Underpricing and Ex-Post Value Uncertainty*

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ABSTRACT

As documented by a vast empirical literature, IPOs are characterized by underpricing. A number of papers have shown that underpricing is directly related to the amount of ex-ante uncertainty concerning the IPOs valuation. Recent theoretical papers propose that not all value uncertainty is resolved prior to the start of trading, but rather continues to be resolved into the beginning of the after market. We term this type of uncertainty as ex-post value uncertainty and develop proxies for it. We find strong support for the existence of ex-post value uncertainty and find that including a proxy for it more than doubles the explanatory power of previous models.

Keywords: underpricing, volatility, trading system, demand uncertainty, ex-post value uncertainty

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1. Introduction

As documented by a large empirical literature, a peculiar feature of initial public offerings (IPOs) is underpricing: i.e. the spike in the price of a share relative to its offering price on the first day of trading. Many theoretical papers have tried to explain *why* new issues are underpriced. Most of these explanations are based on the existence of some type of asymmetric information in the IPO process.[1] A main empirical implication (Ritter (1984), Beatty and Ritter (1986)) is that underpricing can be interpreted as a premium for the ex ante uncertainty about firm market value.

Recently theoretical studies have posited that, despite the underwriter's best effort, the degree of uncertainty and informational asymmetry among investors is not completely resolved on the primary market and, instead, remain significant "during the transition to normal secondary market trading conditions" (Chen and Wilhelm, 2005) as proved by the substantial use of price stabilization practices in the immediate aftermath of the offering (we will refer to this period as ex-post.) In this paper we develop proxies to measure the amount of ex-post value uncertainty. We then investigate the link between ex-post value uncertainty and IPO underpricing by employing regressions, which also control for other factors known to be associated with IPO underpricing. We find that including a proxy for ex-post value uncertainty more than doubles the explanatory power of previous models that have only considered ex-ante uncertainty as the main determinant of IPO underpricing. In particular, including the standard deviation of quote midpoints for several sub-periods immediately following the start of trading increases the R^2 to

[1] Rock (1986) explains underpricing as the result of a winner's curse problem retail (uninformed) investors face vis-à-vis institutional (informed) investors. Allen and Falhauber (1989) interpret underpricing as a way for the firm to signal its quality to the market whose cost will be offset by the higher price good firms will be able to charge in the subsequent seasoned offerings. In Benveniste and Spindt (1989) underpricing is the result of the informational rents the underwriter needs to pay to institutional investors in order to elicit their information about the market value of the issue. Lowry and Schwartz (2004) find empirical support for Benveniste and Spindt by showing that underwriters do no fully adjust offer prices for all private information acquired prior to the offering date.

0.66. Standardizing the standard deviations by the offering price further increases the explanatory power to 72%.

Related to uncertainty is a recent paper by Saar (2001). In that paper the author argues that investor demand uncertainty leads to wider spreads. We find support for Saar's argument. In particular, we find that spreads on average narrow from $0.48 to $0.35 within the first four minutes of trading. We also find that on average 18.9% of the total number of shares offered trades in the first 4 minutes after initial opening.

The remainder of the paper is organized as follows. The next section presents a short review of the literature and develops our hypotheses based on it. In Section 3, we describe the data set used to test our hypotheses. Section 4 describes the empirical results, while Section 5 concludes.

2. Literature Review

Beatty and Ritter (1986) argue that the amount of ex ante uncertainty as to true firm value is the main determinant of the level of underpricing in IPOs. They build on Rock (1986) which interprets underpricing as a premium to uninformed investors for the winner's curse problem they face *vis-à-vis* informed investors, who observe the true firm value. Beatty and Ritter further develop this idea by claiming that more ex ante uncertainty worsens the winner's curse problem and, consequently, requires larger underpricing. They test their theory by using as a proxy for ex ante uncertainty the inverse of the gross proceeds raised in the offering as well as the number of uses mentioned in the prospectus. Ritter (1984) uses instead the standard deviation of the daily aftermarket return. Both studies find support for the relationship between ex ante uncertainty and the level of underpricing.

Corwin and Harris (2001) examine the initial listing decisions of firms going public. Their sample of IPOs consists of firms that either listed on the NYSE or met the NYSE's minimum-listing requirements and listed on the NASDAQ National Market for the period 1991 to 1996. They control for other possible variables affecting the difference in the underpricing including ex ante uncertainty, which they proxy with the aftermarket standard deviation of return (5 day returns over a 100 day window). They find that underpricing is related to their proxy. .

Although the above studies (and others) find empirical support for the use of aftermarket standard deviation of return as a proxy for ex-ante uncertainty, However, Jenkinson and Ljungqvist (2001) point out that using standard deviation of return may be an inadequate proxy since it may reflect the relationship between risk and return. Additionally, it is well established in the literature that the standard deviation of return contains both market and unique risk. Therefore, it is possible for two firms with the same standard deviation of return to have very different levels of value uncertainty. Table 1 presents a list some of the previous studies that use at least one proxy for ex-ante uncertainty in regressions to explain the amount of underpricing in IPOs.[2]

Examining Table 1 we observe that previous studies have examined a broad range of proxies for ex-ante uncertainty.[3] It is clear from Table 1 that studies typically use more than one proxy for ex-ante uncertainty, making a discussion of the efficacy of individual proxies problematic. The table also reports the highest adjusted R^2 found in the study as we will focus on the amount of variation in underpricing explained by the studies.

Among the studies examining U.S. IPOs, as our study does, Habib and Ljungqvist (2001) are able to explain the largest portion (33.2%) of variation in IPO underpricing by including (among other variables) age, sales, gross proceeds, underwriting fee, and underwriter

[2] The table is based on table 3.2 in Jenkinson and Ljungqvist (2001). We have included some more recently published studies and we have focused only on those that use regression tecniques. See Chapter 3 of Jenkinson and Ljungqvist (2001) for a complete discussion of each of the proxies.

