative grey market returns. The results of Table 7 are unchanged. For the full sample, the relation between price revisions and grey market returns is not nonlinear. For the unconstrained subsample, however, the relation is nonlinear. The coefficients on negative grey market returns are not significantly different from the coefficients in Table 7 (in columns (2) and (3)), but the coefficients on the positive grey market returns of unconstrained IPOs are not significantly different from zero. This is consistent with the selection bias described at the end of Section VI.B: IPOs that are in the unconstrained subsample either had low grey market returns, or the underwriter did not respond to the grey market return in setting the offer price.

Robustness Checks. We conduct two additional robustness checks. First, we check for a possible simultaneity bias in the estimates in Tables 6 and 7. An earlier draft of this paper reports instrumental variables estimates of equations (1) and (2), in which we treat three variables (the choice of underwriter, the fraction of an issuer's shares that are sold at the IPO, and the range center) as endogenously determined in the IPO pricing process. Even though exogeneity is rejected, none of the key results change.

Second, we check whether our results are driven by our treatment of IPO pricing as being right-censored only. In this robustness check, we regard IPO pricing as left-censored for IPOs that were priced exactly at the lower bound of the price range and that had a grey market price strictly below this lower bound. (Keep in mind that there are IPOs in our sample that are priced strictly below this bound.) Again, none of the key results are changed.

VII. Regression Analysis: IPO Underpricing

In the previous section, we present evidence consistent with investors receiving rents for providing information that can be used for setting the IPO offer price. In this section, we model IPO underpricing and test hypothesis H_{REV}. If we reject

this hypothesis, then there is a partial adjustment phenomenon and thus evidence of rents being paid for information that underwriters gather *after* grey market trading commences. If we are unable to reject this hypothesis, then there is no such evidence. In the latter case, we will conclude that the evidence presented in the last section is consistent with informational rents being paid for information that is gathered *prior* to the onset of grey market trading.

A. Underpricing: The Unconstrained IPOs

We begin by testing hypothesis H_{REV} for the subsample of unconstrained IPOs. In doing so, we use a methodology that is similar to that of Hanley (1993). Then, in subsection B, we extend this methodology in order to test hypothesis H_{REV} for the full sample of constrained and unconstrained IPOs.

As with the price revision, it is likely that inital returns can be partially explained by publicly available information, such as recent market returns. Hypothesis H_{REV}, however, refers only to that part of the initial returns that cannot be explained with public information. We thus model initial returns as

$$IR = IR_0 + (1 - \beta) \times i, \tag{3}$$

where IR_0 is the initial return that can be explained by public information and i represents information that the underwriter obtains from investors. $\beta \times i$ is the amount by which the underwriter adjusts the offer price in response to the information i. If the underwriter fully adjusts the offer price, then $\beta = 1$. The term $(1 - \beta) \times i$ represents per share informational rents that are paid to investors in the form of initial returns. As demonstrated in the example of Section IV, if information i is obtained after the range is set, then we can proxy for $\beta \times i$ with $PREV - PREV_0$, where $PREV$ is the actual price revision and $PREV_0$ is the predicted price revision, given public information.[26] Thus, equation (3) may be written as

$$IR = IR_0 + \gamma_U \times (PREV - PREV_0) + \varepsilon_U \tag{4}$$

$$= IR_0 + \gamma_U \times SURP + \varepsilon_U, \tag{5}$$

where $SURP \equiv (PREV - PREV_0)$ denotes the "surprise" component of the price revision, $\gamma_U = (1 - \beta)/\beta$, and ε_U is an econometric disturbance term. Our null hypothesis H_{REV} states that $\gamma_U = 0$; that is, $\beta = 1$ so that no informational rents are paid to investors for any information i that is provided after the range is set. If, instead, rents are paid for such information, then $\beta < 1$. Hence, the alternative hypothesis is that $\gamma_U > 0$.

We present in Table 8 the results of three regressions. In column (1), we present a benchmark analysis in which IR is regressed only on the set of control variables that captures that part of initial returns, IR_0, that can be explained by publicly available information, not including the grey market return, $GREYMKT$. This set of control variables includes the variables defined in Table 5, as well as a risk measure, the log of sales of the issuer ($Log(SALES)$). In column (2),

[26] In the numerical example of Section IV, $\beta = 3/4$, $PREV_0 = 2$, and $i = 8$ and 4 for the first and second IPOs, respectively.

we add the variable *SURP* to the regression in order to estimate equation (5). In calculating the variable *SURP*, we estimate $PREV_0$ using the model of column (1) of Table 6. In column (3), we estimate a standard "partial adjustment" regression similar to that proposed by Hanley (1993). In this column, we replace the variable *SURP* with the actual price revision *PREV* and let the set of control variables proxy for $PREV_0$.[27]

A number of results exhibited in Table 8 are consistent with the findings of prior studies of IPO underpricing. We find that initial returns are positively related to recent secondary market returns, consistent with the findings of Lowry and Schwert (2002), Loughran and Ritter (2002), and Bradley and Jordan (2002) for U.S. markets. Also, consistent with patterns in the U.S. IPO market during the same period of time, we find that non-high tech, Internet firms are underpriced more than other firms.

