CENTRO STUDI IN ECONOMIA E FINANZA

CENTRE FOR STUDIES IN ECONOMICS AND FINANCE

WORKING PAPER NO. 99

IPO underpricing and after-market liquidity

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First draft: March 2001

This version: May 2003

DIPARTIMENTO DI SCIENZE ECONOMICHE - UNIVERSITÀ DEGLI STUDI DI SALERNO

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Abstract

The underpricing of the shares sold through Initial Public Offerings (IPOs) is generally explained with asymmetric information and risk. We complement these traditional explanations with a new theory. Investors who buy IPO shares are also concerned by expected liquidity and by the uncertainty about its level when shares start trading on the after-market. The less liquid shares are expected to be, and the less predictable their liquidity is, the larger will be the amount of "money left on the table" by the issuer. We present a model that integrates such liquidity concerns within a traditional framework with adverse selection and risk. The model's predictions are supported by evidence from a sample of 337 British IPOs effected between 1998 and 2000. Using various measures of liquidity, we find that expected after-market liquidity and liquidity risk are important determinants of IPO underpricing, after controlling for variables traditionally used to explain underpricing.

Keywords: liquidity, initial public offering, post-IPO market, after-market trading.

JEL classification: G1, G2, G3.

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Acknowledgements: We thank Utpal Bhattacharya, John Chalmers, Venkat Eleswarapu, Craig Holden, Jonathan Karpoff, Tullio Jappelli, Alexander Ljungqvist, Andy Lo, Stewart Myers, Kjell Nyborg, Mario Padula, Kristian Rydqvist and Ingrid Werner for useful discussions and comments. We also thank participants to seminars at MIT and Indiana, to the 2002 Yale-Nasdaq-JFM Market Microstructure Conference, the Bocconi University conference on Risk and Stability in the Financial System, and the FEEM conference on Auctions and Market Design. We acknowledge financial support from the Italian National Research Council (CNR) and the Italian Ministry of Education, University and Research (MIUR). This paper is produced as part of a CEPR research network on "The Industrial Organization of Banking and Financial Markets in Europe", funded by the European Commission under the TMR Programme (contract No. ERBFMRXCT980222).

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1. Introduction

The underpricing of the shares sold through Initial Public Offerings (IPOs) is generally explained in the literature with asymmetric information about the security's value and with its fundamental risk. For the IPO to attract sufficient interest, the issuer must leave enough "money on the table" to compensate investors for the uncertainty about the security's value. However, until now the literature has largely disregarded how after-market liquidity may impact on the IPO underpricing. This is a striking omission in view of the established evidence that the returns of seasoned securities include a liquidity premium. One would expect such premium to be paid also by stocks in the process of being floated. Moreover, at the IPO stage investors do not know precisely how liquid the after-market will be. This suggests that they will not only care about expected liquidity but also about the uncertainty about it, that is, about liquidity risk.

Our paper fills this gap. It complements traditional explanations with theory and evidence showing that after-market liquidity is an important determinant of IPO underpricing. We provide a simple model showing that an IPO that is expected to be more illiquid and to have higher liquidity risk should feature higher underpricing. Several IPO investors anticipate that they may have to resell the stock in the immediate aftermarket due to liquidity needs, or may even plan such an immediate resale ("flippers"). These investors require compensation for the expected trading cost that they will incur, as well as for the associated uncertainty, just as they would for a random transaction tax. The correlations predicted by the model are therefore stronger in markets where a substantial fraction of initial investors are "flippers".

The model nests these predictions with those of more traditional models. We then test for the presence of these liquidity effects on IPO underpricing, controlling for the variables suggested by other theories of IPOs. Our sample includes data for all the companies that went public on the London Stock Exchange (LSE) between June 1998 and December 2000.

British data are uniquely suited for a test of our hypothesis. First, the London aftermarket does not feature pervasive underwriter stabilization, unlike U.S. markets where the lead underwriter always becomes the most active dealer in the issue

(Aggarwal, 2000, and Ellis, Michaely and O'Hara, 2000). Underwriter stabilization *per se* could account for IPO underpricing, by reducing the occurrence of initial negative returns (Ruud, 1993). Since stabilization can also artificially enhance liquidity, it may generate a spurious relationship between underpricing and aftermarket liquidity. Second, our data are particularly rich, allowing us to build accurate measures of liquidity while controlling for many company characteristics.

In line with our model and with previous market microstructure studies, we measure liquidity by the after-market's bid-ask spread, defined in various alternative ways. Our main empirical challenge is to estimate the market's expectation of after-market liquidity and of its variability, conditioning on information known at the time of the IPO. We use various methodologies to tackle this issue.

Consistent with our hypotheses, we find that IPO underpricing is higher for shares featuring lower expected liquidity and higher liquidity risk. The effects of liquidity variables are found to be robust to (a) the inclusion of the other factors traditionally used to explain IPO underpricing, that is, variables capturing asymmetric information and fundamental risk, and (b) the use of alternative econometric methodologies.

To gain perspective, it is useful to set our contribution against the background of the literature. Many models explain IPO underpricing with some form of information asymmetry about the true value of the IPO shares. In Baron (1982), the issuer knows less about the true value of the company than the investment bank entrusted with the sale, while in Benveniste and Spindt (1989) the issuing firms elicit information from investors via their bank's book-building effort. In Rock (1986) the information asymmetry is among potential IPO investors: some are "informed" and others "uninformed", generating a winners' curse problem. The informational asymmetry may also induce investors to rely on other buyers' behavior in placing their bids, leading to an informational cascade. This happens in Welch (1992), where issuers underprice IPO shares to attract some potential investors in the IPO, whose bids will in turn attract other investors.

Little attention has been instead devoted to the link between secondary market liquidity and IPO underpricing. The only exception is the study by Booth and Chua

(1996), who suggest that IPO underpricing aims to elicit the interest of a target number of potential investors. They assume that enlarging the pool of dispersed shareholders raises the valuation of the firm, by creating liquidity in the after-market, but requires attracting investors with higher information collection costs. The optimal price will weigh the liquidity benefit of added investor participation against its cost. Our paper turns this argument on its head. Since different IPO shares feature different after-market liquidity, the IPO underpricing required to attract uninformed investors will differ accordingly. The causality runs from aftermarket liquidity to IPO underpricing, contrary to Booth and Chua's logic. Also the predicted sign of the correlation between the two variables is opposite in the two models: higher underpricing should lead to greater liquidity according to Booth and Chua (1996), while greater liquidity calls for lower underpricing in our model. Finally, a distinctive prediction of our model is that underpricing should reflect also liquidity risk.

So far, the relationship between returns and liquidity has been modeled and tested only with reference to seasoned securities. Many studies – both theoretical and empirical – argue that illiquid securities must provide investors with a higher expected return to compensate them for the larger trading costs they have to bear. The first paper to model and test this relationship is Amihud and Mendelson (1986). Other studies find a significant cross-sectional association between liquidity (as measured by the tightness of the bid-ask spread or trading volume) and asset returns, controlling for risk: among these, Brennan and Subrahmanyam (1996), Chordia, Roll and Subrahmanyam (2000), Datar, Naik and Radcliffe (1998), and Eleswarapu (1997). More recently, some studies have investigated also the relationship between liquidity risk and stock returns: while Chordia, Subrahmanyam and Anshuman (2001) find a negative relationship between returns and the variability of trading volume, Pástor and Stambaugh (2003) document a positive cross-sectional relationship between systematic liquidity risk and stock returns.

Liquidity affects also the returns of fixed-income securities, according to several studies.[1] Among these, the closest paper to ours is by Goldreich, Hanke and Nath (2002), who investigate the impact of *expected* liquidity on current securities' prices. They analyze the prices of Treasury securities as their liquidity changes predictably, in the transition from on-the-run to the less liquid off-the-run status. They show that more liquid securities command higher prices, but this liquidity premium depends on the expected future liquidity over their remaining lifetime rather than on their current liquidity.

Our paper can be seen as extending the insight from this literature to the primary equity market. If seasoned securities provide a liquidity premium in their returns, it is reasonable to expect also stocks on the primary market to provide such premium – especially if the market for IPO shares is much less liquid than that for seasoned issues, as we find empirically. Moreover, for IPO shares liquidity is also an additional source of uncertainty, unlike for seasoned securities. By their very nature, IPO shares are of unknown liquidity. At the IPO stage, investors do not know yet how liquid the after-market will be, and therefore will want to be compensated *also* for liquidity risk.

The paper is organized as follows. Section 2 presents a model nesting the impact of liquidity on IPO underpricing with the more traditional theories, and providing the basis for our empirical tests. Section 3 reviews the data and presents the measures of liquidity used in the estimation. Section 4 presents the empirical methodology and illustrates the results. Section 5 concludes.

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[1] Amihud and Mendelson (1991) show that the yield to maturity of treasury notes with six months or less to maturity exceeds the yield to maturity on the more liquid treasury bills. Other studies on U.S. public debt securities by Warga (1992), Daves and Ehrhardt (1993), Kamara (1994) and Krishnamurthy (2000) confirm these findings. However, using more recent data Strebulaev (2001) finds that the yield spread between bills and matched notes is much smaller than previously found, especially when bills are on-the-run. Some studies apply the same basic idea, by comparing securities with identical cash flows but different trading opportunities. Silber (1991) compares stocks with different trading restrictions. Dimson and Hanke (2001) examine equity-linked bonds with the same cash flows as an investment in an equity index, and find that they sell at a discount relative to their underlying value – a mispricing that can be attributed to the their low liquidity.

2. The Model

In this section, we develop a simple theoretical model to explain the relationship between after-market liquidity and IPO underpricing and derive the hypotheses to be tested. In this model there are three stages: at $t = 0$, the IPO occurs; at $t = 1$, the company's shares are traded on the after-market, and at $t = 2$ the shares are liquidated (or can be traded) at their fundamental value. The time line in Figure 1 illustrates these three stages, and describes the information and actions of market participants at each stage.

[Insert Figure 1 here]

The model captures the presence and interaction of two distinct adverse selection problems: that affecting the primary market (as in the classic model of IPO underpricing by Rock, 1986) and that determining secondary market liquidity (as in the equally classic model by Glosten and Milgrom, 1985). In the model's baseline version, developed assuming risk neutrality, IPO underpricing is determined not only by adverse selection in the IPO process, but also by the magnitude of the spread in the after-market. When uninformed investors are assumed to be risk-averse, IPO underpricing is also affected by fundamental risk, by its interaction with adverse selection in the IPO and with the after-market spread, and by a quadratic term in the bid-ask spread. Finally, we extend the model to encompass also liquidity risk, assuming that at the IPO stage investors do not know the precise level of the after-market bid-ask spread. In this extended version, IPO underpricing is also increasing in liquidity risk: investors require compensation not only for the expected level of trading costs in the after-market, but also for their variability.

Before turning to the model, it is worth stressing that its ideas are more general than the specific modeling strategy chosen to capture them. For instance, the results would be qualitatively unchanged if the bid-ask spread resulted from the inventory costs of risk averse dealers or from their order processing costs. The result that IPO underpricing must include a reward for the expected liquidity costs and the corresponding risk borne by investors does not depend on the specifics of the market microstructure.

2.1 Information Structure

The company's fundamental value is $\tilde{V} = V + \tilde{u}_1 + \tilde{u}_2$, where V is a positive constant and $\tilde{u}_1$ and $\tilde{u}_2$ are independently distributed random variables that represent "news" publicly disclosed at stages 1 and 2 respectively. The variable $\tilde{u}_1$ equals $-\eta$ or η with probability 1/2 each: if $\tilde{u}_1 = \eta$ the company is disclosed to be of high quality in after-market trading, while if $\tilde{u}_1 = -\eta$ the company is revealed to be of low quality. Similarly, $\tilde{u}_2$ equals $-\varepsilon$ or ε with probability 1/2, implying that in after-market trading there is still some residual uncertainty about the final value of the company. Therefore, the expected value of a share based only on public information is V at t = 0, $V + \tilde{u}_1$ at t = 1, and $V + \tilde{u}_1 + \tilde{u}_2$ at t = 2.

Some investors base their actions not only on public but also on private information, at the IPO stage as well as in after-market trading. At t = 0, the investors who can buy the company's shares are of two types: while M of them are uninformed, N have advance knowledge of the realized value of $\tilde{u}_1$, that is, know the company's quality. Similarly, at t = 1, with probability Q a trader has advance information about the realized value of $\tilde{u}_2$, that is, knows the company's final value and conditions his orders on such information. The sequence of events and the evolution of the information structure are shown in Figure 1.

2.2 Primary and Secondary Market Structure

The primary market is modeled as in Rock's model. The company sells S shares in the IPO, and chooses the highest offer price P_0 consistent with selling them. If possible, the S shares are sold by filling all the bids made at the preset price P_0; otherwise, they are allocated via a lottery that gives the same probability of receiving one share to each bidder. The uninformed investors are wealth-constrained: each of them can buy at most one share with his initial wealth (plus any the credit he can obtain), at the equilibrium price P_0. Investors cannot buy fractional values of a share in the IPO.

Uninformed investors are sufficiently numerous that they can buy all the shares on sale if they all bid ($M > S$), while informed investors cannot, if they bid for one share each ($S > N$). Since informed investors must bid for one unit each to avoid giving themselves away, the IPO price must be chosen so as to attract also bids from uninformed investors.

The secondary market that opens at $t = 1$ is operated by dealers. Apart from its analytical convenience, this assumption is attuned to our data, which refer to a dealer market. Dealers are assumed to be risk-neutral and perfectly competitive. Each order is to be filled at the quoted price for one unit: at the time of accepting a trade, dealers do not know whether another buy or sell order has also arrived on the market. Hence the ask price at which they are willing to offer one unit is the expected value of the security, given a buy order by a trader of unknown identity. Symmetrically, the bid price is the expected value of the security, given a sell order by a trader of unknown identity.

2.3 Investors' Preferences and Liquidity Needs

We assume all investors to be risk-neutral – an assumption that we shall relax later. In addition, all investors have potential liquidity needs: anyone who buys shares at $t = 0$ has to liquidate them with probability z at $t = 1$, and therefore holds them until $t = 2$ only with probability $1 - z$. For notational simplicity (and with no loss of generality), we assume that each potential liquidity trader is matched with one dealer, so that z is also the probability with which a dealer will receive a liquidity-motivated sell order in the after-market. At $t = 1$ each dealer receives also orders from liquidity-motivated buyers with probability x. We do not model the process that generates these buy orders, but this is not relevant for our results about IPO underpricing, since these are affected only by the sell side of after-market. (In fact, IPO underpricing would be unaffected even if dealers were to receive only sell orders in the after-market.)