[3] We focus on the most commonly used proxies only. In the IPO literature, other variables have been proposed as potential determinants of ex-ante uncertainty and as such of the IPO underpricing. For instance, Michaely and Shaw (1995) look at the auditor quality and more recently Cai et al. (2004) investigate the impact of prior debt issuance on the pricing of the subsequent IPO.

reputation in their models. Among the studies examining non-U.S. IPOs, McGuinness (1992) is able to explain 44% of variation in the amount the underpricing in IPOs in the Hong Kong market by including the log of the number of uses, underwriter reputation, and the standard deviation of after-market returns. The fact that over 50% of the variation in the amount of underpricing has not yet been explained suggests either that the remainder is random or that there are factors that have not yet been discovered.

A recent paper by Chen and Wilhelm (2005) suggests that in addition to ex-ante uncertainty, there is also uncertainty as the beginning of trading in an IPO. We will refer to that type of uncertainty as ex-post value uncertainty. Chen and Wilhelm (2005) propose a model of the transition to the secondary market trading of new issues based on the working assumption that not all information is disclosed during the offering and that, consequently, asymmetric information and uncertainty persists in the aftermarket until stable trading conditions are reached. They show that in these circumstances, the underwriter can achieve price stabilization by relying on institutions which would temporarily hold shares until they can be distributed to the ultimate secondary market investors. IPOs are then underpriced to compensate these institutions for holding the shares. The authors also argue that "early secondary market uncertainty provides incentive for further information production" beyond that produced in the bookbuilding process. It then follows that the greater the uncertainty the greater the incentive needed to compensate institutions for facilitating the distribution of IPO shares to the ultimate secondary market investors.

Support for this contention is provided by Draho (2001) who develops a model of IPOs where both the primary and secondary prices are endogenous. Draho shows that underpricing occurs if there is uncertainty about the price of the IPO on the secondary market and that underpricing will be increasing in this (ex-post) uncertainty about the firm value. We test this hypothesis by examining the relationship between the level of early secondary market uncertainty and the amount of underpricing of an issue.

Related to the IPO uncertainty literature is Saar (2001). In that paper Saar argues that increased uncertainty about investor demand leads to wider bid-ask spreads. The traditional market microstructure literature explains the impact of trades on prices as a result of the asymmetric information among investors about the future cash flows of assets. Saar instead claims that it is reasonable to assume uncertainty about investors' preferences and endowments (demand or investor uncertainty).

Several studies examine how other types of uncertainty relate to IPO underpricing. For example, Ellul and Pagano (2003) conjecture that, IPO underpricing also depends on the uncertainty about the level of *liquidity* in the aftermarket. Using a sample of IPOs on the London Stock Exchange, the authors examine several measures of aftermarket liquidity uncertainty including the volatility of quoted and effective spread measured over the first four weeks of trading in the aftermarket. Their results support their hypothesis that larger uncertainty about aftermarket liquidity results in larger underpricing. Corwin, Harris, and Lipson (2004) also examine aftermarket liquidity for a sample of NYSE IPOs. They find that depth relative to volume as well as percentage spreads increases steadily in the days following an IPO.

The literature on IPOs discussed above suggests that uncertainty is related to underpricing and that the uncertainty is not fully resolved until after the IPO has begun trading. We develop and test several proxies for ex-post value uncertainty. The focus of our paper is on value uncertainty. This paper then does not examine uncertainty of liquidity. For studies examining the relationship between IPO underpricing and liquidity uncertainty see Ellul and Pagano (2003) and Corwin, Harris, and Lipson (2004).

3. Data

Our first step is to compile a list of all IPOs between January 1993 and December 1998 from the Securities Data Corporation (SDC) New Issues Database. Since we are concerned with the opening of trading in an IPO, we set the beginning of our sample period to coincide with the availability of intraday data on the NYSE TAQ database, 1993. We end our sample period in 1998 to avoid influences from the NASDAQ technology bubble and its subsequent bursting. Barry and Jennings (1993) find that the returns of operating companies and closed-end-funds behave very differently. Therefore, consistent with Corwin and Harris (2001), we exclude investment funds (including mortgage securities), REITs, and real estate firms from our sample. Also excluded are ADRs and firms incorporated outside the United States since they are most likely cross-listed firms with established stock values on other exchanges.

We cross-check the offering date and market on both the TAQ and CRSP databases. Corrections are made to issue dates by confirming the first trade date on the TAQ data base. The resulting sample consists of 2,752 stocks. Since we want to control for variables that previous studies find to be related to the amount of underpricing, we next check for data availability for those variables. The list of those variables is contained in Table 2. After excluding those firms without complete data, our sample results in 2,029 IPOs. Table 2 contains the descriptive statistics of each variable for our sample.

Examining Table 2 reveals that our sample covers a wide range of firm types. For example, while the average IPO offering size is about $58 million, offering sizes range from just over $2 million to almost $4 billion. First day returns range from a loss of 29.2% to a gain of over 600%. This range indicates that our sample includes IPOs that are underpriced, equally price, and overpriced, which adds power to our tests. The distribution of values for the remaining variables indicates that our sample includes a wide range of firm risk levels, ages, and underwriter ranks.

As mentioned earlier, Saar (2001) develops a model of that shows that demand uncertainty and spread width are directly related. Chen and Wilhelm (2005) assert that uncertainty persists in the aftermarket until stable trading conditions are reached. Together these two studies suggest that spreads will initially be wide following the beginning of trading of an IPO and then decrease as this residual uncertainty is resolved. Our data provide a good test of this hypothesis. To do so we examine the intraday spread pattern for our IPO sample to determine how long it takes for the differences in spread width to reduce. We find that the differences observed at the open reduce greatly within the first few minutes of trading as illustrated in Figure 1. The pattern of spreads exhibits a dramatic decline within the first 4 minutes of trading. In particular spreads decline by about 27% in the first few minutes, from an average of $0.48 to $0.35. Since a large portion of our sample are NASDAQ IPOs, these findings stand in contrast with Chan, Christie, and Schultz (1995) who find spreads are fairly stable on NASDAQ stocks over the first 2 hours of trading.