The most significant difference between the results in Table 8 and the results of previous studies of U.S. IPOs is that we find no partial adjustment phenomenon as defined by Hanley (1993). We are unable to reject the null hypothesis H_{REV} that $\gamma_U = 0$. Thus, we find no evidence that rents are paid for information that is obtained by the underwriter after the range is set and grey market trading commences. This is the case regardless of whether we include the variable *SURP* or the actual price revision, *PREV*, in the regression. In the following subsection, we confirm that this result holds for the full sample of IPOs.

B. Underpricing: The Full Sample of IPOs

When modeling the intitial returns for the full sample of IPOs we must take into account the fact that many of the IPOs are constrained in their pricing. The price revision from the midpoint of the price range to the offer price can be expressed as

$$PREV = \min[PREV^*, MAXREV], \tag{6}$$

where *PREV* denotes the *observed* price revision (the percent difference between the offer price and the center of the price range), *MAXREV* is the maximum possible price revision (the percent difference between the top and the center of the price range), and $PREV^*$ is the *latent* price revision that would result if the underwriter were able to set the offer price above the top of the price range.

For unconstrained IPOs, $PREV^* = PREV$; that is, the observed price revision equals the latent price revision. For constrained IPOs, we are unable to directly observe the latent price revision, and so we draw on the results of our prior analysis in order to estimate the latent price revision. As demonstrated in Section VI.C, the grey market prices are highly significant predictors of IPO pricing, containing not only public information but also information for which investors may receive informational rents. We therefore use the model in column (2) of Table 7 to com-

[27]The model in column (2) can be seen as a restricted version of that in column (3), with the restriction that the coefficients of *PREV* and $PREV_0$ have opposite signs but are equal in absolute value.

TABLE 8

Initial Returns and Price Revision for Unconstrained IPOs

OLS regressions, where the dependent variable initial return is the percentage return from the IPO offer price to the first day closing pricing in the secondary market. *PREV* is the percentage revision of the offer price from the center of the price range. *SURP* is *PREV* minus $PREV_0$, the predicted price revision, using the regression in column (1) of Table 6. *Log(SALES)* is the log of the issuer's sales (Euros) in the year prior to the IPO. The other independent variables are defined in Table 5. The *t*-statistics for robust standard errors are reported in parentheses.

Dependent Variable: *INITIAL RETURN* = 100(%) × (1*stCLOSE* − *OFFER*)/*OFFER*

	(1)	(2)	(3)
Intercept	6.343	6.336	6.555
	(0.73)	(0.72)	(0.73)
SURP (%): coeff. γ_U		0.008	
		(0.04)	
PREV (%)			0.017
			(0.08)
Issue-Specific Variables:			
UMSHARE	0.038	0.038	0.042
	(0.10)	(0.10)	(0.11)
FSOLD (%)	−0.235	−0.235	−0.236
	(−1.04)	(−1.04)	(−1.03)
Log(SALES)	0.503	0.507	0.515
	(0.61)	(0.59)	(0.60)
Industry Dummies:			
$I_{INTERNET}$	23.458**	23.466**	23.415**
	(2.08)	(2.06)	(2.08)
$I_{HIGHTECH}$	3.139	3.143	3.227
	(0.44)	(0.44)	(0.44)
$I_{HIGHTECH} \times I_{INTERNET}$	−26.821**	−26.825**	−26.756**
	(−2.15)	(−2.14)	(−2.12)
Secondary Market Index:			
$IX_{t_W \to t_P}$ (%)	0.538*	0.538*	0.535*
	(1.81)	(1.79)	(1.73)
Primary Market Indices:			
$I\tilde{R}^{NM}_{t_W \to t_P}$ (%)	−0.010	−0.010	−0.010
	(−0.14)	(−0.14)	(−0.14)
$I\tilde{R}^{NQ}_{t_W \to t_P}$ (%)	−0.088**	−0.088**	−0.089*
	(−2.02)	(−2.01)	(−1.99)
$I\tilde{R}^{NM}_{t_W - 2m}$ (%)	−0.011	−0.011	−0.013
	(0.19)	(0.19)	(−0.24)
$I\tilde{R}^{NQ}_{t_W - 2m}$ (%)	0.207*	0.207	0.206
	(1.68)	(1.65)	(1.59)
IPO Activity:			
$N^{NM}_{t_W \to t_P}$	0.146	0.145	0.162
	(0.11)	(0.10)	(0.11)
$N^{NM}_{t_W - 2m}$	−0.449	−0.450	−0.460
	(−1.11)	(−1.11)	(−1.15)
p: zero coeff. of issue-specific variables	0.536	0.564	0.573
p: zero coeff. of primary market indices	0.193	0.204	0.160
F	2.79	2.68	2.68
R^2	26%	26%	26%
No. of observations	80	80	80

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

pute estimates of the latent price revisions for the constrained IPOs.[28] We denote this estimated latent price revision as $PREV_G$.