To decide whether bidding for a share in the IPO, each investor will consider if the expected value of the share to him, conditional on the information that he has, exceeds the IPO offer price P_0. To compute this expected value, the investor will consider that with probability *z* he will have to liquidate his shareholdings at the bid price $\tilde{P}_1$ that the dealer will post at *t* = 1. With probability $1-z$, instead, he will be able to hold them until *t* = 2 and then sell them at the price $\tilde{P}_2$. Investor *j*, where $j = \{i, u\}$ indexes informed and uninformed investors respectively, will bid price P_0 for a share in the IPO if:

$$zE(\tilde{P}_1^B \mid \Omega_0^j) + (1-z)E(\tilde{P}_2 \mid \Omega_0^j) \geq P_0, \tag{1}$$

$\tilde{P}_1^B$ being the price at which the investor can resell the share at *t* = 1 (the dealer's bid price) and Ω_0^j being the investor's information set at *t* = 0, so that $\Omega_0^i = \{\Omega_0^u, \tilde{u}_1\}$. In computing the expectations in (1), uninformed investors have to take into account the probabilities that by bidding P_0 they get high- or low-quality shares. We shall denote these probabilities by π_u and $1-\pi_u$ respectively.

2.4 Market Equilibrium with Risk-Neutral Investors

The equilibrium is found by backward induction. Since at *t* = 2 all information is public, the final price of a share equals its fundamental value: $\tilde{P}_2 = \tilde{V}$.

At *t* = 1, the quality of the company sold at the IPO is public knowledge: $\tilde{u}_1$ is known by all investors. However, some uncertainty remains for dealers and most investors, $\tilde{u}_2$ being known at most to an insider. The insider observes $\tilde{u}_2$ with probability *Q*, and thus sees $\tilde{u}_2 = \varepsilon$ or $\tilde{u}_2 = -\varepsilon$ with probability $Q/2 \equiv q$ each. To maximize the expected gain from his trades, the insider will place a buy order if $E(\tilde{V} \mid \tilde{u}_2) - P_1^A = \tilde{V} - P_1^A > 0$ and a sell order if $E(\tilde{V} \mid \tilde{u}_2) - P_1^B = \tilde{V} - P_1^B < 0$. To avoid revealing his identity, the insider's order size will be equal to that of liquidity traders' orders.

Recalling that at t = 0 each investor bought at most one share, liquidity traders sell a unit at t = 1, and therefore also the insider sells at most one unit if $\tilde{V} - P_1^B < 0$. Since a liquidity trader sells a unit with probability z, the conditional probability that a sell order comes from the liquidity trader is $z/(q+z)$ and the conditional probability that it comes from the informed trader is $q/(q+z)$. The bid price set by the competitive dealers is the conditional expectation of the share's value:

$$\tilde{P}_1^B = E(\tilde{V}|\tilde{u}_1) = \frac{q}{q+z}(V + \tilde{u}_1 - \varepsilon) + \frac{z}{q+z}(V + \tilde{u}_1) = V + \tilde{u}_1 - \frac{q}{q+z}\varepsilon \,. \qquad (2)$$

Similarly, recalling that a liquidity trader buys a unit with probability x, the ask price is:

$$\tilde{P}_1^A = E(\tilde{V}|\tilde{u}_1) = \frac{q}{q+x}(V + \tilde{u}_1 + \varepsilon) + \frac{x}{q+x}(V + \tilde{u}_1) = V + \tilde{u}_1 + \frac{q}{q+x}\varepsilon \,. \qquad (3)$$

The bid-ask spread therefore is:

$$S \equiv \tilde{P}_1^A - \tilde{P}_1^B = \underbrace{\frac{q}{q+x}\varepsilon}_{S_A} + \underbrace{\frac{q}{q+z}\varepsilon}_{S_B} \,, \qquad (4)$$

The terms S_A and S_B are the spread's bid-side and ask-side portions respectively, that is, the trading costs that an uninformed buyer or seller pays relative to his estimate $V + \tilde{u}_1$ of the share value. The spread S increases in the probability of the insider's orders (q) and decreases in the probability of liquidity buy (x) and sell orders (z). Notice that the spread's bid-side portion S_B increases in q and decreases in z, but is unaffected by x: the liquidity faced by a seller is unaffected by the behavior of liquidity buyers.

Now let us turn to the equilibrium at t = 0. From equation (1), we know that investors informed about $\tilde{u}_1$ bid for shares at the IPO only if

$$zE(\tilde{P}_1|\Omega_0^i) + (1-z)E(\tilde{P}_2|\Omega_0^i) \geq P_0 \,. \qquad (5)$$

So these investors will condition their bids on their private information $\tilde{u}_1$ only if

$$zE(\tilde{P}_1^B | \tilde{u}_1 = \eta) + (1-z)E(\tilde{P}_2 | \tilde{u}_1 = \eta) \geq P_0 > zE(\tilde{P}_1^B | \tilde{u}_1 = -\eta) + (1-z)E(\tilde{P}_2 | \tilde{u}_1 = -\eta),$$

which, using (2) and recalling that $\tilde{P}_2 = V + \tilde{u}_1 + \tilde{u}_2$, can be rewritten as

$$V + \eta - z\frac{q}{q+z}\varepsilon \geq P_0 > V - \eta - z\frac{q}{q+z}\varepsilon . \tag{6}$$

Condition (6), which will be shown to hold in equilibrium, ensures that the informed traders' optimal strategy is to bid only if the company is of good quality ($\tilde{u}_1 = \eta$). Otherwise, they would always bid or never bid irrespective of their private information.

As for uninformed investors, from equation (1) they will bid if

$$zE(\tilde{P}_1^B | \Omega_0^u) + (1-z)E(\tilde{P}_2 | \Omega_0^u) \geq P_0, \tag{7}$$

where, as explained before, expectations are computed using the firm's quality probability distribution conditional on the uninformed bid's success. If π_u denotes the probability that an uninformed investor bidding P_0 gets shares of a high-quality company ($\tilde{u}_1 = \eta$) and $1-\pi_u$ the probability that he will get shares of a low-quality company ($\tilde{u}_1 = -\eta$), the prices that this investor expects to face in the two subsequent periods are:

$$E(\tilde{P}_1^B | \Omega_0^u, P_0) = \pi_u(V + \eta - \frac{q}{q+z}\varepsilon) + (1-\pi_u)(V - \eta - \frac{q}{q+z}\varepsilon) =$$

$$= V - \frac{q}{q+z}\varepsilon - (1-2\pi_u)\eta \tag{8}$$

and

$$E(\tilde{P}_2 | \Omega_0^u, P_0) = \pi_u(V + \eta) + (1-\pi_u)(V - \eta) = V - (1-2\pi_u)\eta . \tag{9}$$

From the last three equations, the condition ensuring that uninformed investors participate in the IPO can be rewritten as:

$$V - (1-2\pi_u)\eta - z\frac{q}{q+z}\varepsilon \geq P_0 . \tag{10}$$

The company will set the offer price at the highest level consistent with participation by the uninformed investors in the IPO, that is, will choose P_0 so that condition (10) holds with equality. This implies also that condition (6) concerning informed investors is satisfied. Therefore, if the company is of high quality, both types of investors bid, and uninformed investors get shares with probability $\lambda = M/(M+N)$. If the company is of low quality, only uninformed investors bid, and get shares with probability 1. Since the unconditional probability of the firm being of high quality is 1/2, the probability that the company is of high quality conditional on uninformed investors being allocated shares is:

$$\pi_u = \frac{\lambda/2}{\lambda/2 + 1/2} = \frac{\lambda}{1+\lambda}. \tag{11}$$

Using this result in condition (10) taken with equality, we get the equilibrium offer price:

$$P_0 = V - \frac{1-\lambda}{1+\lambda}\eta - z\frac{q}{q+z}\varepsilon = V - \frac{1-\lambda}{1+\lambda}\eta - zS_B, \tag{12}$$

where in the second step we used the fact that the spread's bid-side portion $S_B = \frac{q}{q+z}\varepsilon$.

This immediately yields the following expression for average IPO underpricing:

$$E(\tilde{P}_1) - P_0 = \frac{1-\lambda}{1+\lambda}\eta + zS_B, \tag{13}$$

where $E(\tilde{P}_1)$ is the average transaction price in the after-market.[2] Notice that, as percentage of the offer price, IPO underpricing is a convex function of expression (13). Denoting the latter by *A*, it is easy to see that (one plus) percentage underpricing is:

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[2] To obtain (13), we have used the fact that $E(\tilde{P}_1) = V$. To see this, notice that in computing $E(\tilde{P}_1)$ each of the prices quoted by the dealer is weighted by the frequencies of the corresponding orders. The dealer receives a buy order with probability $(q+x)/(2q+x+z)$, so that the transaction price is the bid price $\tilde{P}_1^B$ in (2). He receives a sell order with probability $(q+z)/(2q+x+z)$, so that the transaction price is the ask price $\tilde{P}_1^A$ in (3). As a result, the

$$\frac{E(\tilde{P}_1)}{P_0} = \frac{V}{V - A}, \qquad (13')$$

Equation (13) has a simple interpretation. In equilibrium, IPO underpricing compensates uninformed investors not only for the adverse selection costs borne at the IPO stage (the first term) but also for the expected trading costs that they will bear by liquidating their shares in the after-market (the second term). As in Rock's model, the adverse selection cost at the IPO stage is decreasing in the fraction of uninformed investors, λ, and increasing in the standard deviation of the signal they observe, η, which measures their informational advantage. The expected trading costs are increasing both in the probability of reselling shares in the after-market, z, and in the bid-side portion of the spread, S^B, which in this model reflects the severity of the adverse selection problem in secondary market trading. However, the after-market bid-ask spread would contribute to IPO underpricing exactly as does in equation (13) even if it were to result from causes *other* than adverse selection, such as for instance order-processing costs. The idea captured by this equation is more general than the model presented here may suggest.

Even remaining within the framework of the present model, however, it is possible to generalize it to include the case of risk-averse investors, allowing for IPO underpricing to be affected by risk. This case is developed in the next subsection.

2.5 Market Equilibrium with Risk-Averse Investors

Suppose that the investors with no private information at the IPO maximize expected utility $E[U(\tilde{W})]$, where $U(\cdot)$ is concave and twice differentiable in final wealth W. For simplicity, other market participants and dealers are still assumed risk-neutral. Thus, only the condition for the participation of uninformed investors now changes from (7) into:

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average transaction price conditional on a given realization of $\tilde{u}_1$ is $E(\tilde{P}_1 | \tilde{u}_1) = V + \tilde{u}_1$. Since the expected value of $\tilde{u}_1$ is zero, the unconditional average of the after-market price $E(\tilde{P}_1) = V$.

$$zE\left[U(\tilde{P}_1^B)\middle|\Omega_0^u\right]+(1-z)E\left[U(\tilde{P}_2)\middle|\Omega_0^u\right]\geq P_0\,, \tag{14}$$

where, as before, expectations are computed using the probability distribution of the firm's quality conditional on the uninformed bid's success.

As in the previous section, in equilibrium the offer price makes uninformed investors just indifferent between bidding and not bidding for the company's shares: it is the value of P_0 that makes condition (14) hold with equality. As shown in the appendix through steps similar to those used in the previous section, the equilibrium offer price P_0 solves:

$$U(P_0)=U(V)-U'(V)\left(\frac{1-\lambda}{1+\lambda}\eta+zS_B\right)+\frac{U''(V)}{2}\left[\eta^2+(1-z)\varepsilon^2+z\left(S_B^2+2\frac{1-\lambda}{1+\lambda}\eta S_B\right)\right].$$

Given the properties of $U(\cdot)$, one can write $U(V)-U(P_0)=f(V-P_0)$ where $f(\cdot)$ is an increasing and concave function. Using this fact and recalling that $E(\tilde{P}_1)=V$, IPO underpricing can be written as $E(\tilde{P}_1)-P_0=h(U(E(\tilde{P}_1)-U(P_0))$, where $h(\cdot)=f^{-1}(\cdot)$, which is an increasing and convex function. Using this result in the last equation yields the following expression for average IPO underpricing:

$$E(\tilde{P}_1)-P_0=h\left\{\alpha\left(\frac{1-\lambda}{1+\lambda}\eta+zS_B\right)+\frac{\alpha\rho}{2}\left[\eta^2+(1-z)\varepsilon^2+z\left(S_B^2+2\frac{1-\lambda}{1+\lambda}\eta S_B\right)\right]\right\}, \tag{15}$$

where $\alpha\equiv U'(V)$ and ρ is the coefficient of absolute risk aversion.

Expression (15) nests various sub-cases:

(i) As expected, it reduces to equation (13) in the case of risk neutrality (where $V-P_0=(1/\alpha)[U(V)-U(P_0)]$ and $\rho=0$).

(ii) The equation yields a purely risk-based model of IPO underpricing if investors are risk-averse ($\rho>0$) but adverse selection problems are absent both at the IPO stage ($\lambda=1$) and in the after-market ($q=0$, implying $S_B=0$). In this case, underpricing is $E(\tilde{P}_1) - P_0 = h\{(\alpha\rho/2)[\eta^2 + (1-z)\varepsilon^2]\}$, that is, it compensates investors only for fundamental risk (the variance of fundamentals decreases in *z*, because investors do not bear the risk deriving from the shock $\tilde{u}_2$ if they liquidate at *t* = 1).

(iii) With adverse selection at the IPO stage ($\lambda < 1$), but not in the after-market ($S_B = 0$), we have the additional term $\alpha[(1-\lambda)/(1+\lambda)]\eta$. Instead, the risk-premium component (the term in square brackets multiplied by ρ) stays unchanged. This shows that in the context of a Rock-style model there is no interaction between the adverse selection and the risk premium components of IPO underpricing.

(iv) If there is also adverse selection in the after-market, i.e. with a positive bid-ask spread ($S_B > 0$), underpricing is higher for three reasons. First, as in the risk-neutrality case, there is the direct disutility due to the expected trading cost ($\alpha z S_B$). Second, the bid-ask spread increases the risk to be borne by the investor ($\alpha\rho z S_B^2/2$): the interaction between informed traders and dealers impounds advance information about $\tilde{u}_2$ in the after-market price, and thereby increases the risk borne in case of early liquidation of the shares. The illiquidity of the after-market exacerbates risk, and increases the risk premium component of IPO underpricing. Thirdly, equation (15) shows that underpricing also includes an interaction term between risk, adverse selection at the IPO stage, and after-market illiquidity ($\alpha\rho z[(1-\lambda)/(1+\lambda)]\eta S_B^2$).