Four minutes is slightly more than 1% of the 390 minutes in a full trading day. It could therefore be argued that resolving uncertainty in the first 4 minutes of trading is of little consequence. To examine this issue, we calculate the proportion of total first day share volume traded in the first 4 minutes of trading. Returning to Table 2 and examining the last row, we find that the volume of shares traded in the first 4 minutes is on average 18.9% of the total shares offered for firms in our sample of IPOs. This provides initial support for the existence of significant uncertainty during the beginning of secondary trading in an IPO. We examine other proxies for ex-post value uncertainty in the next section.

It is clear that a large amount of trading occurs in the first few minutes of trading. Aggarwal (2002) finds that institutions flip an average of 32% of the shares they are allocated in hot issues. Since trades cannot occur unless initial owners flip, this suggests that this short time span is important for a large group of investors.

Motivation for flipping is provided in a 1991 SEC investigation into IPO under-pricing. That study suggests that investment bankers allocate shares to favored clients who sell them quickly in the secondary market.[4] In 2003 testimony before the Senate Banking Committee, then SEC Chairman Donaldson discussed "spinning" which he defined as "the allocation of "hot" IPO

[4] See "Crime and punishment: Initial public offerings," *The Economist*, December 15, 2001, p. 61.

shares to senior executives in the belief or expectation of receiving future investment-banking business from their companies."[5] Theoretical support for the above argument is provided by Fulghieri and Spiegel (1993) who develop a theory of IPO underpricing in which shares are allocated to firms who may generate revenue for other areas of the bank (e.g., trading commissions). Empirical evidence supporting the SEC allegations is provided by Aggarwal, Nagpurnanand, and Puri (2002). They document that indeed underwriters favor their institutional clientele by allocating them more shares in *hot* issues that they trade immediately in the aftermarket. This again suggests that the focus of ex-post value uncertainty should be short term in nature.

The intuition as to why this ex-post value uncertainty should be priced is straightforward – assume a risk-averse informed investor who knows the expected value, and distribution, of the opening price of an IPO. Further assume a desired underpricing amount (consistent with the related business compensation theory of Fulghieri and Spiegel (1993) as well as the laddering agreements documented by Griffin, Harris, and Topaloglu (2005)), then it follows that the more variable the distribution of prices in the immediate after-market, the larger the underpricing.[6]

4. Empirical Results

As mentioned earlier Chen and Wilhelm (2005) and Draho (2001) assert that uncertainty as to an IPO's value has both an ex-ante and an ex-post component (relative to the start of secondary market trading.) We list a number of empirical studies that proxy for ex-ante value uncertainty, but we are aware of no studies that have yet proposed proxies for ex-post value uncertainty. In this section, we set out to fill that gap, and propose several proxies for ex-post

[5] See http://www.sec.gov/news/testimony/ts050703whd.htm.

[6] Laddering denotes the practice by underwriters to use underpricing to compensate institutional investors for providing aftermarket price support through additional purchases. Griffin et al. (2005) find evidence consistent with the existence of laddering agreements.

value uncertainty. In our development of the proxies, we have two main objectives: to test whether ex-post value uncertainty matters significantly, and, if it does, how long it takes before this uncertainty is resolved.[7] Therefore, we also examine different time intervals during the first and second day of trading.

Cao, Ghysels, and Hatheway, (2000) examine the pre-opening on NASDAQ for existing stocks and find that market makers seem to use the pre-opening quotes to signal each other as to their supply and demand. Aggarwal and Conroy (2000) examine the pre opening period on NASDAQ for a set of IPOs and reach similar conclusions. This signaling may continue into the opening of trading, at least for NASDAQ stocks.[8] In addition, higher ex-post uncertainty, as to firm value, will result in wider dispersion of quotes and trades in the immediate aftermarket. It is then natural to proxy for the level of ex-post uncertainty by examining the disperion of prices in the after market.[9] We can focus on either quotes or trades. We focus on the dispersion of quote midpoints rather than the dispersion of trade prices order to remove any spurious volatility caused by the familiar bid-ask bounce.

The first proxy we consider is then the standard deviation of quote midpoints. Recall our previous finding that a large amount of trading occurs in the first few minutes of trading. In determining the intervals for the calculation of standard deviation we also note that not *all* IPOs trade significant amounts in the first few minutes. Therefore, we establish the first two hours as period of time over which we will calculate the initial standard deviation of quote midpoints.[10] We also define periods for the remainder of the first trading day and the entire first day of

[7] We thank the reviewer for suggesting this to us.

[8] During the period of our study trades for NASDAQ stocks were consumated via telephone or e-mail. Therefore, displayed quotes may be changed before trades occur on NASDAQ.

[9] Note that using the standard deviation of return over a long horizon (e.g., 20 days) will not capture uncertainty that is resolved in the immediate aftermarket. As others have noted, long horizon standard deviation of return is a better proxy of overall firm risk. If value uncertainty is resolved in the immediate aftermarket, then short-lived measures such as the ones examined here will provide better proxies.

[10] If the majority of uncertainty is resolved in the first few minutes then choosing a two hour interval biases us against finding any relationship between underpricing and ex-post value uncertainty. Thus finding a relationship would lend our tests more power.

trading. The second day of trading is also partitioned in a similar way as we are also interested in the persistence of the ex-post uncertainty beyond the first day of trading.

Descriptive statistics for the above proxies for ex-post value uncertainty are contained in Table 3. Examining the average standard deviations for day one and two reveals that our proxy for ex-post value uncertainty is about 50% greater on the first day of trading than on the second day 32.25% versus 21.73%). Of the daily sub-periods, the greatest standard deviation is for the first two hours of the first trading day (27.69%.)