[28]Even though the explanatory power of the model in column (2) of Table 7 is very high, this methodology has a potential errors-in-variables problem that may give rise to an attenuation bias. We run a robustness check of the results in Table 9 using instrumental variables, as suggested by Lewbel (1997). The results of this regression, which may be obtained from the authors, give no indication that the results reported in Table 9 are due to an errors-in-variables problem.

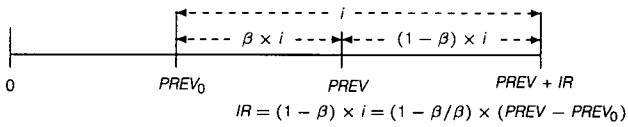
As modeled in equation (3), if the offer price is not constrained, then initial returns may be represented as consisting of two components: IR_0, which is the initial return that can be explained by public information, and $(1 - \beta) \times i$, which represents per share informational rents that are paid to investors in the form of initial returns. For unconstrained IPOs, we proxy for $\beta \times i$ (the price revision due to private information) with $PREV - PREV_0$, where $PREV_0$ is the predicted price revision, given public information. This is illustrated in Graph A of Figure 2. (It is assumed in Figure 2 that $IR_0 = 0$.) The entire graph represents the return from the range center to the first day closing price. This is composed of the price revision, *PREV*, plus the initial return, *IR*.

FIGURE 2

Price Revisions and Initial Returns for Constrained and Unconstrained IPOs

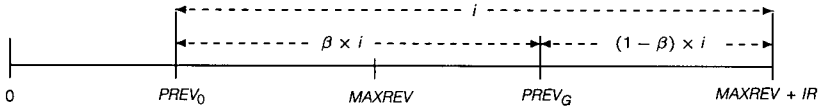
PREV and *MAXREV* are the observed price revisions. $PREV_0$ is the predicted price revision, given public information. $PREV_G$ is the estimated latent price revision. i represents information that the underwriter obtains from investors. We assume for simplicity that $IR_0 = 0$.

Graph A. Unconstrained IPOs



$$IR = (1 - \beta) \times i = (1 - \beta/\beta) \times (PREV - PREV_0)$$

Graph B. Constrained IPOs



$$IR = (1 - \beta) \times i + (PREV_G - MAXREV)$$
$$= (1 - \beta/\beta) \times (PREV_G - PREV_0) + (PREV_G - MAXREV)$$

For constrained IPOs, we proxy for $\beta \times i$ with $PREV_G - PREV_0$, where $PREV_G$ is the estimate of the *latent* price revision. Thus, the term $(1 - \beta) \times i$ represents those rents that the issuer would cede to investors, in the absence of binding pricing constraints. As is illustrated in Graph B of Figure 2, $PREV_G$ is greater than the actual price revision, which is equal to *MAXREV*, the maximum possible price revision. Investors who purchase shares in constrained IPOs thus receive additional returns $(PREV_G - MAXREV)$ due simply to the fact that the actual offer price is below the latent price. Equation (4) is therefore extended in the following way,

$$(7) \quad IR = IR_0 + \begin{cases} \gamma_U \times (PREV - PREV_0) + \varepsilon_U & \text{if } I_{CON} = 0 \\ \gamma_C \times (PREV_G - PREV_0) \\ \quad + (PREV_G - MAXREV) + \varepsilon_C & \text{if } I_{CON} = 1, \end{cases}$$

where I_{CON} is a dummy variable that is equal to one for constrained IPOs and zero for unconstrained IPOs, ϵ_U and ϵ_C denote econometric disturbances, and γ_U and γ_C are both equal to $(1 - \beta)/\beta$.

In order to test equation (7), we rearrange the equation for the initial returns of constrained IPOs, so that $PREV_G$ appears in only one term,

$$
\begin{aligned}
(8) \qquad IR &= IR_0 + \gamma_C \times (PREV_G - PREV_0) \\
&\quad + (PREV_G - PREV_0) + (PREV_0 - MAXREV) + \varepsilon_C \\
&= IR_0 + (1 + \gamma_C) \times (PREV_G - PREV_0) \\
&\quad + \delta \times (PREV_0 - MAXREV) + \varepsilon_C,
\end{aligned}
$$

where $\delta = 1$. We thus obtain the following model,

$$
(9)\ IR = IR_0 + \begin{cases} \gamma_U \times (PREV - PREV_0) + \varepsilon_U & \text{if } I_{CON} = 0 \\ \gamma'_C \times (PREV_G - PREV_0) & \\ \quad + \delta \times (PREV_0 - MAXREV) + \varepsilon_C & \text{if } I_{CON} = 1 \end{cases}
$$