Since IPO underpricing is generally expressed as a percent of the offer price, it is worth noting that, if equation (15) is rewritten as $E(\tilde{P}_1) - P_0 = h(\alpha A)$, also the percentage IPO underpricing is an increasing and convex function of *A*:

$$\frac{E(\tilde{P}_1)}{P_0} = \frac{V}{V - h(\alpha A)}. \qquad (15')$$

For instance, if utility is logarithmic, the model predicts that $E(P_1)/P_0 = \exp(A/V)$, which can be rewritten as:

$$\log\left(\frac{E(\tilde{P}_1)}{P_0}\right)=\frac{1-\lambda}{1+\lambda}\eta+zS_B+\frac{\rho}{2}\left[\eta^2+(1-z)\varepsilon^2+z\left(S_B^2+2\frac{1-\lambda}{1+\lambda}\eta S_B\right)\right]. \quad (15'')$$

Therefore, if underpricing is measured as $\log\left(E(\tilde{P}_1)/P_0\right)$, it should be a linear-quadratic function of the after-market half-spread S_B, with a linear coefficient equal to the frequency of liquidity sales z and a quadratic coefficient $\rho z/2$. For power utility functions $U(x)=x^\gamma$, with $\gamma \le 1$, the model predicts that $E(\tilde{P}_1)/P_0=[V/(V-\gamma A)]^{1/\gamma}$, which reduces to expression (13') for the risk-neutral case ($\gamma=1$).

2.6 Market Equilibrium with Uncertain Liquidity

So far, investors were assumed to anticipate perfectly the degree of secondary market liquidity, as summarized by the bid-ask spread S_B. But this may not be a reasonable assumption for shares that are not traded yet: when the offer price is set, investors may not know how liquid the secondary market will be.

The uncertainty about liquidity can be captured by assuming that there can be two liquidity regimes, characterized by a different incidence of insider trading and therefore by a different bid-ask spread. More precisely, let the fraction of insider traders be a random variable $\tilde{q}$ that takes a low value q_L or a high value q_H with equal probability. Accordingly, the (bid-side portion of the) spread becomes itself a random variable:

$$\tilde{S}=\frac{\tilde{q}}{\tilde{q}+z}\varepsilon \quad (16)$$

The distribution of $\tilde{q}$ (and therefore that of $\tilde{S}$) is independent of those of $\tilde{u}_1$ and $\tilde{u}_2$. With this change to the model, there are four possible states on the after-market, depending on the quality of the company (high or low: $\tilde{u}_1=\eta$ or $\tilde{u}_1=-\eta$) and on the liquidity regime (high or low: $\tilde{q}=q_L$ or $\tilde{q}=q_H$), with probability 1/4 each.

As in the previous section, the equilibrium offer price is the value of P_0 that makes the uninformed investors' participation constraint (14) hold with equality. As shown in the appendix through steps similar to those of the previous section, in equilibrium the average level of IPO underpricing in this expanded model is:

$$E(\tilde{P}_1) - P_0 = h\left\{\alpha\left(\frac{1-\lambda}{1+\lambda}\eta + zE(\tilde{S}_B)\right) + \frac{\alpha\rho}{2}\left[\eta^2 + (1-z)\varepsilon^2\right] + \right.$$

$$\left. + \frac{\alpha\rho}{2} z\left[Var(\tilde{S}_B) + \left[E(\tilde{S}_B)\right]^2 + 2\frac{1-\lambda}{1+\lambda}\eta E(\tilde{S}_B)\right]\right\}. \quad (17)$$

This expression differs from its analogue (15) obtained under perfect foresight about liquidity only in two respects. The bid-ask spread S_B is replaced by its expected value $E(\tilde{S}_B)$, and its square S_B^2 by $E(\tilde{S}_B^2) = Var(\tilde{S}_B) + [E(\tilde{S}_B)]^2$. We recover expression (15) as a special case of (16) for $q_H = q_L = q$, where the spread is non-stochastic ($\tilde{S}_B = S_B$).

Therefore, the extended model with uncertain liquidity predicts that IPO underpricing is an increasing function of the expected bid-ask spread $E(\tilde{S}_B)$ and of its variance $Var(\tilde{S}_B)$. The model nests this prediction with those of models based on adverse selection in the IPO – the first term in (17) – and those of models based on fundamental risk – the terms in square brackets in the first line of (17). In keeping with this feature of the model, therefore, our tests for the presence of liquidity effect on underpricing will control for variables designed to capture adverse selection and risk, along the lines of previous empirical studies on this matter.

3. Data Description and Liquidity Measures

3.1. Data Description

We analyze all the IPOs undertaken on the London Stock Exchange (LSE) between June 1998 and December 2000.[3] From this sample we eliminate closed-end funds, open-end funds and investment companies. This leaves us with 337 IPOs, of which 37 went public in 1998, 121 in 1999 and 179 in 2000. Table 1 illustrates the composition of the sample, by size and sector (Panel A) and by market (Panel B).

[Insert Table 1 here]

For each company, we collect two types of data: (i) tick-by-tick transaction and quote data provided by the LSE, and (ii) company-level data, drawn from IPO prospectuses filed with the Financial Services Authority (FSA), the UK Listing Authority.

The LSE data include: (a) date and time of each trade executed in the after-market, (b) quantity transacted in each trade, (c) transaction price, and (d) trade direction (buyer- or seller-originated). All these data are available for each company from inception of trading up to the end of 2000.

The FSA data concern the terms of the IPO (offer price, IPO mechanism, number of shares issued in the IPO, stabilization agreement with the underwriter, etc.), firm characteristics (age,[4] sector, sales, assets, leverage, presence of venture capitalists), and ownership and control (shares sold by the initial shareholder, percentage of shares held by private investors after the IPO, changes in stock options held by insiders, etc.). When the prospectus was not available from the FSA, these data were drawn from Worldscope.

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[3] For the period from July 1996 to June 1998, price and quote data are unavailable from the London Stock Exchange.

[4] In this paper, the age of the company dates from the year of incorporation. If the company results from a merger, its assumed birth date is the year of incorporation of the oldest merged company.

The companies in our sample list either on the Main Market (MM) or on the Alternative Investment Market (AIM) of the LSE, depending on their accounting records. The two markets have the same trading system (they are both dealer markets with designated market-makers), but list different types of companies. The AIM caters exclusively to small companies with a short track record, while the MM lists companies with no less than three years of accounting profits, though this requirement was relaxed in our sample period to accommodate some young, high-growth firms with no earnings. As a result, the companies listed on the MM are generally larger and older than those listed on AIM. As shown by Panel B of Table 1, 91 percent of the companies under two years from incorporation went public on the AIM. The sector distribution of the two markets is roughly the same. Due to the different listing requirements of the two market segments, companies have little discretion as to the market they will list on, so that their distribution across the two segments can be regarded as largely exogenous.

The design of the IPO sale also differs considerably within our sample. Most small companies go public via a fixed-price auction, where the price is set before the bidding and, in case of overbidding, rationing occurs according to a scheme set in the IPO prospectus. Large companies set their IPO price either through a fixed-price auction or via a book-building process. Underwriters' stabilization is far less widespread in the London market than in the U.S., and its occurrence is explicitly stated in IPO prospectuses. Our data reveal that some companies listing on the Main Market enter into a price stabilization agreement with the underwriter, and in this case they generally provide the underwriter with a "green shoe" option. The infrequency of stabilization is explained by the greater specialization of British investment banks, which seldom have market-making capabilities beside advisory and sponsoring skills, unlike their U.S. counterparts (Ljungqvist, 2002).

[Insert Table 2 here]

Table 2 provides descriptive statistics for the IPOs in our sample. The Table shows that the typical firm making an IPO operates for more than seven years prior to the IPO, has total sales of £51.2 millions in the year before the IPO, fixed assets totaling £135.1 millions and is valued at £174.3 millions at the time of the IPO. Of interest are the changes in the insiders' holdings that occur during the IPO stage. On average, the insiders sell 6.65% of their stake (in the pre-IPO share capital) during the IPO. These sales, together with the amount of new shares issued by the company, on average reduce the insiders' holdings by 26.5% in the post-IPO company. Furthermore, executive and independent directors hold, on average, options worth 2.38 percent of post-IPO shares.

3.2. Liquidity Measures

Since our hypothesis is that IPO underpricing is not only related to fundamental risk and adverse selection, but also to the expected level of liquidity and its variability, the accurate measurement of liquidity is crucial for our study. The bid-ask spread, which measures the cost of trading at each point in time, is an accurate measure of liquidity for small trades, in the context of a dealer market such as the LSE. The bid-ask spread can be regarded as the opportunity cost of undertaking the immediate execution of a small trade at the current quotes, rather than waiting for a more favorable price.

The two most common measures of the spread are (i) the quoted spread, which is the difference between the best ask and bid quotes, Q_A and Q_B, as a fraction of the mid-quote M, i.e. $(Q_A - Q_B)/M$; and (ii) the effective spread, generally computed as (twice the absolute value of the) percentage difference between the transaction price P and the mid-quote M, i.e. $2|P-M|/M$. The effective spread takes into account that trades can occur either inside or outside the quoted spread. It is a better measure of liquidity on dealership platforms, because it takes into account trading practices whereby dealers give preferential treatment to some customers (preferencing) or match the best quote on the market (internalization of the order flow). It also avoids the risk of using stale quotes, which is particularly acute on thin markets such as AIM.

However, both the quoted and the effective spread fail to take into account the depth of the market, since they do not weigh transactions costs by the size of the corresponding trades. For the quoted spread, this occurs by construction, since the quoted spread refers to a given trade size – in London the officially determined Minimum Marketable

Quantity (MMQ). But also the average effective spread suffers from a similar limitation, since it gives the same weight to all trades irrespective of their size.

To tackle this problem, we measure liquidity not only by the effective spread, but also by the "amortized spread", an indicator proposed by Chalmers and Kadlec (1998) that takes into account the depth of the market, by combining the effective spread and the stock's share turnover. The amortized spread is defined as

$$AS_{jt} = \frac{\sum_{i=1}^{N_{jt}} \left| P_{ji} - M_{ji} \right| Q_{ji}}{P_{jt} K_j},$$

where P_{ji} is the price for transaction i during day t, M_{ji} is the respective mid quote at the time of the transaction, Q_{ji} is the corresponding number of shares traded, N_{jt} is the number of observations for stock j on day t, P_{jt} is the closing transaction price and K_j is the stock's market capitalization. This measure of liquidity effectively weighs transaction costs by the magnitude and frequency of the trades on which they are incurred. This dimension of liquidity is quite important in our setting, since after-market turnover changes very significantly over time, as we shall see below.

In this paper, we measure the amortized spread for each of the 102 ten-minute intervals in every trading day rather than once per day; correspondingly, the variable P_{jt} is the final transaction price for each ten-minute interval rather than for the trading day. This is a natural choice since our analysis focuses on a shorter time interval that the study by Kadlec and Chalmers (1998), and it allows us to exploit fully our high-frequency data.

We capture a stock's liquidity risk by the variability of the spreads. Our data allow us to measure the variability of spreads at different frequencies and in various ways. We can compute the standard deviation of the spreads by sampling high-frequency data over small intervals, for example every five minutes, or by using only data recorded at the close of each trading day. In addition, we can consider measures of dispersion other than the standard deviation, such as the range between the highest and the lowest spread.

Experimenting with different sampling frequencies and different measures of dispersion yields highly correlated measures of the variability of effective spreads. We choose to use the range between the highest and the lowest effective spread recorded in each trading day. This measure appears to be both closest to normality among the measures of dispersion considered and the most intuitive from an investor's standpoint.

Similarly, when we measure liquidity by the amortized spread, we define liquidity risk as the range of variation of the amortized spread. Specifically, we measure the amortized spread twice per day in the first four weeks of trading (half-way through the trading day and at the close), thus generating 40 values of the amortized spread for each stock, and compute the range of variation within this sample. In this case, we refrain from sampling the data at higher frequency, lest the resulting indicator might reflect more the high intra-day trading volume volatility than the variability of trading costs.

[Insert Table 3 here]

Table 3 reports descriptive statistics about underpricing and liquidity in Panel A, and about their evolution in the first four weeks of trading in Panel B.

Panel A shows the average quoted, effective and amortized spreads in the first four weeks of trading are 5.71, 5.03 and 5.59 percent respectively. Breaking down these averages across markets reveals that, not surprisingly, shares listed on the MM are more liquid than those listed on the AIM: for instance, the average effective spread on the MM is 3.22 percent, whereas on the AIM it is 5.80 percent.

Panel B illustrates how underpricing and liquidity evolve over the first four weeks of after-market trading. Underpricing is defined as the percentage change from the offer price to the closing price in each week. Liquidity is measured by the quoted, effective and amortized spreads, volume transacted, turnover (defined as the number of shares traded per week divided by the number of shares outstanding), number of trades, time interval (in seconds) between successive trades and order imbalance (defined as buyer-initiated volume less seller-initiated volume).

Average underpricing declines from 42.21 percent after the first week to 29.58 percent after the fourth week. Also all the measures of the bid-ask spread decline over the first four weeks of trading. For example, the effective spread declines from 5.48 to 4.81 percent from the first to the fourth week. The decline is most visible for the amortized spread, which reflects also the reduction in trading activity in the after-market. This reduction of the spread may reflect either a decrease in adverse selection (as more public information emerges after the IPO) or a reduction in fundamental risk, or both. The variability of the spread also declines. The variability "within" firms – that is, the time-series variability of the spread for a given company – shows a much more substantial decline than the variability "between" firms. This suggests that the market gradually learns about the liquidity of the firm.

[Insert Figures 2, 3 and 4 here]

Figures 2, 3 and 4 show that a similar, and even more striking, pattern emerges over a longer horizon. The average quoted spread falls steadily from around 6 percent in immediate after-market activity to about 4.90 around the 20^{th} week after the IPO, and then settles around 3.50% after the 40^{th} week. The effective spread has a similar pattern, while the amortized spread features a much sharper decline in the first three weeks after the IPO, again reflecting both the reduction of the bid-ask spread and the sharp fall in trading activity after the first few weeks of trading. Just as the average level of the effective spread, its variability declines dramatically throughout the first year after the IPO, as illustrated by Figure 4.

This pattern suggests that both liquidity and its variability are much more of a problem in the immediate after-market trading than they are in a more mature market. Therefore, a rational IPO investor who reckons that she might have to liquidate in the immediate after-market or plans to do so should be much more concerned about liquidity than a buy-and-hold investor. This calls for focusing the analysis between IPO returns and liquidity on the first few weeks of after-market trading. As we move away from the IPO date, investors face an increasingly liquid market, so that trading costs should become less of a concern for them. They also face a more predictable bid-ask spread, which again should reduce their concerns about liquidity. Finally, confounding events may increasingly cloud the IPO price-liquidity relationship.