In our sample, there are some firms with no uncertainty, i.e., a standard deviation of zero, during the sub-periods.[11] When examining these observations, we find that during the first two hours of trading in the after market, only about five percent of firms exhibit no uncertainty as to value (i.e., 95% have some ex-post uncertainty).. In contrast, over 25% of firms exhibit no value uncertainty over the remainder of the first trading day. On the second day, almost 20% of firms appear to have no dispersion of quote midpoints in the first two hours and almost 30% exhibit that trait for the remainder of the day. Overall, these preliminary findings provide initial support to the hypothesis that a large portion of ex-post value uncertainty is resolved at the beginning of trading.

While the standard deviation of quote midpoints may be a good proxy for ex-post value uncertainty, it is an absolute rather than a relative measure. Since underpricing is generally expressed as a relative measure, a relative transformation of the proxy may provide a better fit. Accordingly, we also examine two proxies for ex-post value uncertainty that are relative.

The first relative measure we examine is the standard deviation of return based on quote midpoints. Employing returns based on fixed units of time (e.g. five minutes) may not capture the intensity of trading (therefore uncertainty) in the first few minutes of the aftermarket. Therefore, we calculate returns as quote update to quote update and then calculate the

[11] Complete results not reported here, but available from the authors upon request.

standard deviation of returns. The second relative measure we calculate is to standardize the quote midpoint standard deviations by the offering price. Examining the various periods for both measures in Table 3 reveals the same general pattern as that for the standard deviation of quote midpoints.

Although all three measures suggest that there is value uncertainty at the beginning of trading in IPOs, the findings thus far provide no evidence that this uncertainty is priced as Chen and Wilhelm (2005) suggest. In order to test their hypothesis we regress the percentage underpriced on our various proxies for ex-post value uncertainty, while controlling for other variables known to be associated with underpricing (and used in previous studies.) This includes the standard deviation of daily return over the 20 days immediately following the IPO as well as the offering size as measured by the IPO proceeds. We also control for other deal-specific characteristics. This includes an indicator of whether the issue is oversubscribed (*hot issues)* since there is evidence in the literature (Cornelli and Goldreich (2001)) that oversubscription is positively related to underpricing. We also control for the reputation of the IPO lead underwriter which the literature documents to be positively related to the degree of underpricing during our sample period. In addition, we also incorporate firm specific characteristics such as the age of the firm and whether the firm is technology based or a dot com, which previous studies have shown to be related to underpricing (see Loughran and Ritter (2004) among others). Finally, previous studies have used the log of the first day's volume as a proxy for ex-ante uncertainty, but is also a potential proxy for ex-post value uncertainty. Consequently, we perform the following regression

$$\begin{aligned} \%Under_i &= \alpha + \beta_1 \sigma_{return,i} + \beta_2 LN(OfferProceeds_i + \beta_3 Hot + \beta_4 Ln(1+age)_{i\,i} \\ &+ \beta_5 Internet + \beta_6 Tech_i + \beta_7 Rank_i + \beta_8 LN(Volume) + \sum_{j=9}^{n} \beta_j Proxy_j \quad (1) \end{aligned}$$

where *%Under*$_i$ is defined as (First Day Closing Price – Offering Price) / First Day Closing Price; $\sigma_{return,1}$ is the standard deviation return based on daily closing prices over the 20 days starting with the IPO date, LN(*Offer Proceeds)* is the log of firm *i*'s offering size (in millions of dollars) computed as the total number of shares issued at the offering times the offering price. *Hot*$_i$ is defined as (*Offering Price – Mid Range)/Mid Range*; where *Mid Range* is the midpoint of the originally filed price range.[12] *Ln(1+age)* is the measure used in Loughran and Ritter (2004) where age is the number of years since the company was founded.[13] *Internet* and *Tech* are dummy variables assigned the value of 1 if the IPO is an internet or technology IPO, respectively.[14] *RANKi* is the lead underwriter rank obtained from Loughran and Ritter's (2004) classification which is based on Carter and Manaster (1990) and Carter, Dark and Singh (1998) rankings. Underwriters are ranked from 1 to 9 with higher numbers indicating higher reputation and quality. LN(*Volume*) is the log of the first day's volume. Finally *Proxy*$_j$ is one of the candidates for ex-post value uncertainty listed earlier (i.e., standard deviation of quote midpoints, standard deviation of midpoint returns, or the standardized standard deviation of quote midpoints) over various periods following the beginning of secondary market trading.

We estimate eight different models based on Equation (1.) Tthe parameter estimates are reported in Table 4. White consistent t statistics are in parentheses below the parameter estimates. As a base line, we first examine the model without any proxies for ex-post value uncertainty. This is identified as Model 1 in Table 4. The parameter estimate signs and significances are similar to those of previous studies and the amount of variation in the dependant variable (31%) is similar to recent studies that have included these variables.

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[12] Cornelli and Goldreich (20023) show that hot issues are more likely to be priced close to the upper bound of the originally filed price range

[13] The source of founding dates is the Field-Ritter dataset of company founding dates, as used in Laura C. Field and Jonathon Karpoff "Takeover Defenses of IPO Firms" in the October 2002 Journal of Finance Vol. 57. No. 5, pp. 1857-1889, and Tim Loughran and Jay R. Ritter, "Why Has IPO Underpricing Changed Over Time?" in the Autumn 2004 Financial Management Vol. 33, No. 3, pp. 5-37.

[14] Both are obtained from Jay Ritter's website and constitute Appendix C and D of Loughran and Ritter (2004).