$$
(10) \qquad = IR_0 + \begin{cases} \gamma_U \times SURP + \epsilon_U & \text{if } I_{CON} = 0 \\ \gamma'_C \times SURP_G + \delta \times CEXTENT + \epsilon_C & \text{if } I_{CON} = 1, \end{cases}
$$

where $\gamma'_C = \gamma_C + 1 = 1 + (1 - \beta)/\beta = 1/\beta$, $SURP \equiv (PREV - PREV_0)$ denotes the "surprise" component of the price revision of unconstrained IPOs, $SURP_G \equiv (PREV_G - PREV_0)$ denotes the surprise component of the latent price revision of constrained IPOs, and $CEXTENT \equiv (PREV_0 - MAXREV)$ denotes the extent to which offer prices are constrained.

As discussed in relation to equation (5), the null hypothesis H_{REV} can be written as $\beta = 1$: underwriters fully adjust IPO offer prices with respect to any nonpublic information i that is obtained after the range is set. Since $\gamma_U = (1 - \beta)/\beta$ and $\gamma'_C = 1/\beta$, H_{REV} must be written as two separate hypotheses for the two groups of IPOs:

H^U_{REV}. When regressing the initial returns of *unconstrained* IPOs on that part of the price revision that cannot be explained with public information, the coefficient (γ_U) is equal to zero.

H^C_{REV}. When regressing the initial returns of *constrained* IPOs on that part of the *latent* price revision that cannot be explained with public information, the coefficient (γ'_C) is equal to one.

The alternative hypothesis is that offer prices are only partially adjusted relative to the nonpublic information i ($\beta < 1$), and thus $\gamma_U > 0$ and $\gamma'_C > 1$.

In Table 9, we present the results of three regressions. These regressions are similar to those in Table 8, but with the following differences. i) In Table 9, since the entire sample of IPOs is included, we estimate models (9) and (10). As specified by these models, we include in the regressions of Table 9 the indicator variable I_{CON}, which is equal to one for constrained IPOs and zero otherwise. ii) The regressions reported in Table 9 are generalized least squares (GLS) rather than OLS regressions, since we control for heteroskedasticity induced by the constrained pricing of IPOs.

As in Table 8, column (1) of Table 9 presents benchmark results in which IR is regressed only on the set of control variables. In column (2), we include the variables $SURP \times (1 - I_{CON})$, $SURP_G \times I_{CON}$, and $CEXTENT \times I_{CON}$ in order to estimate model (10). In column (3), we replace these three variables with

TABLE 9

Initial Returns and Price Revision for All IPOs

GLS regressions, where the dependent variable initial return is the percentage return from the IPO offer price to the first day closing pricing in the secondary market. I_{CON} is equal to one for constrained IPOs, and zero otherwise. *PREV* is the percentage revision of the offer price from the center of the price range. *SURP* is *PREV* minus $PREV_0$, the predicted price revision, using the regression in column (1) of Table 7. $PREV_G$ is the predicted price revision, using the regression in column (2) of Table 7. $SURP_G$ is $PREV_G$ minus $PREV_0$. *CEXTENT* is $PREV_0$ minus the maximum possible price revision. *Log(SALES)* is the log of the issuer's sales (Euros) in the year prior to the IPO. The other independent variables are as defined in Table 5. In estimating these models, we assume multiplicative conditional heteroskedasticity specified by I_{CON}. The *z*-statistics for robust standard errors are reported in parentheses.