[Insert Figure 5 here]

In spite of the abnormally high trading costs prevailing immediately after the IPO, it is precisely at that time that trading activity appears to reach the highest levels, possibly a reflection of the frantic activity of “flippers”. The fact that these abnormally high trading costs are incurred so frequently suggests that they are unlikely to be negligible from the ex-ante perspective of an IPO investor. As shown by Panel B of Table 3, trading activity is heaviest in the first week of trading, and then declines steadily. All the relevant measures – volume transacted, turnover, number of trades, and waiting time between trades – agree on this point. Also in this case, the pattern of the first four weeks continues over the entire two years after the IPO, as shown in Figure 5.

4. Methodology and Results

The main objective of our research strategy is to measure how IPO underpricing is affected by expected liquidity and liquidity risk, as perceived by investors at the time of the IPO. In this exercise, we control for other factors, whose role has already been tested in the literature. Our baseline methodology is to measure expected liquidity and its variability by the sample moments of the bid-ask spread in the first four weeks of after-market trading, and to use these moments as explanatory variables in OLS regressions.

A potential problem with this approach is that these sample moments may measure the market's expectations of liquidity with some error. To overcome this problem, our second approach is to estimate a regression with instrumental variables (IV).

Another problem with the sample moments of the bid-ask spread is that they are unconditional estimates of the expected value and the variance of liquidity. The IPO offer price should instead reflect conditional expectations, that is, the expected value and the variance of liquidity conditional on the variables known to investors at the time of the IPO. To take this further point into account, we implement a third methodology, whereby our measure of expected liquidity and of liquidity risk is conditional only on firm characteristics known to investors at the time of the IPO.

4.1 Model Specification

Consistently with the model presented in Section 2, we wish to nest our liquidity-based explanation of IPO underpricing with the two main explanations advanced in the literature: fundamental risk and asymmetric information. Therefore, the specifications used in previous work to test these hypotheses are our natural starting point. Table 4 presents the list of explanatory variables that we employ in our specification.

[Insert Table 4 here]

Liquidity. Our model predicts both after-market liquidity and liquidity risk to have positive coefficients. The more liquid the secondary market is expected to be, the lower the liquidity premium that IPO underpricing must incorporate. Similarly, the harder it is to predict liquidity, the higher the return required by investors at the IPO stage. Our two alternative measures of after-market liquidity are the effective and the amortized bid-ask spreads. According to our model, these liquidity measures are to be included in the regression as expectations formed by investors at the time of the IPO. As already mentioned, there are various ways to measure expectations. Accordingly, we shall present results obtained with a variety of estimation strategies.

Asymmetric information. The amount of shares sold by the insiders is a key variable to gauge the presence of asymmetric information in the IPO process. If the initial owners know that their company is of low quality, at the IPO stage they will sell a large stake, as in the adverse selection model by Leland and Pyle (1977). The same prediction holds in a moral hazard model such as Jensen and Meckling (1976): the higher the stake sold by controlling shareholders, the higher is their incentive to extract private benefits at the expense of minority shareholders. In both cases, the insiders' decision to sell a large stake is bad news for the market, and therefore should induce higher underpricing.

In an environment where managers are partly compensated via options, especially in young and R&D-intensive firms, the attribution of options to management can play the same role as a larger insiders' stake, both as quality signal and as incentive device. Up to now, the literature has not used this variable to explain underpricing, perhaps due to lack of data. But since this information is available in IPO prospectuses, we use it as an additional test of the Leland-Pyle and Jensen-Meckling predictions.

However, the logic of these models is not unchallenged: Habib and Ljungqvist (2001) argue that initial owners who sell a large stake will want as little underpricing as possible, and can do so by spending more resources on "promotion activities". Their prediction is that underpricing is decreasing in the amount of shares that insiders sell at the IPO. As a result, the relationship between insiders' sales (or directors' amount of options) and underpricing is in principle ambiguous.

With asymmetric information, the presence of a venture capitalist can be a quality signal, leading to lower underpricing (Barry, Muscarella, Peavy and Vetsuypens, 1990, and Megginson and Weiss, 1991). Therefore, a dummy variable for the presence of a venture capitalist should carry a negative coefficient. Since venture capitalists typically enter the shareholder base long before the IPO, this variable is predetermined relative to the offer price.

The offer price of each company can also be affected by the earlier IPO activity in the market or in the same sector, due to an information spillover. Previous IPOs can provide guidance about the investors' appetite for the company's shares and thus about the price they are willing to pay. Benveniste, Ljungqvist, Wilhelm and Yu (2002) provide evidence that underpricing is lower when many IPO issues were floated in the recent past. Consistently with such evidence, we expect a negative coefficient on the number and the proceeds of the IPOs carried out in the previous and current quarters.

Fundamental risk. We control for fundamental risk by predetermined variables such as size (measured by the logarithm of total assets), age (measured by logarithm of the number of years since incorporation)[5] and sector of the company, and more directly by the volatility of after-market returns. We measure the latter by calculating the standard deviation of returns using mid-quotes (to avoid potential problems caused by the bid-ask bounce) sampled at one-hour intervals over the first four trading weeks. We expect underpricing to be higher for shares with greater after-market return volatility. But the latter may not fully measure the risk of IPO shares: then age, size and sector could still play a role. If so, IPO underpricing should be lower for issues of older and larger companies, which generally feature less risk. The opposite should be true of IPOs undertaken by companies in the information-technology (IT) sector, as shown by Loughran and Ritter (2000) on U.S. data. This is important for our sample, which

[5] Firms' age and size can proxy for both risk and adverse selection. For example, age should be inversely related to risk, insofar as companies grow into more diversified businesses over time, as well as to adverse selection, since mature companies have a longer track record.

includes the Internet bubble. Hence, we would expect the coefficients of return volatility and an IT dummy to be positive, and those of size and age to be negative.

The impact of the total IPO proceeds may also capture the effect of risk. Investors may require an extra return to "digest" very large IPOs, since to purchase the implied stakes they may have to accept at least some temporary imbalance in their portfolios. However, from the econometric point of view this variable cannot be considered as exogenous, in the same sense in which the quantity sold by a monopolist cannot be regarded as exogenous with respect to the price chosen. This applies also to other characteristics of IPOs, such as insiders' sales, which are chosen by the issuers jointly with the level of underpricing at the time of the IPO. Despite such endogeneity problems, these variables have been extensively used in past empirical work. When we include them as regressors, we attempt to control for their possible endogeneity by IV estimation.

4.2 OLS Estimates

The simplest approach is to measure the expected value and the variance of the after-market liquidity level by the two corresponding sample moments, computed over the first weeks of trading. This method rests on the assumption that at the time of the IPO investors correctly anticipate the true moments of these variables, of which the corresponding sample moments are unbiased estimates. If these sample moments measure the expected liquidity level and its variance with no error, the OLS method produces unbiased and consistent estimates.

In the estimation, in keeping with the spirit of our model we measure underpricing as the natural log of the ratio of the after-market price to the offer price ($\log(P_1 / P_0)$).This measure differs slightly from that used in the literature, which is the percent return from the offer price to the after-market price ($(P_1 - P_0)/P_0$). We rely on the former measure of underpricing for two reasons. First, according to the theoretical model presented in Section 2 the ratio between the after-market price and the offer price holds a convex relationship with the explanatory variables that we employ. In particular, as shown by equation (15″), a logarithmic transformation of the dependent variable is appropriate if utility is logarithmic. Secondly, from a statistical point of view, the $\log(P_1 / P_0)$ is much closer to a normally-distributed variable than the measure $(P_1 - P_0) / P_0$ so far used in the literature. In particular, the skewness and kurtosis of our underpricing measure for the first day are 1.16 and 6.90, respectively, compared with 3.84 and 22.08 for the traditional measure. Likewise, the skewness and kurtosis of our underpricing measure for the first four weeks are 1.10 and 6.68, respectively, and 2.97 and 14.46 for the traditional measure. However, we also test our empirical model by using the traditional measure of underpricing, and find that the estimates are qualitatively unchanged.

We measure underpricing over various different horizons. In our baseline estimates, the horizon is the first four weeks of trading: we measure the after-market price P_1 as the closing price of the 20th trading day, to ensure consistency between the time period over which we measure liquidity and the time period used to calculate underpricing. But, as a robustness check, we repeat the estimation by using a measure closer to the existing IPO literature, that is by defining P_1 as the closing price of the *first* trading day. Finally, we repeat the estimation with underpricing measured over other horizons: the first week, second week and third week of after-market trading.

In Panel A of Table 5 we report the regression estimates obtained when we use the effective bid-ask spread to measure after-market liquidity.[6] In Panel B the estimation is repeated by replacing it with the amortized spread. The OLS coefficient estimates and t-statistics are displayed in the first column. The t-statistics are based on robust standard errors, computed using the Huber-White estimator. Since, as explained above, the sales by insiders and the size of the IPO may be endogenous variables, we exclude these variables from our OLS regression (method 1a), and include them only in the IV estimation whose results appear in the second column of Table 5 (method 1b). This

[6] Estimates very similar to those reported in Panel A are obtained if the effective bid-ask spread is replaced with the *quoted* bid-ask spread. Using method 1a (as in the first column of Panel A), we estimate the coefficient of the quoted spread to be 0.02247, with a t-statistic of 3.58, and that of its variability to be 0.0299, with a t-statistic of 3.67. The other coefficient estimates are almost identical to those reported in the first column of Panel A.

strategy is supported by the result of a Hausman test, which rejects the null hypothesis of consistency of OLS estimates when these two variables are included.

The overall explanatory power of the OLS regression in the first column of both Panel A and B is satisfactory compared with those reported in previous studies of IPO underpricing, since it accounts for about 30 percent of the variance in the dependent variable. The coefficients of all the explanatory variables carry the signs predicted in Table 4, except for those of the corporate governance variable (i.e., the fraction of independent directors) and of the number of IPOs in the same quarter, which are positive though not statistically significant.

[Insert Table 5 here]

4.2.1 Impact of the Effective Spread

The average effective spread in the four weeks of after-market trading has a positive coefficient, and so does its variability.[7] These coefficients are not only statistically significant at the 1-percent confidence level, but also economically significant. A 100-basis-point increase in the effective spread from its average level (5.03 percent) is associated with an increase of 256 basis points in underpricing.[8] A 100-basis-points in the range of variation of the effective spread relative to its average value (4.41 percent) increases underpricing by 450 basis points.

Considering that fundamental risk and adverse selection are already controlled for by the inclusion of other variables, it is remarkable that the level and the variability of the bid-ask spread have such a large and precisely estimated impact on IPO underpricing. In particular, the estimated coefficient of effective spread may appear excessively large if

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[7] If the variability of the spread is measured by its standard deviation instead of its range of variation, its coefficient is 0.0649, significant at the 1 percent confidence level.

[8] This estimate is obtained by taking the difference between the antilog of the dependent variable's predicted value conditional on a 100-basis-points increase in the effective spread and the antilog of the dependent variable's sample mean.

compared with the prediction of the model: from equation (15″), a 100-basis-points increase in the spread should translate into an increase of underpricing equal to 100 basis points multiplied by half the frequency of liquidity sales,[9] and thus should range between 0 and 50 basis points. But this prediction reflects the model's assumption of a single round of interim trading in the after-market, so that the transaction cost implied by the half-spread S_B is paid at most once by an IPO investor. If one allows for multiple rounds of trading in the immediate after-market, the IPO price must discount the expected trading costs born by all the potential subsequent buyers (and re-sellers) of the shares. As a result, the impact on underpricing is increasing in the post-IPO share turnover rate, and can easily be a multiple of the increase in the half-spread S_B, so that the impact of a 100-basis-points spread increase may well exceed 50 basis points. This accords with our earlier observation that share turnover is abnormally large in the first weeks after the IPO.

According to equation (15″), the ratio of estimated coefficient of the variability of the spread and of its expected value equals half the risk aversion parameter ρ. The estimates of Table 5 therefore imply an estimate of ρ around 4, which appears reasonable.

4.2.2 Impact of the Amortized Spread

In Panel B of Table 5, the estimation just described is repeated replacing the effective spread by the amortized spread, a liquidity measure that – as explained in Section 3.2 – takes into account also the magnitude and frequency of the trades on which transaction costs are paid. By the same token, liquidity risk is measured by the range of variation of the amortized spread.

Comparing the estimates in Panel B with their Panel-A analogues, it is apparent that reliance on this alternative measure of the spread does not change the sign and significance of the estimates of the key variables, but it reduces by almost half the

[9] The model relates underpricing to the half-spread. If this were replaced with the entire bid-ask spread, the predicted value of its coefficient would halve.

coefficient of the bid-ask spread, and reduces marginally that of its variability. To understand the economic significance of these changed estimates, with method (1a) we now estimate that a 100-basis-points increase in the effective spread from its average level is associated with an increase of 163 basis points in IPO underpricing, which is smaller than the 256 basis points estimated using the effective spread, though it is still an economically large effect. Instead, the impact of the variability of the amortized spread is almost identical as in Panel A: a 100-basis-points in the range of variation of the amortized spread relative to its average value increases underpricing by 479 basis points.

Irrespective of the variables used to measure after-market liquidity and its variability, the magnitude and the precision of the coefficients of the company and IPO characteristics in Table 5 do not change appreciably. Now we turn to these variables, whose role is of independent interest.

4.2.3 Impact of Company and IPO Characteristics

The estimates indicate that underpricing is significantly lower when directors have large holdings of options in the post-IPO firm or a venture capitalist has a stake in the company at the time of the IPO. In line with the information spillover hypothesis, underpricing is significantly lower if more IPOs are carried out in the previous quarter, though not in the current one. The spillover appears contemporaneous rather than lagged if it is measured by the proceeds rather than by the number of recent IPOs. In such a specification (not reported in the table), the coefficient of the IPO proceeds in the same quarter is negative (-0.0535) and statistically significant at the 1 percent level, whereas the coefficient of current IPO proceeds lacks statistical significance.

As predicted by risk aversion models, older companies face less underpricing when they go public, while the opposite holds for companies with more volatile after-market returns, other things equal. The coefficient of the total assets is negative, as predicted, but is not precisely estimated. This reflects collinearity with the age variable: the log of total assets has a strong correlation (0.58) with the firm's age, and its coefficient becomes significant at the 1-percent confidence level if age is dropped.

The IT Sector dummy, which identifies IPOs in the information-technology industry, has a positive but imprecisely estimated coefficient. Also the fraction of independent directors, that many view as a mechanism to improve a firm's corporate governance, does not affect significantly the level of underpricing, possibly because of its endogeneity.