In Models 2 through 5 are Model 1 with the addition of the standard deviation of quote midpoints for various ex-post subperiods. We first include the standard deviation for all of the first trading day. Examining the parameter estimate in Model 2 we find that this proxy for ex-post value uncertainty is of the expected sign and statistically significant. The parameter estimate for 20 day standard deviation of return is still significant, but its parameter estimate is smaller than the first model suggesting that our measure may be correlated with these other measures, rendering our results spurious. We therefore test for multicollinearity by calculating variance inflation factors (VIFs) for our independent variables. All of the VIFs are less than 2.75 suggesting no multicollinearity in our model. Turning to the R^2 for Model 2, we find that including our first candidate proxy for ex-post value uncertainty increases the explanatory power of the baseline model from 0.31 to 0.58. The R^2 of Model 2 is much larger than any of the previous studies reported in Table 1. This suggests that ex-post value uncertainty is priced in IPOs and has been overlooked in previous studies.

In the next model, we disaggregate the day into the first two hours of trading and the remainder of the first trading day to determine if any additional power can be obtained. Examing the parameter estimates for Model 3, reveals that both parameter estimates are of the expected sign and statitically significant. The R^2 increases to 0.61. This suggests that the expost uncertainty does not completely resolve itself in the first two hours of trading. To explore this topic further, we next include the standard deviation of quote midpoints on day two, as well as the disaggregation of day two. Exmining Model 4 revels that additional explantory power can be acheived by includsing day 2. However, examining the day 2 disaggrgaetion variables in Model 5, reveals that including the standard deviation of quote midpoints for the first two hours of trading on day 2 results in a statistically significant coefficient, the reaminder of the day is not significant. Further, no additional explantory power is acheived by disaggreegating the second trading day, as the R^2 remains at 0.66.

Recall that the model with the largest explanatory power for US markets reported in Table 1 is Habib and Ljungqvist (2001) with an R^2 of 0.332. Our finding of an R^2 almost double that, therefore suggests that ex-post value uncertainty is an important determinant of IPO underpricing. Our findings provide strong support for the theory of Chen and Wilhelm (2005.)

We next examine whether alternative forms of our measure can provide any additional explanatory power beyond that already reported. In particular, we calculate relative versions of our measure, as previously reported in Table 3. Model 6 includes the standard deviation of return based on quote midpoints. Examining the parameter estimate we find that it is of the correct sign but statistically insignificant. The last relative measure is to standardize the standard deviation of quote midpoints by the offering price.[15] The last two colums of Table 4 contain the results for two forms of the model.[16] Models 7 and 8 are the same as Models 3 and 4 except that the two relative measures of ex-post value uncertainty are used. Comparing the relative ex-post value uncertainty variables in Model 8 to those in Model 4, we find that the relative measures are of the expected sign and significant. Of most importance is that using the realtive measure of ex-post value uncertainty increases the explanatory power of the model from 66% to 72%.

Our results may be driven by outliers in our sample. To test for this possibility, we identify influential observations, exclude them, and rerun our regressions.[17] Our results are qualitatively similar to those reported in Table 4 leading us to conclude that our results are not being driven by outliers.

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[15] This is similar to calculating the coefficient of variation, except that we are using the offering price for each standard deviation measure rather than the mean of the distribution. In this way, all of the measures are similarly standardized.

[16] To save on space, only the two models with the greatest R^2 are reported. Complete results are available from the authors upon request.

[17] Following the methodology proposed by Belsley, Kuh, and Welsch (1980), we adjust for sample size by excluding any obervation which has a DFFITS statistic greater than $2\sqrt{\frac{P}{N}}$ where P is the number of parameters in the model and N is the number of observations used in the regression. Following this criteria excludes approximately 3% of our sample.

Note that in Models 7 and 8, we are dividing by the offering price to obtain a relative proxy of ex-post uncertainty. The dependent variable is also constructed by dividing by the offering price. Therefore the higher power of Model 8 may be a statistical artifact or may reflect the fact that the independent variables are a better fit for the actual dollar amount of underpricing. To determine which of these is true, we rerun Model 4 using the actual dollar amount of underpricing as the dependent variable.[18] We find that the explanatory power of the model incresaes from 66% to 75%. This suggests that our previous finding of an increase in explanatory power is not a statistical atifact but rather that previous models of IPO underpricing may be best thought of as explaining the dollar amount of underpricing rather than the relative amount (i.e. first day return).

Our results provide very strong support for Chen and Wilhelm (2005) and suggest that uncertainty about firm value in IPOs has two componenmts – ex-ante and ex-post. More importantly, our findings indicate that, of the two, ex-post uncertainty appears to explain a larger portion of variation in the amount of underpricing in IPOs.

5. Conclusion and Areas for Further Research

This paper examines whether ex-post value uncertainty is a determinant of IPO underpricing. While numerous previous studies consider and proxy for ex-ante value uncertainty, only recently have theoretical papers considered that value uncertainty may continue to be resolved after the start of trading (ex-post). In particular Chen and Wilhelm (2005) argue that underwriters rely on institutions to temporarily hold shares until they can be distributed to the ultimate secondary market investors. This then provides price stabilization and the IPOs are underpriced to compensate these institutions for holding the shares.

[18] Not reported here, but available from the authors upon request.

Chen and Wilhelm (2005) also argue that "early secondary market uncertainty provides incentive for further information production" beyond that produced in the bookbuilding process. It then follows that the greater the ex-post value uncertainty the greater the incentive needed to compensate institutions for facilitating the distribution of IPO shares to the ultimate secondary market investors.

In the same vein, Saar (2001) and Draho (2001) also develop theoretical models that stress the importance of ex-post value uncertainty on bid-ask spreads and (in the case of Draho) on IPO underpricing. These two studies together with Chen and Wilhelm (2005) all suggest that spreads in IPOs will be widest at the start of trading and will narrow as uncertainty is resolved. We find support for Saar's hypothesis in that spreads on our sample of IPOs narrows from $0.48 to $0.35 within four minutes of the start of trading. These four minutes (about 1% of the time in a typical trading day) also represent the period during which 18.9% of the total offering is traded.

The main contribution of this paper is a) to develop several proxies for ex-post value uncertainty - which are based on our observation that ex-post value uncertainty appears to resolve quickly and b) to provide a first empirical test for the hypothesis that ex-post value uncertainty affects IPO underpricing and specifically, that the two are positively correlated.