Dependent Variable: *INITIAL RETURN* = 100(%) × (1*stCLOSE* − *OFFER*) / *OFFER*

	(1)	(2)	(3)
Intercept	3.384	13.279*	16.901**
	(0.44)	(1.67)	(2.12)
I_{CON}	52.459***	12.613**	−1.462
	(9.65)	(1.98)	(−0.29)
$SURP * (1 - I_{CON})$ (%): coeff. γ_U		−0.022	
		(−0.12)	
$SURP_G * I_{CON}$ (%): coeff. γ'_C		1.085***	
		(10.82)	
$CEXTENT * I_{CON}$ (%): coeff. δ		0.734**	
		(2.47)	
$PREV * (1 - I_{CON})$ (%)			0.037
			(0.21)
$PREV_G * I_{CON}$ (%)			1.052***
			(10.69)
UMSHARE	−0.119	−0.059	−0.032
	(−0.34)	(−0.15)	(−0.10)
FSOLD (%)	−0.268	−0.413*	−0.427**
	(−1.25)	(−1.94)	(−2.02)
Log(SALES)	−0.060	0.162	0.284
	(−0.08)	(0.21)	(0.37)
$I_{INTERNET}$	18.612*	17.318	16.907
	(1.85)	(1.60)	(1.57)
$I_{HIGHTECH}$	6.830	1.695	1.543
	(1.07)	(0.32)	(0.29)
$I_{HIGHTECH} \times I_{INTERNET}$	−29.147**	−24.052**	−21.439*
	(−2.57)	(−2.02)	(−1.85)
Market Indices: $IX_{t_W \to t_P}$ (%)	0.877***	0.499**	0.429*
	(3.29)	(2.20)	(1.94)
$I\tilde{R}^{NM}_{t_W \to t_P}$ (%)	0.048	−0.007	−0.026
	(0.74)	(−0.13)	(−0.47)
$I\tilde{R}^{NQ}_{t_W \to t_P}$ (%)	−0.051	−0.034	−0.047
	(−1.41)	(−0.93)	(−1.27)
$I\tilde{R}^{NM}_{t_W - 2m}$ (%)	0.109**	−0.002	−0.025
	(2.02)	(0.04)	(−0.49)
$I\tilde{R}^{NQ}_{t_W - 2m}$ (%)	0.248**	0.114	0.081
	(2.50)	(1.20)	(0.91)
IPO Activity: $N^{NM}_{t_W \to t_P}$	0.134	−0.117	−0.177
	(0.11)	(−0.09)	(−0.15)
$N^{NM}_{t_W - 2m}$	−0.889**	−0.258	−0.245
	(−2.53)	(−0.82)	(−0.79)
Estimation of log(dist. variance): intercept	5.182***	5.135***	5.147***
I_{CON}	3.368***	2.378***	2.390***
p: $\gamma'_C = 1$		0.396	
p: $\delta = 1$		0.436	
p: coeff. of $PREV_G * I_{CON} = 1$			0.300
p: zero coeff. of issue-specific variables	0.637	0.218	0.165
p: zero coeff. of primary market indices	0.000	0.611	0.339
χ^2	267.5	451.3	446.3
$R^2_{ML(VWLS)}$	41%	75%	74%
No. of observations	254	254	254

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

$PREV \times (1 - I_{CON})$ and $PREV_G \times I_{CON}$ in order to more closely replicate Hanley's (1993) test for a partial adjustment phenomenon. In calculating these variables, we estimate $PREV_0$ for all IPOs using the model of column (1) of Table 7. $PREV_G$ is estimated, for the constrained IPOs, using the model of column (2) of Table 7. (*PREV* and *MAXREV* are given in our data set.)

The results presented in Table 9 are similar to those in Table 8, but with some differences. Initial returns continue to be positively related to recent secondary market returns in Germany and to primary market returns in the U.S. prior to range setting ($\overline{IR}^{NQ}_{t_w-2m}$). Initial returns are also higher for Internet firms, but this is less significant in Table 9 than in Table 8. Consistent with results in Habib and Ljungqvist (2001), Loughran and Ritter (2002), (2004), and Bradley and Jordan (2002), we find that initial returns are negatively related to the fraction of an issuer's outstanding shares that are sold in the IPO (*FSOLD*), and consistent with Booth and Chua (1996), initial returns are negatively related to the number of recent IPOs in the same industry. These latter results are present, but not significant in Table 8.

The results of Table 9 are the same as those in Table 8 in that we again fail to find a partial adjustment phenomenon of the type defined by Hanley (1993). We are unable to reject either of the null hypotheses H^U_{REV} or H^C_{REV}.[29] The first of these results confirms our findings in Table 8 for the sample of unconstrained IPOs: we can neither reject that $\gamma_U = 0$, nor that the coefficient on the price revision $PREV * (1 - I_{CON})$ equals zero. For the constrained IPOs, we obtain similar results: according to the p-values stated at the bottom of Table 9, the coefficient γ'_C and the coefficient on the price revision $PREV_G * I_{CON}$ are not significantly different from one. Therefore, we cannot reject the null hypothesis H^C_{REV}.

Perhaps the most striking difference between Tables 8 and 9 is that in Table 9 the explanatory power of the regressions increases significantly when we add the price revision variables, whereas in Table 8 this does not happen. This effect is almost certainly due to the fact that a large part of the initial returns for constrained IPOs is explained by the constraint itself. In addition, the coefficient δ on the variable *CEXTENT* is not significantly different from its theoretical value of one. Hence, initial returns are directly proportional to our estimates of the extent to which underpricing is directly caused by the pricing constraint. Using these estimates, we can compute the IPO proceeds that issuers forgo due to this constraint. For the constrained IPOs, *CEXTENT* is on average equal to 20.2% of the range center. After multiplying *CEXTENT* by issue size for each constrained IPO, we calculate that, within the set of constrained IPOs, an average of 11.8 million Euros per IPO were left on the table, due just to the policy of not pricing above the range. Across the 174 IPOs within this set, the total amount of money left on the table is more than two billion Euros.