The underwriter's stabilization in the after-market is a further control variable. The literature shows that underwriters do stabilize the IPO in the very first days of after-market trading. Stabilization could be a potential problem for our estimates if we do not control for it since it tends to increase both the degree of underpricing and the liquidity in the market. The stabilization dummy variable codes if a stabilization agreement is mentioned in the IPO prospectus, which happens in several medium-sized and large IPOs (mainly undertaken on the MM). As expected, the coefficient of this variable is positive, in agreement with the evidence reported by Ruud (1993).

Next, we consider a specification that includes the amount of shares sold by insiders at the IPO stage and the size of the IPO. Due to the potential endogeneity of these two variables, we estimate this specification by IV, using as instruments (i) the industrial sector of the IPO firm, (ii) the company's sales (in logs) in the year before the IPO, and (iii) the leverage ratio just before the IPO is carried out.[10]

The estimates are reported in the second column of Table 5. Insiders' sales carry a positive coefficient, consistently with signaling and agency models, but lacks statistical significance. Contrary to the expectations, the estimated coefficient of the IPO proceeds is negative but lacks significance at the 10 percent level. The estimates and statistical significance of the other coefficients in the first two columns do not change appreciably when insiders' sales and the IPO size are included as regressors. Also the coefficients of the liquidity variables change only marginally.

The estimates reported in the first two columns may suffer from two types of problems as far as liquidity and liquidity risk are concerned. First, the ex-post average and variance

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[10] The R^2 of the first-stage regressions for the amount of shares sold by insiders and for the size of the IPO are 0.174 and 0.204, respectively.

of the effective spread may measure with error the corresponding estimates held by investors. The inconsistency induced by measurement error may be compounded by the potential endogeneity of after-market liquidity. In the next subsection, we try to address these problems via IV estimation.

An additional problem may derive from our reliance on after-market data to measure the expected level of liquidity and its perceived volatility. This may impute to investors more information than that they truly have at the time of the IPO. We shall address this problem in Section 4.4 by constructing measures of investors' expectations based only on information publicly known at the time of the IPO.

4.3 Instrumental Variables Estimates

If our measures of expected liquidity and liquidity risk are subject to substantial measurement error, the estimated coefficients of these variables are inconsistent and biased toward zero, with the magnitude of the bias proportional to the variance of the measurement error. These coefficients may be biased also if liquidity were endogenous with respect to the degree of IPO underpricing. For instance, higher underpricing may induce greater market participation by small investors (as argued by Booth and Chua, 1996, and by Brennan and Franks, 1995). If the latter makes the after-market more liquid, our measures of liquidity may be correlated with the error of the underpricing equation.

To tackle this errors-in-variables problem, we need appropriate instruments for the liquidity variables, that is, variables correlated with liquidity and its variability but not with the error in the underpricing equation. We use the following instruments: (i) the fraction of the share capital held by the major shareholders after the IPO, (ii) the log of the amount of new shares issued in the IPO, (iii) the IPO mechanism ("placing" versus "offer"), (iv) the market on which the IPO is carried out, and (v) the industrial sector.

The concentration of the share capital, i.e. the amount of the share capital closely held by the major shareholders, determines how much of the firm's share capital is publicly traded and thus directly influences the firm's liquidity. (We leave the *sales* by the initial main shareholders to capture the signal sent to the market regarding the firm's quality.)

We consider also the IPO mechanisms and the type of market chosen by the firm as valid instruments because both are likely to affect underpricing primarily via their impact on aftermarket liquidity. The choice of IPO mechanism is a dummy variable indicating whether the IPO occurred via (i) a “placing” (similar to the firm commitment in the U.S.), which is entirely addressed to institutional investors, or (ii) a “public offer”, addressed both to institutional investors and retail investors. The type of market used for the IPO is a dummy variable indicating if shares were floated on the MM or the AIM.

The third column of Table 5, Panel A, reports the IV estimates. These suggest that indeed the OLS coefficient on the effective spread is biased toward zero. The IV estimate is more than twice as large as the OLS estimate, indicating a much larger effect of after-market liquidity on underpricing. A 100-basis-point increase in the effective spread from its average level is now associated with a 752-basis-points increase in underpricing. The effect of the variability of the spread also increases significantly (from 0.0372 to 0.0657). Instead, most other coefficients, with the exception of those of return variability and firm age that lose statistical significance, are virtually unchanged relative to the OLS estimates.

The model estimated in the third column excludes the insiders’ sales and the IPO size. To include these variables, we turn to an expanded IV approach that attempts to control for the potential endogeneity in (i) liquidity, (ii) liquidity risk, (iii) insiders’ sales, and (iv) IPO size. For the latter two variables, we rely on the same instruments described in Section 4.2.3. The coefficient estimates are shown in the fourth column of Table 5. Again, the coefficients for insiders’ sales and IPO size are not statistically significant in the new specification. Besides this, one notable difference is that both the coefficients for the spread and the variability of the spread are marginally smaller than those estimated in the third column.

The IV estimate of the bid-ask spread’s coefficient is much larger than the corresponding OLS estimate also when liquidity is measured by the amortized spread, as shown by the results reported in the fourth and fifth columns of Panel B of Table 5. In contrast, the OLS and IV estimates for the coefficient of the variability of the amortized spread are almost identical.

4.4 Forecasting Liquidity from Firm Characteristics

Finally, we obtain the expected levels and uncertainty of the spread through a different approach, which is based on inferring the expected spread and its variability from the realized spread for previously listed companies.

We forecast the expected effective bid-ask spread and its range of variation using the following variables obtained for past IPOs: (i) industrial sector, (ii) size (by total assets), (iii) the leverage ratio, (iv) the concentration of the share capital held by the major shareholders after the IPO, (v) the IPO mechanism, and (vi) the market on which the IPO is carried out. For every company, we estimate a regression that uses all the observations concerning the firms that went public up to that date, so that the observation window is increasing over time. The fitted values from each regression are then used as measures of investors' expectation about future bid-ask spreads and liquidity risk. This method runs into the problem of lacking observations for the first IPOs in our sample, i.e. those occurring in 1998. Since no price and quote data are provided by the London Stock Exchange for the period between July 1996 and May 1998, we resort to the data for IPOs carried out in the first half of 1996 to forecast the liquidity of the IPOs of 1998.

The fifth column of Table 5, Panel A, report the coefficient estimates when we use these conditional estimates of liquidity and liquidity risk. The coefficient of the effective spread obtained with this method lies halfway between those obtained with OLS and those obtained with IV estimation, whereas the coefficient of the variability of the spread is almost identical to its IV estimate. This confirms that the OLS estimates of the liquidity coefficients are biased towards zero. Instead, most of the coefficients of the other explanatory variables are very close to the respective OLS estimates, the main difference being that the impact of the return volatility is somewhat lower.

4.5 Holding Period

Another major issue is to identify the period over which period we should measure underpricing, liquidity and its volatility. This amounts to asking what is the typical trading horizon that is relevant for IPO investors. Different time horizons will be relevant for different "types" of liquidity-motivated traders. If we were to take, for example, the spread's dynamics in the very first day/s, then we would be implicitly assuming a short-term liquidity trader, who intends to buy the IPO and divest her shares immediately (a "flipper"). On the other hand, assuming a long time interval to analyze the spread would imply that we consider a buy-and-hold investor who, unless hit by a liquidity shock, holds shares for the long term.

The statistics reported in Table 3 show that trading activity is abnormally high in the first few days in the after-market. This suggests that "flippers" are likely to be a considerable fraction of the initial IPO investors. However, since underpriced IPOs attracts substantial interest from investors, who are often severely rationed at the time of the offer, the large volumes transacted in the very first days may also reflect pent-up demand for these securities by long-term investors.

The decision on the optimal time period for our analysis must also trade-off the benefit from a more accurate measurement of liquidity associated with a longer interval, and the danger of including confounding events (such as news releases) that can affect liquidity and its variability.

We test the robustness of our results to changes in the holding period in two directions. In Table 6, we shorten the horizon over which we measure underpricing, computing it relative to the closing price of the first trading day, as customary in the IPO literature. However, the liquidity variables used as explanatory variables are the same as those used in Table 5, that is, are measured over the first four weeks of trading. In Table 7, instead, we investigate how the results change if *all three* variables – underpricing, average bid-ask spread and variability of the spread – are measured over the first day of trading (column 1 in Table 7), and over the first trading week (column 2 in table 7).[11]

[Insert Tables 6 and 7 here]

[11] The same regressions were estimated also for the first two days and the first two weeks after the IPO, but the corresponding estimates are not reported since they are not appreciably different from those for the first day and the first week, respectively.

Comparing the coefficient estimates obtained in Tables 6 and 7 with those shown in the first column of Table 5, we see that the impact from liquidity and its risk on underpricing is robust to the choice of the holding period. In Table 6, the impact of the effective spread is somewhat larger when we measure underpricing relative to the first trading day (the coefficient is 0.0250, against 0.0214 when underpricing is measured relative to the fourth week of trading) but the impact of the variability of the effective spread is smaller (the coefficient being 0.0360 instead of 0.0372).

The opposite occurs in Table 7, when the reference period is shortened to one day or one week for both underpricing and the liquidity variables: compared with the OLS estimates in Table 5, the impact of the effective spread is slightly lower and that of its variability is slightly larger. The first of these effects could be due to the greater measurement error in the effective spread induced by the higher noise in the first few days of trading, when high volumes are transacted. As trading activity converges to its normal level, the spread becomes less noisy and its estimate more reliable.

4.6 Type of Market

In principle, the impact of liquidity and liquidity risk on IPO underpricing may differ depending on the type of market used by the issuer to carry out the IPO and list the firm. Liquidity and its risk are likely to play a more important role in the IPO underpricing for firm listing on the AIM since small firms are notoriously less liquid than larger firms. We address this concern by re-estimating the model separately for MM and AIM IPOs.

[Insert Table 8 here]

Table 8 shows the coefficient estimates for our model estimated for both Main Market and AIM. Columns 1 and 2 repeat the OLS estimation performed in the first column of Table 5 separately for IPOs carried out on the MM and on the AIM, respectively. Columns 4 and 5 repeat the same exercise using the IV estimation to instrument for liquidity and liquidity risk.

The table shows that liquidity and liquidity risk influence the IPO underpricing on both markets. Although according to the OLS estimates the effective spread has a smaller coefficient for companies listed on the AIM, this result is reversed by the IV estimates. According to these, however, liquidity risk has a considerably smaller impact on underpricing for AIM stocks.

5. Conclusions

Does after-market liquidity matter for IPO underpricing? In this paper we show that it does. Investors participating in IPOs want to be compensated not only for the firm's fundamental risk and adverse selection costs in the IPO process, but also for the expected liquidity of the shares they are buying and for the risk of an illiquid secondary market.

At the theoretical level, we make this point by a model where IPO underpricing is affected not only by investors' liquidity concerns, but also by adverse selection and risk. Our analytical setting can accommodate also the potential for different liquidity regimes, and therefore formalizes the notion of "liquidity risk" as distinct from fundamental risk as well as from the expected level of liquidity. The model nests nicely both traditional explanations and our liquidity-based view of IPO underpricing.

We test for the presence of liquidity effects on IPO underpricing after controlling for the variables suggested by other theories of IPOs. The main measure of liquidity that we employ is the after-market's effective spread. We use the variability of the effective spread to measure liquidity risk. Using a sample of companies that went public on the LSE between June 1998 and December 2000, we find that expected after-market liquidity and liquidity risk are important determinants of IPO underpricing, even though we control for all the other factors that have traditionally been used to explain underpricing. The results are robust to the use of an alternative measure of liquidity – the amortized spread – that takes into account not only the bid-ask spread, but also the frequency and the size of the trades on which the spread is paid. They are also robust to corrections for measurement error and endogeneity of the liquidity variables, to different holding periods and to splits across market segments.

These results are novel for two reasons. First, they highlight an important and neglected link between market microstructure and corporate finance: secondary market liquidity affects the cost of equity capital for companies that choose to go public, and may even affect that very choice. Second, they document that investors price not only the expected level of liquidity but also liquidity risk – and that the latter possibly matters to investors even more than liquidity itself. This finding, that we document with reference to the primary equity market, squares with the recent evidence by Pastor and Stambaugh (2003) about liquidity risk being priced in secondary market returns.

Appendix

1. Derivation of equation (15)

Under risk aversion, equation (1) must be restated in terms of expected utility: investor j bids for shares at the IPO only if

$$zE\left[U(\tilde{P}_1|\Omega_0^j)\right]+(1-z)E\left[U(\tilde{P}_2|\Omega_0^j)\right]\geq U(P_0). \qquad \text{(A1)}$$

Therefore, informed investors condition their bids on their private information $\tilde{u}_1$ only if

$$zE\left[U(\tilde{P}_1^B|\tilde{u}_1=\eta)\right]+(1-z)E\left[U(\tilde{P}_2|\tilde{u}_1=\eta)\right]\geq U(P_0)$$

$$> zE(\tilde{P}_1^B|\tilde{u}_1=-\eta)+(1-z)E(\tilde{P}_2|\tilde{u}_1=-\eta), \qquad \text{(A2)}$$

which, using (2) and recalling that $\tilde{P}_2=V+\tilde{u}_1+\tilde{u}_2$, can be rewritten as

$$zU\left(V+\eta-\frac{q}{q+z}\varepsilon\right)+\frac{1-z}{2}\left[U(V+\eta+\varepsilon)+U(V+\eta-\varepsilon)\right]\geq U(P_0)$$

$$> zU\left(V-\eta-\frac{q}{q+z}\varepsilon\right)+\frac{1-z}{2}\left[U(V-\eta+\varepsilon)+U(V-\eta-\varepsilon)\right]. \qquad \text{(A3)}$$

If condition (A3) holds, the informed traders' optimal strategy is to bid only if $\tilde{u}_1=\eta$. We shall see that this condition is met in equilibrium, if uninformed investors participate.