In particular, we focus on the standard deviation of quote midpoints over several time periods immediately following the initial start of trading. The first and second days of trading are disaggregated into the first two hours and the remainder of the trading day. We find that volatility is highest during the first two hours of trading and then declines, consistent with Saar (2001) and Chen and Wilhelm (2005.) In addition to the standard deviation of quote midpoints, we also construct tow relative measures: the standard deviation of returns based on the midpoint of quote updates; and the standard deviation of quote midpoints divided by the issue's offering price. A similar pattern is found for these relative measures as well.

To determine the explanatory power of these proxies for ex-post value uncertainty, we regress the percentage underpriced against our proxies as well as control variables used in previous studies. A number of the control variables are proxies for ex-ante uncertainty which Beatty and Ritter (1986) argue is the main determinant of underpricing. We find that including proxies for ex-post value uncertainty more than doubles the explanatory power of previous model. This provides strong support for Chen and Wilhelm (2005) and suggests that ex-post value uncertainty may be more important than ex-ante uncertainty in determining the level of underpricing.

In our study, we group together exchange listed and NASDAQ stocks. These two groups of stocks open very differently. While exchanges provide relatively more centralized collection of supply and demand, the fragmented nature of NASDAQ suggested less efficient information generation. This in turn suggests that ex-post value uncertainty may be very different for NASDAQ IPOs versus exchange-listed IPOs. Future work should explore these different opening procedures and examine their relationship to the amount of ex-post value uncertainty.

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Table 1
Previous Evidence of the Relationship between Underpricing and Ex-Ante Uncertainty

This table lists previous studies that regressed underpricing on proxies for ex-ante uncertainty. Studies are grouped by the proxy used as in Table 3.2 of Jenkinson and Ljungqvist (2001) Listed are the proxy, the authors of the study, the country the studied examined and the largest R^2 the study found for models including the proxy.

Proxy	Study	Country	R^2
Age	Carter and Manaster (1990)	USA	0.015
	James and Wier (1990)	USA	0.110
	Megginson and Weiss (1991)	USA	0.059
	Wasserfallen and Wittleder (1994)	Germany	0.210
	Hamao et al. (2000)	Japan	0.148
	Habib and Ljungqvist (2001)	USA	0.332
	Loughran and Ritter (2004)	USA	0.290
Sales	Wasserfallen and Wittleder (1994)	Germany	0.210
	Habib and Ljungqvist (2001)	USA	0.332
	Loughran and Ritter (2004)	USA	0.290
Gross proceeds	Beatty and Ritter (1986)	USA	0.070
	Tinic (1988)	USA	0.035
	Finn and Higham (1988)	Australia	0.029
	Carter and Manaster (1990)	USA	0.015
	James and Wier (1990)	USA	0.110
	Megginson and Weiss (1991)	USA	0.059
	Wasserfallen and Wittleder (1994)	Germany	0.210
	Hamao et al. (2000)	Japan	0.148
	Habib and Ljungqvist (2001)	USA	0.332
	Corwin and Harris (2001)	USA	0.112
	Aggarwal, Prabhala and Puri (2002)	USA	0.301
Percentage Width of Filing Range	Aggarwal, Prabhala and Puri (2002)	USA	0.301
Offer price	Tinic (1988)	USA	0.035
	Beatty and Welch (1996)	USA	0.103
Underwriting fee	Beatty and Welch (1996)	USA	0.103
	Habib and Ljungqvist (2001)	USA	0.332
Log (1+ Number of uses of IPO proceeds)	Beatty and Ritter (1986)	USA	0.070
	Beatty and Welch (1996)	USA	0.103
	McGuinness (1992)	Hong Kong	0.440
Venture-backing	Megginson and Weiss (1991)	USA	0.059
	Hamao et al. (2000)	Japan	0.148
	Corwin and Harris (2001)	USA	0.112
	Loughran and Ritter (2004)	USA	0.290
Underwriter reputation	Tinic (1988)	USA	0.035
	Carter and Manaster (1990)	USA	0.015
	Megginson and Weiss (1991)	USA	0.059
	McGuinness (1992)	Hong Kong	0.440
	Habib and Ljungqvist (2001)	USA	0.332
	Loughran and Ritter (2004)	USA	0.290
	James and Wier (1990)	USA	0.110
Standard deviation of after-market returns	Finn and Higham (1988)	Australia	0.029
	McGuinness (1992)	Hong Kong	0.440
	Wasserfallen and Wittleder (1994)	Germany	0.210
	Corwin and Harris (2001)	USA	0.112

Table 2
Descriptive Statistics

This table provides descriptive statistics for a sample of 2,029 initial public offerings (IPO) of common stock that opened between January 1993 and December 1998. Our sample includes IPOs that list on the AMEX, NASDAQ, or NYSE during the sample period and have no missing observations for any of the listed variables. Listed are the mean, median, minimum, and maximum for each variable.

Variable	Mean	Median	Minimum	Maximum
Offering Size	$58,395,135	$31,360,000	$2,250,000	$3,963,148,032
Offering Price	$11.98	$12.00	$3.00	$35.00
First day Return	16.3%	8.9%	-29.2%	605.5%
First Day Volume	1,366,201	1,773,996	100	52,886,798
20 day Standard Deviation of Return	3.84%	3.46%	0.36%	31.08%
Age of Firm	7.96 Years	8	0	152
Hot	-0.4%	0	-60.5%	118.2%
Underwriter Rank	6.6	8.0	1.0	9.0
Percentage of shares traded in 1st four minutes	18.9%	13.6%	0	100%

Table 3

Proxies for Ex-post Value Uncertainty

This table provides descriptive statistics for candidate measures of ex-post value uncertainty, for a sample of 2,029 initial public offerings (IPO) of common stock that opened between January 1993 and December 1998. Our sample includes IPOs that list on the AMEX, NASDAQ, or NYSE during the sample period and have no missing observations for any of the control variables used in our regressions. Candidate variables are the standard deviation of quote midpoints, standard deviation of transaction returns, and the standard deviation of quote midpoints divided by the offering price, Values for each variable are estimated for each IPO over three time periods on the first two days of trading: the entire day, and the day partitioned into the first two hours and the remainder of the trading day. Listed are the mean, median, minimum, and maximum for each variable.