[29] In the regressions in Tables 8 and 9, we normalize the price revision by the range center and the initial returns by the offer price. We follow this convention in order to be consistent with existing literature. However, using different normalizing factors can affect the values of the coefficients γ_U, γ'_C, and δ. In the standard test for a partial adjustment phenomenon (testing H^U_{REV}) this does not matter, because the null hypothesis is that $\gamma_U = 0$. One could argue, however, that the null hypthesis H^C_{REV} should be that γ'_C= range center/offer price, which is less than one. (For constrained IPOs, the mean is 0.9244, with a standard deviation of only 0.0179.) We test this alternative null hypothesis and are unable to reject it either.

The absence of a partial adjustment phenomenon means that we find no evidence of an informational role of bookbuilding *after* the opening of the grey market. In interpreting this result, there are two possible explanations. First, it may be the case that once the grey market opens, underwriters no longer gather information directly from investors ($i = 0$). Second, it may be the case that underwriters obtain some information from investors after the grey market opens, but this information is also contained in the grey market prices. Since these prices are freely and publicly available, the investors do not receive rents for providing the information ($\beta = 1$).[30] Either way, we fail to find evidence that underwriters gather costly information through bookbuilding *after* the onset of grey market trading.

VIII. Conclusion

We examine an IPO market that has active pre-IPO when-issued trading and find that there is no partial adjustment phenomenon, as has been documented with respect to the U.S. IPO market. This result obtains despite the fact that, as in the U.S., bookbuilding is the method of choice for pricing and marketing IPOs. Thus, it appears that bookbuilding in this market is not the same as bookbuilding in the U.S.

To understand how IPOs are priced in the presence of both bookbuilding and when-issued trading, we bring together the results of the two parts of this paper: the results on the relation between IPO pricing and the prices of shares in the when-issued market, and the results on IPO underpricing. We find that underwriters do not fully revise IPO offer prices with respect to information impounded in prices in the when-issued market. Consistent with the theory of Benveniste and Spindt (1989), this underrevision can be interpreted as evidence of rents that investors receive for providing underwriters with information. However, such rents are *not* paid for information that underwriters obtain *after* the opening of when-issued trading. Otherwise, we should find a partial adjustment phenomenon as defined by Hanley (1993). The lack of such a phenomenon suggests that, once when-issued trading commences, bookbuilding is not a source of costly information for IPO pricing. Any such informational role of bookbuilding is therefore confined to the period before the opening of the when-issued market. Indeed, our findings suggest that underwriters do gather information through bookbuilding in order to set price ranges *before* when-issued trading begins.

These findings raise the question of why underwriters do not just wait for all relevant information to be revealed through when-issued trading. Put differently, why do underwriters not set arbitrarily wide ranges, so as not to constrain IPO pricing prior to learning information from when-issued trading? We believe that this is because of externalities in the bookbuilding process, in the absence of which when-issued trading cannot open. In setting price ranges, underwriters give publicly observable indications of the likely value of IPO shares. Such revelation of information can mitigate informational asymmetries across traders

[30]These alternative explanations for our findings are put into perspective by the findings of Jenkinson and Jones (2004). They analyze the books of 27 European IPOs and find that only 7% of the bids are price sensitive. This finding is consistent with such bookbuilding not serving an informational purpose (i.e., $i = 0$ in our model).

in the when-issued market, thereby facilitating the opening of the market. This argument is consistent with three stylized facts. First, when-issued trading never opens before the underwriter posts the price range. Second, price ranges vary across IPOs, perhaps due to information that underwriters obtain through bookbuilding before they set the range. Third, the setting of a price range is not just "cheap talk," since the range imposes a potentially costly constraint on the subsequent pricing of the IPO. This last fact has two implications. First, there is a value to gathering information before setting the range. Second, the range is a signal of information held by the underwriter.

Our results are also relevant for understanding IPO pricing in markets without when-issued trading. For example, we provide indirect validation of the common interpretation of the partial adjustment phenomenon. This phenomenon is typically interpreted as evidence that underwriters pay informational rents to investors who submit informative orders for IPO shares during the bookbuilding process. Our results support this interpretation. If when-issued trading of IPO shares reveals investors' private information for free, then there is no need to pay them informational rents once when-issued trading commences. Following this line of thought and the common interpretation of the partial adjustment phenomenon, because when-issued trading commences immediately after the posting of ranges, there should be no such phenomenon. This is indeed what we find.

An important open question remains. We cannot determine from our data whether when-issued trading enhances the efficiency of IPO pricing. Even though when-issued trading may not be able to fully supplant bookbuilding as a source of information for pricing, it may allow underwriters to reduce the scale of costly information gathering. Thus, it is plausible that the existence of a when-issued market lowers the cost of information gathering. However, it is also possible that when-issued trading interferes with information gathering through bookbuilding. For example, investors may wish to conceal information about the value of IPO shares in order to realize profits by trading in the when-issued market. Recent theoretical work (discussed in the Introduction) tends to support the former rather than the latter argument. In addition, we find that even after taking into account the lower fraction of Internet IPOs on the German Neuer Markt, average underpricing on the Neuer Markt was lower than on Nasdaq for the years 1999 and 2000. This could, however, be due to factors other than the existence of a when-issued market. In order to test whether the presence of when-issued trading is beneficial for issuers, we would need a more controlled experiment than what is provided by a simple comparison of two different markets. We thus leave this question open for future research, although we believe that our findings represent an important step toward an answer.