From (A1), uninformed investor instead bid for shares if:

$$z\left[\pi_u U(\tilde{P}_1^B|\tilde{u}_1=\eta)+(1-\pi_u)U(\tilde{P}_1^B|\tilde{u}_1=-\eta)\right]+$$

$$(1-z)\pi_u\left[\frac{1}{2}U(\tilde{P}_2|\tilde{u}_1=\eta,\tilde{u}_2=\varepsilon)+\frac{1}{2}U(\tilde{P}_2|\tilde{u}_1=\eta,\tilde{u}_2=-\varepsilon\right]+ \qquad \text{(A2')}$$

$$(1-z)(1-\pi_u)\left[\frac{1}{2}U(\tilde{P}_2|\tilde{u}_1=-\eta,\tilde{u}_2=\varepsilon)+\frac{1}{2}U(\tilde{P}_2|\tilde{u}_1=-\eta,\tilde{u}_2=-\varepsilon\right]\geq U(P_0),$$

which, using equation (2) and the definition of $\tilde{P}_2$, becomes:

$$z\left[\pi_u U\left(V+\eta-\frac{q}{q+z}\varepsilon\right)+(1-\pi_u)U\left(V-\eta-\frac{q}{q+z}\varepsilon\right)\right]+$$

$$\frac{1-z}{2}\{\pi_u[U(V+\eta+\varepsilon)+U(V+\eta-\varepsilon)]+(1-\pi_u)[U(V-\eta+\varepsilon)+U(V-\eta-\varepsilon)]\}\geq U(P_0).$$

The company will set the offer price at the highest level consistent with participation by the uninformed investors in the IPO, that is, will choose P_0 so that this condition holds with equality. This implies that condition (A3) concerning informed investors is satisfied, since $U(P_0)$ is an average of its left-hand and right-hand-side expressions, with weights π_u and $1-\pi_u$. It follows that, as under risk neutrality, $\pi_u = \lambda/(1-\lambda)$. Using this result in the previous condition taken with equality, we obtain the following condition defining the equilibrium offer price:

$$U(P_0) = z\left[\frac{\lambda}{1-\lambda}U\left(V+\eta-\frac{q}{q+z}\varepsilon\right)+\frac{1}{1-\lambda}U\left(V-\eta-\frac{q}{q+z}\varepsilon\right)\right]+$$
$$\frac{1-z}{2}\left\{\frac{\lambda}{1-\lambda}\left[U(V+\eta+\varepsilon)+U(V+\eta-\varepsilon)\right]+\frac{1}{1-\lambda}\left[U(V-\eta+\varepsilon)+U(V-\eta-\varepsilon)\right]\right\}. \quad \text{(A4)}$$

Taking a second-order Taylor-series approximation of the right-hand-side and collecting terms, one can rewrite expression (A4) as:

$$U(P_0) = U(V) - U'(V)\left(\frac{1-\lambda}{1+\lambda}\eta + z\frac{q}{q+z}\varepsilon\right)+$$
$$\frac{U''(V)}{2}\left\{z\left[\eta^2+\left(\frac{q}{q+z}\right)^2\varepsilon^2+2\frac{1-\lambda}{1+\lambda}\frac{q}{q+z}\eta\varepsilon\right]+(1-z)\left(\eta^2+\varepsilon^2\right)\right\}. \quad \text{(A4')}$$

and, collecting terms and recalling that the spread's bid-side portion $S_B = \frac{q}{q+z}\varepsilon$:

$$U(P_0) = U(V) - U'(V)\left(\frac{1-\lambda}{1+\lambda}\eta + zS_B\right)+\frac{U''(V)}{2}\left[\eta^2+(1-z)\varepsilon^2+z\left(S_B^2+2\frac{1-\lambda}{1+\lambda}\eta S_B\right)\right],$$

which yields equation (15) through the steps explained in the text.

2. Derivation of equation (17)

For the sake of brevity, for this case we shall concentrate on the condition that ensures the participation of uninformed investors, which determines the equilibrium price P_0. Based on (A1), uninformed investor bid for shares if:

$$z\frac{\pi_u}{2}\left[U(\tilde{P}_1^B \mid \tilde{u}_1=\eta, \tilde{q}=q_H)+U(\tilde{P}_1^B \mid \tilde{u}_1=\eta, \tilde{q}=q_L)\right]+$$
$$z\frac{1-\pi_u}{2}\left[U(\tilde{P}_1^B \mid \tilde{u}_1=-\eta, \tilde{q}=q_H)+U(\tilde{P}_1^B \mid \tilde{u}_1=-\eta, \tilde{q}=q_H)\right]+$$

$$(1-z)\frac{\pi_u}{2}\left[U(\tilde{P}_2|\tilde{u}_1=\eta,\tilde{u}_2=\varepsilon)+U(\tilde{P}_2|\tilde{u}_1=\eta,\tilde{u}_2=-\varepsilon\right]+$$

$$(1-z)\frac{1-\pi_u}{2}\left[U(\tilde{P}_2|\tilde{u}_1=-\eta,\tilde{u}_2=\varepsilon)+U(\tilde{P}_2|\tilde{u}_1=-\eta,\tilde{u}_2=-\varepsilon\right]\geq U(P_0)\,. \qquad \text{(A5)}$$

Taking this condition with equality, substituting the conditional values of $\tilde{P}_1^B$ and $\tilde{P}_2$ for this case and setting $\pi_u=\lambda/(1-\lambda)$, one obtains the following condition for the equilibrium offer price P_0:

$$U(P_0)=\frac{z}{2}\frac{\lambda}{1-\lambda}\left[U\left(V+\eta-\frac{q_H}{q_H+z}\varepsilon\right)+U\left(V+\eta-\frac{q_L}{q_L+z}\varepsilon\right)\right]+$$

$$\frac{z}{2}\frac{1}{1-\lambda}\left[U\left(V-\eta-\frac{q_H}{q_H+z}\varepsilon\right)+U\left(V-\eta-\frac{q_L}{q_L+z}\varepsilon\right)\right]+$$

$$\frac{1-z}{2}\left\{\frac{\lambda}{1-\lambda}\left[U(V+\eta+\varepsilon)+U(V+\eta-\varepsilon)\right]+\frac{1}{1-\lambda}\left[U(V-\eta+\varepsilon)+U(V-\eta-\varepsilon)\right]\right\}. \qquad \text{(A6)}$$

Taking a second-order Taylor-series approximation of the right-hand-side and collecting terms, one can rewrite expression (A6) as:

$$U(P_0)=U(V)-U'(V)\left[\frac{1-\lambda}{1+\lambda}\eta+\frac{z}{2}\left(\frac{q_H}{q_H+z}+\frac{q_L}{q_L+z}\right)\varepsilon\right]+ \qquad \text{(A6')}$$

$$\frac{U''(V)}{2}\left\{\eta^2+\frac{z}{2}\left[\left(\frac{q_H}{q_H+z}\right)^2+\left(\frac{q_L}{q_L+z}\right)^2\right]\varepsilon^2+(1-z)\varepsilon^2+z\frac{1-\lambda}{1+\lambda}\left(\frac{q_H}{q_H+z}+\frac{q_H}{q_H+z}\right)\eta\varepsilon\right\}.$$

Since $E(\tilde{S}_B)=\frac{1}{2}\left(\frac{q_H}{q_H+z}+\frac{q_L}{q_L+z}\right)\varepsilon$ and $E(\tilde{S}_B^2)=\frac{1}{2}\left[\left(\frac{q_H}{q_H+z}\right)^2+\left(\frac{q_L}{q_L+z}\right)^2\right]\varepsilon^2$, one can rewrite expression (A6') as:

$$U(P_0)=U(V)-U'(V)\left\{\left(\frac{1-\lambda}{1+\lambda}\eta+zE(\tilde{S}_B)\right)+\frac{U''(V)}{2}\left[\eta^2+(1-z)\varepsilon^2\right]+\right.$$

$$\left.+\frac{U''(V)}{2}z\left[\left[Var(\tilde{S}_B)+\left(E(\tilde{S}_B)\right)^2\right]+2\frac{1-\lambda}{1+\lambda}\eta E(\tilde{S}_B)\right]\right\},$$

which yields equation (17) through steps similar to those explained in the text for the derivation of equation (15).

References

Aggarwal, Reena, 2000, Stabilization activity by underwriters after initial public offerings, *Journal of Finance* 55(3), 1075-1103.

Amihud, Yakov and Haim Mendelson, 1986, Asset pricing and the bid-ask spread, *Journal of Financial Economics* 17, 23-249.

Amihud, Yakov and Haim Mendelson, 1991, Liquidity, maturity, and the yields on U.S. Treasury securities, *Journal of Finance* 46, 1411-1425.

Baron, David P., 1982, A model of the demand for investment banking advising and distribution services for new issues, *Journal of Finance* 37, 955-76.

Benveniste, Lawrence M., and Paul Spindt, 1989, How investment bankers determine the offer price and allocation of new issues, *Journal of Financial Economics* 24, 343-361.

Benveniste, Lawrence M., Alexander Ljungqvist, William J. Wilhelm, and Xiaoyun Yu, 2002, Evidence of information spillovers in the production of investment banking services, *Journal of Finance*, forthcoming.

Booth, James R., and Lena Chua, 1996, Ownership dispersion, costly information, and IPO underpricing, *Journal of Financial Economics* 41, 291-310.

Brennan, Michael J., and Julian Franks, 1995, Underpricing, ownership, and control in initial public offerings of equity securities in the UK, *Journal of Financial Economics* 45, 391-413

Brennan, Michael J., and Avanidhar Subrahmanyam, 1996, Market microstructure and asset pricing: On the compensation for illiquidity in stock returns, *Journal of Financial Economics* 41, 441-464.

Chalmers, John M.R., and Gregory B. Kadlec, 1998, An empirical examination of the amortized spread, *Journal of Financial Economics* 48, 159-188.

Chordia, Tarun, Richard Roll and Avanidhar Subrahmanyam, 2000, Market liquidity and trading activity, *Journal of Finance* 56, 501-530.

Chordia, Tarun, Avanidhar Subrahmanyam, and Ravi Anshuman, 2001, Trading activity and expected stock returns, *Journal of Financial Economics* 59, 3-32.

Datar, Vinay, Naik Narayan, and Robert Radcliff, 1998, Liquidity and stock returns: An alternative test, *Journal of Financial Intermediation* 1, 203-219.

Daves, Philip R. and Michael C. Erhardt, 1993, Liquidity, reconstitution, and the value of U.S. Treasury strips, *Journal of Finance* 48(1), 315-329.

Dimson, Elroy, and Bernd Hanke, 2001, The expected illiquidity premium: Evidence from equity index-linked bonds, London Business School Working Paper.

Eleswarapu, Venkat, 1997, Cost of transacting and expected returns in the Nasdaq market, *Journal of Finance* 52, 2113-2128.

Ellis, Katrina, Roni Michael, and Maureen O'Hara, 2000, When the underwriter is the market maker: An examination of trading in the IPO aftermarket, *Journal of Finance* 55(3), 1039-1074.

Glosten, Lawrence, and Paul Milgrom, 1985, Bid, ask, and transaction prices in a specialist market with heterogenously informed traders, *Journal of Financial Economics* 13, 71-100.

Goldreich, David, Bernd Hanke, and Purnendu Nath (2002), The price of future liquidity: Time-varying liquidity in the U.S. Treasury market, London Business School Working Paper.

Habib, Michael, and Alexander Ljungqvist, 2001, Underpricing and entrepreneurial wealth losses in IPOs: Theory and evidence, *Review of Financial Studies* 14, 433-458.

Jensen, Michael C., and William H. Meckling, 1976, Theory of the firm: Managerial behavior, agency costs, and ownership structure, *Journal of Financial Economics* 4, 305-50.

Kamara, Avraham, 1994, Liquidity, taxes, and short-term Treasury yields, *Journal of Financial and Quantitative Analysis* 29(3), 403-417.

Krishnamurthy, Arvind, 2000, The bond/old-bond spread, Northwestern University Working Paper.

Leland, Hayne E., and David H. Pyle, 1977, Informational asymmetries, financial structure, and financial intermediation, *Journal of Finance*, 32, 371-387.

Ljungqvist, Alexander, 2002, Conflicts of interest and efficient contracting in IPOs, New York University Working Paper.

Loughran, Tim, and Jay R. Ritter, 2000, Why has IPO underpricing changed over time?, University of Florida Working Paper.

Megginson, William L., and K. A. Weiss, 1991, Venture capitalist certification in initial public offerings: Theory and evidence, *Journal of Financial and Quantitative Analysis* 27, 55-79.

Pástor, Luboš, and Robert Stambaugh, 2003, Liquidity Risk and Expected Stock Returns, *Journal of Political Economy* 111(3), 642-685.

Rock, Kevin, 1986, Why new issues are underpriced, *Journal of Financial Economics* 15, 187-212

Ruud, Judith S., 1993, Underwriter price support and the IPO underpricing puzzle, *Journal of Financial Economics* 34(2), 135-151.

Silber, William, 1991, Discounts on restricted stock: The impact of illiquidity on stock prices, *Financial Analyst Journal* 47, 60-64.

Strebulaev, Ilya, 2001, Market imperfections and pricing in the U.S. Treasury securities market, London Business School Working Paper.

Warga, Arthur, 1992, Bond return, liquidity, and missing data, *Journal of Financial and Quantitative Analysis* 27, 605-617.

Welch, Ivo, 1992, Sequential sales, learning and cascades, *Journal of Finance* 47, 695-732.

Table 1. Composition of the Sample

The Table illustrates the composition of the sample, which refers to the 337 IPOs carried out between July 1998 and December 2000 on the London Stock Exchange. Panel A shows the breakdown of the sample by sector and size (as measured by total assets). Each cell reports the number of companies in the corresponding sector and size quartile. Panel B shows the breakdown of the sample by age (as measured by years from incorporation to the date of the IPO) and market of listing (Main Market or Alternative Investment Market).

Panel A

Sector:	**1st size quartile**	**2nd size quartile**	**3rd size quartile**	**4th size quartile**	**Total**
1. Resources	0	0	2	3	5
2. Basic Industries	0	1	3	2	6
3. General Industries	2	5	3	7	17
4. Cyclical Consumer Goods	1	6	1	6	14
5. Non-Cyclical Consumer Goods	7	7	8	8	30
6. Cyclical Services	25	18	34	18	95
7. Non-Cyclical Services	19	4	4	6	33
8. Financials	8	6	10	16	40
9. Information Technology	29	30	20	18	97

Panel B

Age (Years):	**Main Market**	**Alternative Investment Market**	**Total**
Age ≤ 1	3	71	74
1 < Age ≤ 2	6	18	24
2 < Age ≤ 3	9	14	23
3 < Age ≤ 4	14	19	33
4 < Age ≤ 5	10	11	21
5 < Age ≤ 6	7	22	29
6 < Age ≤ 7	5	15	20
7 < Age ≤ 8	6	14	20
8 < Age ≤ 9	3	9	12
9 < Age ≤ 10	6	9	14
Age > 10	30	36	67

Table 2. Companies and IPO Characteristics: Descriptive Statistics

The Table shows statistics for the 337 IPOs carried out between June 1998 and December 2000 on the London Stock Exchange. Trading data were supplied by the London Stock Exchange. Data about firm characteristics are drawn from the prospectuses filed with the Financial Services Authority (the UK Listing Authority). All figures are cross-sectional statistics. Firm Sales refer to the year preceding the IPO, and Firm Capitalization refers to the time of the IPO. Firm Age is the number of years between the firm's initial incorporation and the time of the IPO. In case of mergers and takeovers, the date of incorporation refers to the oldest firm. Fixed Assets is the firms' fixed assets at the time of the IPO. Leverage is the cross-sectional average of long-term debt to assets held by the firm at the time of the IPO. Underpricing – First day is the percentage difference between the closing price on the first day of trading and the offer price. Underpricing – First 4 weeks is the same measure with reference to the 20th of trading. Shares Offered is the number of shares placed on the market in the IPO. Shares Sold by Main Shareholders is the number of shares offered by the major shareholders (defined as the shareholders holding 3 percent or more of the share capital at the time of the IPO). Equity Issued is the *new* share capital placed by the company in the IPO expressed as a percentage of the post-IPO capital. Sales by Insiders is the amount of shares sold by insiders (firm's directors and major shareholders holding more than 3 percent of the capital) expressed as a percentage of pre-IPO outstanding shares. Directors' Options are the directors' holdings of options as a percent of outstanding shares after the IPO. Independent Directors' Presence is the percent of independent directors on the board at the time of the IPO.