Measure	Period	Mean	Median	Minimum	Maximum
Standard Deviation of Quote Midpoints	Day 1 – All	32.25%	20.29%	0	773.39%
	Day 1 – 1st 2 hours	27.69%	17.95%	0	1,052.29%
	Day 1 – Rest of day	13.77%	8.41%	0	367.62%
	Day 2 – All	21.73%	12.75%	0	736.59%
	Day 2 – 1st 2 hours	18.67%	10.22%	0	807.09%
	Day 2 – Rest of day	8.05%	3.86%	0	190.15%
Standard Deviation of Quote Midpoint Returns	Day 1 – All	0.61%	0.47%	0	51.83%
	Day 1 – 1st 2 hours	0.59%	0.44%	0	53.75
	Day 1 – Rest of day	0.32%	0.26%	0	3.65%
	Day 2 – All	0.44%	0.37%	0	7.54%
	Day 2 – 1st 2 hours	0.36%	0.29%	0	7.55%
	Day 2 – Rest of day	0.32%	0.25%	0	2.86%
Standard Deviation of Quote Midpoints Divided by Offering Price	Day 1 – All	2.77%	1.89%	0	85.93%
	Day 1 – 1st 2 hours	2.42%	1.62%	0	88.14%
	Day 1 – Rest of day	1.08%	0.72%	0	40.85%
	Day 2 – All	1.80%	1.16%	0	81.84%
	Day 2 – 1st 2 hours	1.55%	0.94%	0	89.67%
	Day 2 – Rest of day	0.62%	0.32%	0	15.64%

Table 4
Regression Results

This table examines the relationship between the first day return (offer to close) and a number of candidates that proxy for ex-post value uncertainty. The sample includes 2,029 initial public offerings (IPO) of common stock that opened between January 1993 and December 1998. Our sample includes IPOs that list on the AMEX, NASDAQ, or NYSE during the sample period and have no missing observations for any of the control variables used in our regressions. Candidate variables are the standard deviation of transaction returns, standard deviation of quote midpoints and the standard deviation of quote midpoints divided by the offering price, Values for each variables are estimated for each IPO over three time periods on the first two days of trading: the entire day, and the day partitioned into the first two hours and the remainder of the trading day. First day return is defined as (Closing Trade Price – Offering Price) / Closing Trade Price. Control variables include *20-Day* σ_{Return} which is the standard deviation of daily return over the first 20 of trading, ***LN(Offer proceeds)*** is the log of the dollar size of firm *i*'s offering (in millions), *Hot* is defined as (*Offering Price – Mid Range)/Mid Range*; where *Mid Range* is the midpoint of the original filed price range. *Ln(1+age)* is the log of 1 plus the age of the firm. *Internet* and *Tech* are dummy variables assigned the value of 1 if the IPO is an internet or technology IPO, respectively. *Rank* is the rank of the lead underwriter based on Loughran and Ritter (2004) and varies from 1 to 9. Ln(Volume) is the log of the trading volume on the first day of trading. Due to data limitations, the number of observations for each regression is 2,029. White consistent t statistics are in italics. We report the adjusted R^2 for each regression in the last row.

Table on following page.

Table 4 (continued)

	1	2	3	4	5	6	7	8
		$\sigma_{Midpoints}$				$\sigma_{MPreturn}$	$\frac{\sigma_{Midpoints}}{\text{Offer Price}}$	
Intercept	0.22 *1.59*	0.47*** *5.62*	0.67*** *5.94*	0.79*** *7.32*	0.76*** *7.54*	0.22 *1.61*	-0.05 *-0.46*	0.01 *0.10*
20-Day σ_{Return}	2.88*** *3.46*	1.09** *2.25*	0.78* *1.78*	-0.21 *-0.65*	-0.23 *-0.07*	2.88*** *3.46*	0.27 *0.96*	-0.41* *-1.80*
LN(Offer proceeds)	-0.06*** *-6.26*	-0.06*** *-6.12*	-0.06*** *-6.01*	-0.06*** *-6.94*	-0.07*** *-7.04*	-0.06*** *-6.23*	-0.01 *-1.18*	-0.01* *-1.89*
Hot	0.49*** *7.37*	0.24*** *2.85*	0.23*** *3.32*	0.19*** *3.68*	0.20*** *4.21*	0.49*** *7.38*	0.35*** *12.29*	0.34*** *12.71*
Ln(1+Age)	-0.005 *-1.27*	-0.001 *-0.46*	-0.002 *-0.67*	-0.001 *-0.26*	-0.001 *-0.44*	-0.005 *-1.27*	0.000 *0.03*	0.001 *0.25*
Internet IPO	0.19** *2.41*	0.02 *0.51*	0.02 *0.44*	0.02 *0.43*	0.01 *0.15*	0.19** *2.41*	0.03 *0.85*	0.03 *0.97*
Technology IPO	0.01 *0.29*	0.04 *1.61*	0.02 *1.06*	0.03 *1.05*	0.03 *1.41*	0.01 *0.29*	0.01 *0.85*	0.02 *0.88*
Underwriter Rank	-0.001 *-0.42*	-0.001 *-0.76*	-0.001 *-0.58*	-0.001 *-0.79*	-0.001 *-0.64*	-0.001 *-0.42*	- 0.002 *-0.77*	-0.002 *-1.65*
Ln(Volume)	0.06*** *6.31*	0.04*** *4.18*	0.03*** *4.04*	0.03*** *4.04*	0.03*** *4.36*	0.06*** *6.33*	0.02*** *3.09*	0.02*** *3.77*
1st Day $\sigma_{midpoints}$		0.37*** *4.05*						
1st 2 Hours $\sigma_{midpoints}$			0.23** *2.27*	0.17** *2.14*	0.16** *2.09*			
Rest of Day 1 $\sigma_{midpoints}$			0.49*** *3.60*	0.36*** *4.18*	0.37*** *4.10*			
2nd Day $\sigma_{midpoints}$				0.27*** *4.21*				
1st 2 Hours 2nd $\sigma_{midpoints}$					0.24*** *3.16*			
Rest of Day 2 $\sigma_{midpoints}$					0.05 *0.94*			
1st Day σ_{Return}						0.04 *0.28*		
1st 2 Hours $\sigma_{midpoints}$/Offer							3.77*** *7.73*	3.06*** *6.39*
Rest of Day 1 $\sigma_{midpoints}$/Offer							5.61*** *8.14*	4.37*** *7.29*
2nd Day $\sigma_{midpoints}$/Offer								2..19*** *5.41*
Adj. R^2	0.31	0.58	0.61	0.66	0.66	0.31	0.70	0.72