Appendix A. Underwriters on the Neuer Markt

The following table summarizes data on the banks that were active as lead underwriters in the Neuer Markt IPO market from February 1999 to December 2000. Close to half of the IPOs (123 out of 254) were lead managed by banks that do not have a Carter-Manaster rank assigned to them, presumably because these banks have not been active in U.S. IPO markets. For this reason, we use market share as a proxy for underwriter reputation. The market share of a particular underwriter is defined as the *total proceeds* of IPOs on the Neuer Markt featuring this underwriter as lead or co-lead manager divided by the total proceeds of all Neuer Markt IPOs in this period. Proceeds are defined as the offer price times the number of shares sold at the IPO, including shares sold under the greenshoe option. If an IPO has a lead and a co-lead manager, half of the proceeds contribute to the market share order of each underwriter. "C-M Rank" is Jay Ritter's update of the Carter-Manaster reputation ranking, taken from Ritter's home page: http://bear.cba.ufl.edu/ritter/rank.htm.

Underwriter	Market Share *UMSHARE* (%)	No. of IPOs as Lead Manager	No. of IPOs as Co-Lead Manager	C-M Rank
Dresdner Bank AG	13.09	16	1	7
Goldman, Sachs & Co.	11.94	5	2	9
Commerzbank AG	10.77	23	2	7
DG Bank AG	9.78	31	5	none
Deutsche Bank AG	9.52	16	4	9
Hypo- und Vereinsbank AG	7.09	20	2	none
WestLB	4.09	13	0	5
BHF-Bank AG	2.90	11	0	6
Credit Suisse First Boston	2.56	7	0	9
Baden-Württembergische Bank AG	2.53	7	1	none
Sal. Oppenheim jr. & Cie. KGaA	2.51	10	1	none
HSBC Trinkaus & Burkhardt KGaA	2.10	12	0	8
BNP Paribas Group	2.09	7	0	7
Bank J. Vontobel & Co. AG	1.68	4	1	6
Morgan Stanley Bank AG	1.64	3	0	9
Gontard & Metallbank AG	1.52	10	0	none
Salomon Smith Barney International	1.33	2	0	9
UBS Warburg	1.24	1	0	8
Norddeutsche LB Girozentrale	1.18	6	1	none
Concord Effekten AG	1.12	8	0	none
BancBoston Robertson Stephens	1.04	3	0	8
Warburg Dillon Read	0.86	1	1	8
Merrill Lynch International	0.83	2	0	9
M.M. Warburg & Co. KGaA	0.78	5	0	none
LB Baden-Württemberg	0.75	4	1	none
LB Rheinland-Pfalz Girozentrale	0.52	0	1	5
Market Share < 0.5%: 20 underwriters	4.54[a]	27	4	[b]
Total	100.00	254	27	

[a] This is the cumulative market share of all underwriters with a market share below 0.5%. The value of the variable *UMSHARE* for each of these underwriters is <0.5.

[b] Two underwriters have a ranking of 9, 2 have a ranking of 8, 1 has a ranking of 7, and the remainder have no ranking.

Appendix B. Indices for Primary Market Conditions and IPO Activity

To construct indices for primary market conditions, we first identify for each IPO on the Neuer Markt i) an industry classification for that IPO, determined by the values of *both* industry indicator variables $I_{HIGHTECH}$ and $I_{INTERNET}$, ii) the time t_W at which the price range was set, and iii) the time of pricing, t_P. We then identify all IPOs with the same industry classification (matching on both categories) that started trading on Nasdaq or the Neuer Markt i) during the two months before time t_W and ii) between time t_W and time t_P. We then count these IPOs and compute the average initial returns. The counts are denoted as $N^{MKT}_{t_W-2m}$ and $N^{MKT}_{t_W\to t_P}$, respectively, and the average initial returns are denoted as $\overline{IR}^{MKT}_{t_W-2m}$ and $\overline{IR}^{MKT}_{t_W\to t_P}$, respectively, where $MKT \in \{NM, NQ\}$ indicates whether the variable refers to IPOs on the Neuer Markt (NM) or on Nasdaq (NQ).

For each of our IPOs, there was at least one similar IPO on Nasdaq during the two months prior to setting the price range ($t_W - 2m$), and for all but eight there was at least one IPO on the Neuer Markt during this period. However, for 109 of our IPOs there were no Neuer Markt IPOs during the period $t_W \to t_P$, and for 65 of our IPOs there were no Nasdaq IPOs during this period. We fill the missing values for each index with the average of all other (non-missing) values of that index across IPOs with the same industry classification. This strategy for filling in the missing values avoids introducing a bias into the coefficient of that index in our regressions.[31]

[31] We thank Jay Ritter for suggesting this strategy for dealing with missing values.