Variable:	**Mean**	**Median**	**Standard Deviation**	**Minimum**	**Maximum**
Company Characteristics:					
Firm Size (by sales, £ million)	51.22	1.90	318.18	0	3,800
Firm Size (by market cap, £ million)	174.27	25.37	673.19	0.17	7,523
Firm Age (years)	7.12	5.0	12.72	0.04	154
Fixed Assets (in £ million)	135.07	1.01	1757.99	0.0	32,000
Leverage (Short-term Debt) (percent)	49.62	42.10	54.56	0	465.81
Leverage (Long-term Debt) (percent)	69.07	56.25	71.84	0	589.17
IPO Characteristics:					
Underpricing – First day (percent)	47.66	22.80	82.86	-61.20	660.0
Underpricing – First 4 weeks (percent)	29.58	11.36	66.72	-66.00	398.0
Shares Offered (in 1,000)	39,700	13,700	171,600	500	2,950,000
Shares Sold by Main Shareholders (in 100,000)	57.90	0.01	160.0	0	1980.0
Equity Issued (percent)	31.89	25.10	23.84	1.8	99
Sales by Insiders (percent)	6.65	0.0	11.47	0	84.00
Directors' Options (percent)	2.29	1.00	3.14	0	19.46
Venture Capitalists' Presence	0.47	0	0.50	0	1
Independent Directors' Presence (percent)	45.67	42.86	16.53	0	100

Table 3. Liquidity Measures: Descriptive Statistics

The Table reports statistics about underpricing and aftermarket liquidity for the 337 IPOs carried out between June 1998 and December 2000 on the London Stock Exchange. Panel A reports statistics for the entire first four weeks of trading while Panel B reports underpricing and liquidity measures statistics for each of the first four weeks. The Quoted Spread is the percentage difference between ask and bid divided by the mid-quote price. The Effective Spread is twice the deviation of the transaction price from the mid-quote price, multiplied by a trade direction dummy. The Amortized Spread is the sum of all the effective spreads paid in each of the 102 10-minute trading intervals multiplied by the number of shares traded in each interval divided with the stock's market capitalization calculated using the trading interval's last price. The Volatility of the Quoted (Effective) Spread is measured as the average standard deviation of the Quoted (Effective) Spread sampled at one-hour intervals. The Range of Effective Spread is the average of the range between the highest and lowest effective spread, calculated for each trading day. The Range of the Amortized Spread is the range of variation of the amortized spread calculated over the first four weeks of trading. Return Volatility is the standard deviation of returns using mid-quotes sampled at one-hour intervals. For all these variables, the table shows the pooled time-series and cross-sectional averages across sample firms for the first four weeks of trading on the aftermarket. Underpricing is the percentage change from the offer price to the closing price for each week. Volume Transacted is the average daily volume traded in each week. Turnover is the average daily number of shares traded for each week divided by the number of shares outstanding. Number of Trades is the daily average number of all customer seller- and buyer-initiated trades each week. Waiting Time between Trades is the daily average number of seconds between successive trades in each trading week. Order Imbalance is the daily average difference between the total number of buyer-initiated trades and the total number of seller-initiated trades in the corresponding trading week. In Panel B we define the 1st week as the first five days of aftermarket trading. The 2nd, 3rd and 4th weeks are defined similarly.

Panel A. Liquidity Measures for the Entire Four Weeks of Trading

Variable:	Mean	Median	Standard Deviation	Minimum	Maximum
Liquidity and Volatility Variables:					
Quoted Spread (percent)	5.71	5.01	3.05	0.702	15.17
Effective Spread (percent)	5.03	4.29	2.98	0.29	14.81
Amortized Spread (percent)	5.59	4.86	3.44	0.111	24.21
Volatility of Quoted Spread	1.41	1.20	0.95	0.05	6.33
Volatility of Effective Spread	1.46	1.19	1.08	0.015	6.92
Range of Effective Spread	4.41	3.77	2.94	0.250	19.56
Range of Amortized Spread	6.07	5.28	3.51	0.826	24.64
Return Volatility	0.047	0.028	0.0687	0.0024	0.42
Trading Volume (1,000 shares)	2,016	131	14,100	0.100	610,000
Turnover (percent)	1.32	0.44	3.10	0.0001	25.87

Table 3 continues overleaf

Table 3, continued

Panel B. Underpricing and Liquidity Measures at Different Horizons

Variable:	Mean	Median	Standard Deviation "Within" Firms	Standard Deviation "Between" Firms
Underpricing (percent):				
1st week	42.21	21.15	7.1086	154.1135
2nd week	38.46	16.41	0.9947	138.4025
3rd week	34.18	12.82	0.1391	125.5471
4th week	29.58	11.36	0.0424	118.2431
Quoted Spread (percent):				
1st week	6.02	5.19	1.5194	4.3682
2nd week	5.88	5.12	1.2113	4.2189
3rd week	5.71	4.88	1.0671	4.3164
4th week	5.58	4.56	1.0821	4.5048
Effective Spread (percent):				
1st week	5.48	4.64	1.3852	4.4097
2nd week	5.31	4.58	1.0892	4.2941
3rd week	5.06	4.35	1.0573	4.1787
4th week	4.81	4.16	1.0243	4.3154
Amortized Spread (percent):				
1st week	11.38	4.39	3.91	6.57
2nd week	5.04	2.58	1.88	2.93
3rd week	3.26	2.17	1.52	1.13
4th week	2.19	1.51	0.79	1.29
Turnover (percent)				
1st week	4.58	0.81	12.18	18.92
2nd week	1.32	0.26	6.44	8.02
3rd week	1.02	0.18	4.53	3.41
4th week	0.68	0.13	2.96	5.53

Table 3 continues overleaf

Table 3, continued

Variable:	**Mean**	**Median**	**Standard Deviation (variation "within" firms)**	**Standard Deviation (variation "between" firms)**
Volume Transacted (number of shares)				
1st week	6,488,643	442,682	25,500,000	25,80,000
2nd week	1,324,568	163,544	3,266,005	5,139,087
3rd week	898,104	80,159	2,105,702	2,209,598
4th week	840,464	66,400	1,460,000	3,217,608
Number of Trades:				
1st week	286	51	337	715
2nd week	95	24	111	227
3rd week	81	23	104	183
4th week	74	19	106	206
Waiting Time between Trades:				
1st week	191	15	789	1602
2nd week	387	49	1179	3158
3rd week	419	55	1186	3085
4th week	528	68	1411	2928
Order Imbalance:				
1st week	846,750	9,574	5,006,709	15,900,000
2nd week	187,889	1,561	620,562	618,364
3rd week	54,143	811	450,122	929,406
4th week	33,144	406	287,964	748,099

Table 4. Model Specification

Source of underpricing	**Explanatory Variables**	**Predicted Sign of Coefficient**
Liquidity	Quoted Spread	Positive
	Effective Spread	Positive
	Amortized Spread	Positive
Liquidity risk	Variability of the Effective Spread, Quoted Spread or Amortized Spread	Positive
Adverse selection	Sales by insiders	Ambiguous
	Directors' holdings of options	Ambiguous
	Venture capitalists' presence	Negative
	Independent directors' presence	Negative
	Number of previous IPOs	Negative
	Total proceeds of previous IPOs	Negative
Fundamental risk	Size of firm (total assets)	Negative
	Firm's age	Negative
	Return volatility	Positive
	High-risk sector (IT sector)	Positive
	Underwriter stabilization	Positive
	Size of the IPO (proceeds from offering)	Positive

Table 5. Regression Results

The dependent variable is the IPO underpricing, defined as natural log of the ratio between the closing price of the 20th day of trading and the IPO offer price. Method (1a) employs OLS estimation and the average Effective (Amortized) Spread and its Variability over the first four weeks of trading. Method (1b) replicates the specification used in method (1a) with IV estimation, instrumenting Sales by Insiders and IPO Proceeds. Method (2a) uses IV estimation to instrument the Effective (Amortized) Spread and its Variability. Method (2b) uses IV estimation to instrument for the Effective (Amortized) Spread, its Variability, Sales by Insiders and IPO Proceeds. Method (3) relies on the characteristics of companies that already went public to predict the Effective (Amortized) Spread and its Variability. The Effective Spread is twice the deviation of the transaction price from the mid-quote price, multiplied by a trade direction dummy, over the first four weeks of trading. The Variability of the Effective Spread is measured as the average of the range between the highest and lowest effective spreads, calculated for each trading day over the first four weeks of trading. The Amortized Spread is the sum of all the Effective Spreads paid in every of the 102 10-minute trading intervals multiplied by the amount of shares transacted in each interval divided with the stock's market capitalization calculated using the closing price of every trading interval. The Variability of the Amortized Spread is the range of variation of the amortized spread calculated over the first four weeks of trading. Sales by Insiders are the shares sold at the IPO stage by the main shareholders (defined as the shareholders holding three percent or more of the share capital) as percentage of the total shares outstanding at the time of the IPO. Directors' Options are the directors' holdings of options as a percent of outstanding shares after the IPO. Venture Capitalist is a dummy variable that equals 1 if the company had a venture capitalist as one of its main shareholders at the time of the IPO, and 0 otherwise. Total Assets is the logarithm of the sum of fixed assets and current assets in the year preceding the IPO, in thousand pounds. Firm Age is the logarithm of the number of years from the firm's original incorporation to the time of the IPO. Governance is the ratio of independent directors to the total number of directors in the firm's Board of Directors. Return Volatility is the standard deviation of returns using mid-quotes sampled at one-hour intervals over the first four trading weeks. IT Sector is a dummy variable that takes the value of 1 if the company operates in the information technology sector and 0 otherwise. Number of IPOs in the Same (Previous) Quarter is the logarithm of the number of IPOs carried out on the London Stock Exchange in the same (previous) quarter relative to every IPO in the sample. Underwriter Stabilization is a dummy variable that equals 1 when a stabilization agreement is mentioned in the IPO prospectus and 0 otherwise. Size of the IPO is the logarithm of the total proceeds from the IPO. Asterisks (*, ** and ***) indicate statistical significance (at the 10%, 5% and 1% level respectively).

Panel A. Regressions With the Effective Bid-Ask Spread

	Method (1a)	**Method (1b)**	**Method (2a)**	**Method (2b)**	**Method (3)**
Intercept	0.0953	0.1130	-0.2104	-0.2096	-0.2221
	(0.75)	(0.78)	(-1.19)	(-0.99)	(-1.19)
Effective Spread	0.0213***	0.0196***	0.0614***	0.0613**	0.0412**
	(4.01)	(3.18)	(2.90)	(2.23)	(2.46)
Variability of Effective Spread	0.0372***	0.0388***	0.0657***	0.0655***	0.0689***
	(4.45)	(4.57)	(3.14)	(2.98)	(3.71)

Table 5 continues overleaf

Table 5, continued

	Method (1a)	Method (1b)	Method (2a)	Method (2b)	Method (3)
Sales by Insiders		0.0088		0.0015	
		(0.79)		(0.25)	
Directors' Options Holdings	-0.0082*	-0.0068	-0.0046	-0.0043	-0.0051
	(-1.69)	(-1.20)	(-0.87)	(-0.76)	(-1.01)
Venture Capitalist's Presence	-0.0991***	-0.0974**	-0.1022***	-0.1025**	-0.0711*
	(-2.70)	(-2.54)	(-2.54)	(-2.52)	(-1.87)
Firm Age	-0.0529***	-0.0673**	-0.0323	-0.0350	-0.0423**
	(-2.82)	(-2.42)	(-1.48)	(-1.36)	(-2.12)
Total Assets	-0.0066	-0.0091	-0.0007	-0.0016	-0.0056
	(-1.03)	(-0.76)	(-0.09)	(-0.18)	(-0.81)
Governance	0.0009	0.0004	0.0011	0.0010	-0.0000
	(0.63)	(0.25)	(0.72)	(0.62)	(-0.02)
Return Volatility	0.9861***	0.9728***	0.5364	0.5487	1.1503***
	(3.14)	(2.79)	(1.41)	(1.33)	(3.10)
IT Sector	0.0191	0.0299	0.0520	0.0519	-0.0181
	(0.45)	(0.68)	(1.13)	(1.12)	(-0.40)
IPOs in the Same Quarter	0.0670	0.0578	0.0664	0.0643	0.0385
	(1.02)	(0.82)	(0.87)	(0.85)	(0.55)
IPOs in the Previous Quarter	-0.1201**	-0.1046	-0.1411**	-0.1381**	-0.0747
	(-2.05)	(-1.57)	(-2.06)	(-1.98)	(-1.23)
Underwriter Stabilization	0.1224***	0.1218*	0.2130***	0.2098***	0.1486***
	(2.98)	(1.93)	(3.46)	(3.29)	(3.42)
Size of the IPO		-0.0281		-0.0020	
		(-1.17)		(-0.07)	
R^2	0.3243	0.2864	0.1701	0.1736	0.2795
Number of Observations	337	337	337	337	337