*** Denotes significant at the 0.01 level

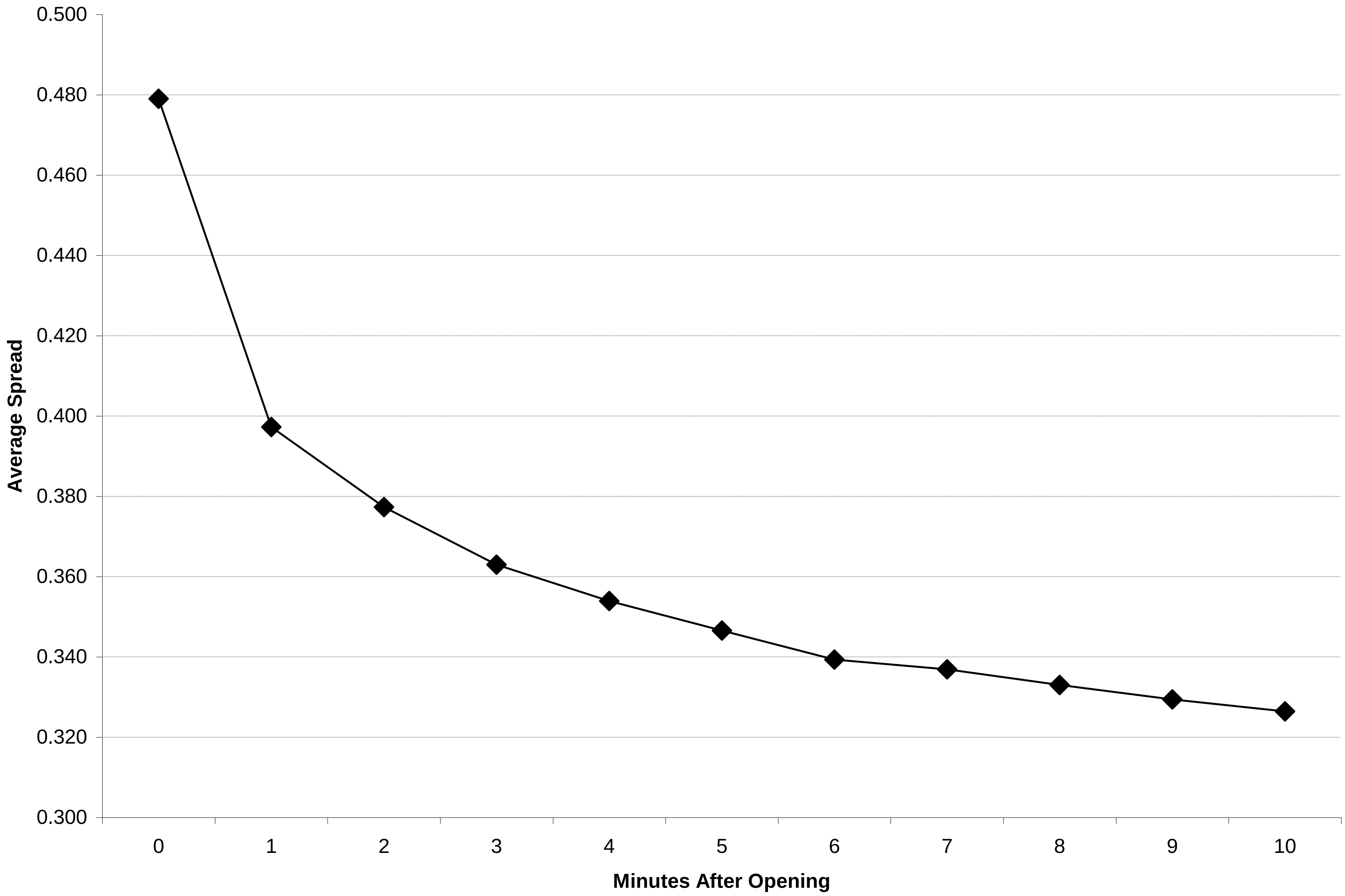
** Denotes significant at the 0.05 level

* Denotes significant at the 0.10evel

Figure 1
Spread Patterns

This figure depicts the pattern of spreads during the first 10 minutes of trading for a sample of 2,029 initial public offerings (IPO) of common stock that opened between January 1993 and December 1998. Our sample includes IPOs that list on the AMEX, NASDAQ, or NYSE during the sample period and have no missing observations for any of the control variables used in our regressions. Spread is defined as the ask minus the bid.

(Figure next page)



0.500
0.480
0.460
0.440
0.420
0.400
0.380
0.360
0.340
0.320
0.300
Average Spread
0
1
2
3
4
5
6
7
8
9
10
Minutes After Opening