References

Beatty, R. P., and I. Welch. "Issuer Expenses and Legal Liability in Initial Public Offerings." *Journal of Law and Economics*, 39 (1996), 545–602.

Benveniste, L.; A. Ljungqvist; W. Wilhelm; and X. Yu. "Evidence of Information Spillovers in the Production of Investment Banking Services." *Journal of Finance*, 58 (2003), 577–608.

Benveniste, L., and P. A. Spindt. "How Investment Bankers Determine the Offer Price and Allocation of New Issues." *Journal of Financial Economics*, 24 (1989), 343–361.

Bikhchandani, S., and C.-F. Huang. "The Treasury Bill Auction and the When-Issued Market: Some Evidence." Working Paper, UCLA (1992).

Bikhchandani, S., and C.-F. Huang. "The Economics of Treasury Securities Markets." *Journal of Economic Perspectives*, 7 (1993), 117–134.

Booth, J. R., and L. Chua. "Ownership Dispersion, Costly Information, and IPO Underpricing." *Journal of Financial Economics*, 41 (1996), 291–310.

Bradley, D. J., and B. D. Jordan. "Partial Adjustment to Public Information and IPO Underpricing." *Journal of Financial and Quantitative Analysis*, 37 (2002), 595–616.

Carter, R. B., and S. Manaster. "Initial Public Offerings and Underwriter Reputation." *Journal of Finance*, 45 (1990), 1045–1067.

Chatterjea, A., and R. A. Jarrow. "Market Manipulation, Price Bubbles, and a Model of the U.S. Treasury Securities Auction Market." *Journal of Financial and Quantitative Analysis*, 33 (1998), 255–289.

Cornelli, F., and D. Goldreich. "Bookbuilding and Strategic Allocation." *Journal of Finance*, 56 (2001), 2337–2369.

Cornelli, F.; D. Goldreich; and A. Ljungqvist. "Pre-IPO Markets." Working Paper, London Business School and New York University (2004).

Dorn, D. "Does Sentiment Drive the Retail Demand for IPOs?" Working Paper, Columbia University (2003).

Glosten, L. R., and P. R. Milgrom. "Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders." *Journal of Financial Economics*, 14 (1985), 71–100.

Habib, M., and A. Ljungqvist. "Underpricing and Entrepreneurial Wealth Losses in IPOs." *Review of Financial Studies*, 14 (2001), 433–458.

Hanley, K. W. "The Underpricing of Initial Public Offerings and the Partial Adjustment Phenomenon." *Journal of Financial Economics*, 34 (1993), 231–250.

Jenkinson, T., and H. Jones. "Bids and Allocations in European IPO Bookbuilding." *Journal of Finance*, 59 (2004), 2309–2338.

Jenkinson, T.; A. Morrison; and W. Wilhelm. "Why Are European IPOs So Rarely Priced Outside the Indicative Price Range?" Working Paper, Oxford University (2004).

Leland, H., and D. Pyle. "Information Asymmetries, Financial Structure, and Financial Intermediation." *Journal of Finance*, 32 (1977), 371–387.

Lewbel, A. "Constructing Instruments for Regressions with Measurement Error When No Additional Data Are Available, with an Application to Patents and R&D." *Econometrica*, 65 (1997), 1201–1213.

Ljungqvist, A., and W. Wilhelm. "IPO Pricing in the Dot-Com Bubble." *Journal of Finance*, 58 (2003), 723–752.

Löffler, G.; P. F. Panther; and E. Theissen. "Who Knows What When? The Information Content of Pre-IPO Market Prices." Working Paper, University of Frankfurt/Main (2002).

Loughran, T., and J. R. Ritter. "Why Don't Issuers Get Upset about Leaving Money on the Table in IPOs?" *Review of Financial Studies*, 15 (2002), 413–443.

Loughran, T., and J. R. Ritter. "Why Has Underpricing Changed over Time?" *Financial Management*, 33 (2004), 5–37.

Lowry, M., and G. W. Schwert. "IPO Market Cycles: Bubbles or Sequential Learning?" *Journal of Finance*, 57 (2002), 1171–1200.

Nyborg, K. G., and S. Sundaresan. "Discriminatory Versus Uniform Treasury Auctions: Evidence from When-Issued Transactions." *Journal of Financial Economics*, 42 (1996), 63–104.

Pichler, P., and A. Stomper. "Primary Market Design: Direct Mechanisms and Markets." Working Paper, Institute for Advanced Studies and University of Vienna (2004).

Titman, S., and B. Trueman. "Information Quality and the Valuation of New Issues." *Journal of Accounting and Economics*, 8 (1986), 159–172.