Panel B. Regressions With the Amortized Bid-Ask Spread

	Method (1a)	**Method (1b)**	**Method (2a)**	**Method (2b)**	**Method (3)**
Intercept	0.0347	0.0411	-0.1546	-0.2243	0.2312*
	(0.28)	(0.29)	(-1.04)	(-1.17)	(1.88)
Amortized Spread	0.0137**	0.0135**	0.0383**	0.0489**	0.0087**
	(2.21)	(1.96)	(2.32)	(2.02)	(1.98)
Variability of Amortized Spread	0.0395***	0.0402***	0.0434***	0.0385*	0.0092***
	(4.94)	(4.94)	(2.58)	(1.92)	(3.04)
Sales by Insiders		0.0054		0.0027	
		(0.50)		(0.57)	
Directors' Options Holdings	-0.0078*	-0.0068	-0.0073	-0.0067	-0.0106**
	(-1.69)	(-1.28)	(-1.51)	(-1.35)	(-2.17)
Venture Capitalist's Presence	-0.0805**	-0.0790**	-0.0690*	-0.0694*	-0.1018***
	(-2.26)	(-2.18)	(-1.81)	(-1.77)	(-2.72)
Firm Age	-0.0459**	-0.0543**	-0.0297	-0.0314	-0.0613***
	(-2.53)	(-2.13)	(-1.53)	(-1.44)	(-3.21)
Total Assets	-0.0066	-0.0082	-0.0046	-0.0090	-0.0103
	(-1.08)	(-0.72)	(-0.72)	(-0.96)	(-1.58)
Governance	0.0008	0.0005	0.0011	0.0010	0.0013
	(0.58)	(0.29)	(0.73)	(0.65)	(0.92)
Return Volatility	0.7056**	0.6932**	0.3367	0.3497	0.9346***
	(2.36)	(2.16)	(0.84)	(0.85)	(2.86)
IT Sector	0.0101	0.0165	0.0203	0.0134	0.0106
	(0.24)	(0.38)	(0.46)	(0.28)	(0.24)
IPOs in the Same Quarter	0.0479	0.0416	0.0594	0.0608	0.0818
	(0.80)	(0.65)	(0.89)	(0.87)	(1.32)
IPOs in the Previous Quarter	-0.0939*	-0.0837	-0.1078*	-0.1091	-0.1265**
	(-1.69)	(-1.35)	(-1.69)	(-1.61)	(-2.20)
Underwriter Stabilization	0.1003***	0.1004*	0.1382***	0.1213**	0.0846**
	(2.62)	(1.75)	(3.20)	(2.52)	(2.08)
Size of the IPO		-0.0162		0.0161	
		(-0.70)		(0.54)	
R^2	0.3596	0.3534	0.3131	0.2749	0.3014
Number of Observations	337	337	337	337	337

Table 6. Regression Results with Underpricing Relative to the First Trading Day

The dependent variable is the IPO underpricing, defined as natural log of the ratio between the closing price of the first day of trading and the IPO offer price. Method (1a) employs OLS estimation and measures the average Effective Spread and its Variability over the first four weeks of trading. Method (1b) replicates the specification used in method (1a) with IV estimation, instrumenting Sales by Insiders and IPO Proceeds. Method (2a) uses IV estimation to instrument the Effective Spread and its Variability. Method (2b) uses IV estimation to instrument for the Effective Spread, its Variability, Sales by Insiders and IPO Proceeds. Method (3) relies on the characteristics of companies that already went public to predict the Effective Spread and its Variability. The Effective Spread is twice the deviation of the transaction price from the mid-quote price, multiplied by a trade direction dummy, over the first four weeks of trading. The Variability of the Effective Spread is measured as the average of the range between the highest and lowest effective spreads, calculated for each trading day over the first four weeks of trading. Sales by Insiders are the shares sold at the IPO stage by the main shareholders (defined as the shareholders holding three percent or more of the share capital) as percentage of the total shares outstanding at the time of the IPO. Directors' Options are the directors' holdings of options as a percent of outstanding shares after the IPO. Venture Capitalist is a dummy variable that equals 1 if the company had a venture capitalist as one of its main shareholders at the time of the IPO, and 0 otherwise. Total Assets is the logarithm of the sum of fixed assets and current assets in the year preceding the IPO, in thousand pounds. Firm Age is the logarithm of the number of years from the firm's original incorporation to the time of the IPO. Governance is the ratio of independent directors to the total number of directors in the firm's Board of Directors. Return Volatility is the standard deviation of returns using mid-quotes sampled at one-hour intervals over the first four trading weeks. IT Sector is a dummy variable that takes the value of 1 if the company operates in the information technology sector and 0 otherwise. Number of IPOs in the Same (Previous) Quarter is the logarithm of the number of IPOs carried out on the London Stock Exchange in the same (previous) quarter relative to every IPO in the sample. Underwriter Stabilization is a dummy variable that equals 1 when a stabilization agreement is mentioned in the IPO prospectus and 0 otherwise. Size of the IPO is the logarithm of the total proceeds from the IPO. Asterisks (*, ** and ***) indicate statistical significance (at the 10%, 5% and 1% level respectively).

	Method (1a)	**Method (1b)**	**Method (2a)**	**Method (2b)**	**Method (3)**
Intercept	0.1913	0.2063	-0.0942	-0.1084	-0.0871
	(1.49)	(1.42)	(-0.54)	(-0.52)	(-0.46)
Effective Spread	0.0250***	0.0235***	0.0631**	0.0654**	0.0406**
	(4.76)	(3.89)	(3.02)	(2.40)	(2.43)
Variability of Effective Spread	0.0360***	0.0375***	0.0616**	0.0610***	0.0648***
	(4.27)	(4.39)	(3.04)	(2.83)	(3.46)

Table 6 continues overleaf

Table 6, continued

	Method (1a)	**Method (1b)**	**Method (2a)**	**Method (2b)**	**Method (3)**
Sales by Insiders		-0.0075		0.0015	
		(0.70)		(0.25)	
Directors' Options Holdings	-0.0082*	-0.0071	-0.0049	-0.0044	-0.0056
	(-1.70)	(-1.27)	(-0.95)	(-0.79)	(-1.09)
Venture Capitalist's Presence	-0.1051**	-0.1040***	-0.1082***	-0.1093***	-0.0776**
	(-2.88)	(-2.75)	(-2.73)	(-2.71)	(-2.02)
Firm Age	-0.0538**	-0.0662**	-0.0350	-0.0373	-0.0453**
	(-2.83)	(-2.42)	(-1.60)	(-1.46)	(-2.23)
Total Assets	-0.0068	-0.0089	-0.0013	-0.0025	-0.0064
	(-1.08)	(-0.77)	(-0.17)	(-0.29)	(-0.92)
Governance	0.0013	0.0009	0.0015	0.0014	0.0004
	(0.91)	(0.56)	(0.99)	(0.86)	(0.28)
Return Volatility	1.0322**	1.0242***	0.6246*	0.6568*	1.2074***
	(3.33)	(2.95)	(1.69)	(1.65)	(3.28)
IT Sector	0.0215	0.0308	0.0524	0.0514	-0.0165
	(0.50)	(0.70)	(1.14)	(1.10)	(-0.36)
IPOs in the Same Quarter	0.0779	0.0705	0.0787	0.0766	0.0481
	(1.19)	(1.01)	(1.05)	(1.01)	(0.69)
IPOs in the Previous Quarter	-0.1317**	-0.1190*	-0.1525**	-0.1504**	-0.0843
	(-2.24)	(1.80)	(-2.24)	(-2.14)	(-1.38)
Underwriter Stabilization	0.1234***	0.1229**	0.2082***	0.2041***	0.1395***
	(3.01)	(1.99)	(3.40)	(3.22)	(3.19)
Size of the IPO		-0.0242		0.0021	
		(-1.01)		(0.07)	
R^2	0.3394	0.3151	0.2082	0.2008	0.2827
Number of Observations	337	337	337	337	337

Table 7. Results' Robustness Over Different Periods

The dependent variable is the IPO underpricing, defined as natural log of the ratio between the closing price on the relevant trading day and the IPO offer price. The table shows OLS coefficient estimates and employs the average of the realized Effective Spread and its Variability over the relevant trading period as explanatory variables. IPO Underpricing, the Effective Spread and the Variability of the Effective Spread are measured over different horizons in the two regressions: the first trading day in column 1, and the first five trading days (one calendar week) in column 2. The Effective Spread is twice the deviation of the transaction price from the mid-quote price, multiplied by a trade direction dummy, over the relevant period. The Variability of the Effective Spread is measured as the average of the range between the highest and lowest effective spreads, calculated for each trading day over the relevant period. Sales by Insiders are the shares sold by the main shareholders (defined as the shareholders holding three percent or more of the share capital at the time of the IPO) at the IPO stage as percentage of the total shares outstanding at the time of the IPO. Directors' Options are the directors' holdings of options as a percent of outstanding shares after the IPO. Venture Capitalist's Presence is a dummy variable taking the value of 1, if the company had a venture capitalist as one of its main shareholders at the time of the IPO, and a value of 0 if no venture capitalist was present. Firm Sales are the sales in the year preceding the IPO. Firm Age is the number of years from the firm's original incorporation to the time of the IPO. Governance is the ratio of independent directors to the total number of directors in the firm's Board of Directors. Return Volatility is the standard deviation of returns using mid-quotes sampled at one-hour intervals over the first four trading weeks. IT Sector is a dummy variable that equals 1 if the company operates in the information technology sector, and 0 otherwise. Number of IPOs in the Same (Previous) Quarter is the total number of IPOs carried out on the London Stock Exchange in the same (previous) quarter relative to every IPO in the sample. Underwriter Stabilization is a dummy variable that takes the value of 1 when a stabilization agreement is mentioned in the IPO prospectus and a value of 0 otherwise. Size of the IPO is the total proceeds from the IPO. Asterisks (*, ** and ***) indicate statistical significance (at the 10%, 5% and 1% level respectively).

	(1)	**(2)**
Intercept	0.1573	0.1101
	(1.17)	(0.83)
Effective Spread	0.0194***	0.0167**
	(2.99)	(2.34)
Variability of Effective Spread	0.0403***	0.0526***
	(4.76)	(5.78)
Directors' Options Holdings	-0.0102**	-0.0096*
	(-2.05)	(-1.74)

Table 7 continues overleaf

Table 7, continued

	(1)	(2)
Venture Capitalist's Presence	-0.0919**	-0.0913**
	(-2.53)	(-2.43)
Firm Age	-0.0582***	-0.0498***
	(-3.00)	(-2.61)
Total Assets	-0.0053	-0.0111*
	(-0.84)	(1.75)
Governance	0.0013	0.0011
	(0.88)	(0.80)
Return Volatility	1.0564***	0.9533***
	(3.09)	(2.77)
IT Sector	0.0102	0.0017
	(0.24)	(0.03)
Number of IPOs in the Same Quarter	0.0818	0.0674
	(1.36)	(1.08)
Number of IPOs in the Previous Quarter	-0.1279**	-0.1144*
	(-2.27)	(-1.90)
Underwriter Stabilization	0.1151***	0.1597***
	(2.79)	(3.57)
R^2	0.2864	0.3369
Number of Observations	337	337

Table 8. Regression Results for Main Market and AIM

The dependent variable is the IPO underpricing, defined as natural log of the ratio between the closing price of the 20th day of trading and the IPO offer price. Columns 1 and 2 report OLS estimates for IPOs carried out on the MM and on the AIM, respectively. Columns 3 and 4 report IV estimates (where instruments are used for the Effective Spread and the Variability of the Effective Spread) for IPOs carried out on the MM and on the AIM, respectively. The Effective Spread is twice the deviation of the transaction price from the mid-quote price, multiplied by a trade direction dummy, over the first four weeks of trading. The Variability of the Effective Spread is measured as the average of the range between the highest and lowest effective spreads, calculated for each trading day over the first four weeks of trading. Sales by Insiders are the shares sold by the main shareholders (defined as the shareholders holding three percent or more of the share capital at the time of the IPO) at the IPO stage as percentage of the total shares outstanding at the time of the IPO. Directors' Options are the directors' holdings of options as a percent of outstanding shares after the IPO. Venture Capitalist is a dummy variable that equals 1 if the company had a venture capitalist as one of its main shareholders at the time of the IPO, and 0 otherwise. Total Assets is the logarithm of the sum of fixed assets and current assets in the year preceding the IPO, in thousand pounds. Firm Age is the logarithm of the number of years from the firm's original incorporation to the time of the IPO. Governance is the ratio of independent directors to the total number of directors in the firm's Board of Directors. Return Volatility is the standard deviation of returns using mid-quotes sampled at one-hour intervals over the first 4 trading weeks. The IT Dummy is a dummy variable that takes the value of 1 if the company operates in the information technology sector and 0 otherwise. Number of IPOs in the Same (Previous) Quarter is the logarithm of the number of IPOs carried out on the London Stock Exchange in the same (previous) quarter relative to every IPO in the sample. Underwriter Stabilization is a dummy variable that takes the value of 1 when a stabilization agreement is mentioned in the IPO prospectus and a value of 0 when no stabilization agreement is in place. Size of the IPO is the logarithm of the total proceeds from the IPO. Asterisks (*, ** and ***) indicate statistical significance (at the 10%, 5% and 1% level respectively).

	(1)	**(2)**	**(3)**	**(4)**
	Main Market	**AIM**	**Main Market**	**AIM**
Intercept	0.4782**	0.1136	0.3071	-0.1348
	(2.35)	(0.69)	(1.56)	(-0.64)
Effective Spread	0.0321***	0.0153**	0.0496**	0.0652**
	(3.43)	(2.48)	(1.98)	(2.01)
Variability of Eff. Spread	0.0420***	0.0377***	0.0718***	0.0363*
	(3.32)	(3.65)	(2.87)	(1.73)

Table 8 continues overleaf

Table 8, continued

	(1) Main Market	(2) AIM	(3) Main Market	(4) AIM
Director Options Holdings	-0.0060	-0.0075	-0.0043	-0.0027
	(-1.02)	(-1.20)	(-0.60)	(-0.40)
Venture Capitalist	-0.1336**	-0.0827*	-0.1568***	-0.0808
	(-2.48)	(-1.75)	(2.73)	(-1.55)
Firm Age	-0.0933***	-0.0524**	-0.0910**	-0.0349
	(-2.62)	(-2.32)	(-2.39)	(-1.32)
Total Assets	-0.0108	-0.0016	-0.0102	-0.0026
	(-1.37)	(-0.19)	(-0.94)	(-0.26)
Governance	-0.0011	0.0017	-0.0001	0.0016
	(-0.50)	(0.97)	(-0.01)	(0.83)
Return Volatility	1.9193***	0.7396**	1.4446**	0.6845*
	(4.15)	(2.20)	(2.41)	(1.84)
IT Sector	0.0162	0.0365	-0.0106	0.0780
	(0.28)	(0.58)	(-0.16)	(1.08)
IPOs in the Same Quarter	-0.1594	0.0950	-0.1361	0.1154
	(-1.41)	(1.24)	(-1.15)	(1.27)
IPOs in the Prev. Quarter	0.0357	-0.1545**	-0.0035	-0.1943**
	(0.38)	(-2.07)	(-0.03)	(-2.07)
Underwriter Stabilization	0.1290*	0.8165***	0.1715**	0.9191***
	(1.71)	(15.98)	(2.04)	(11.35)
R^2	0.4721	0.3057	0.4116	0.1768
Number of Observations	99	238	99	238

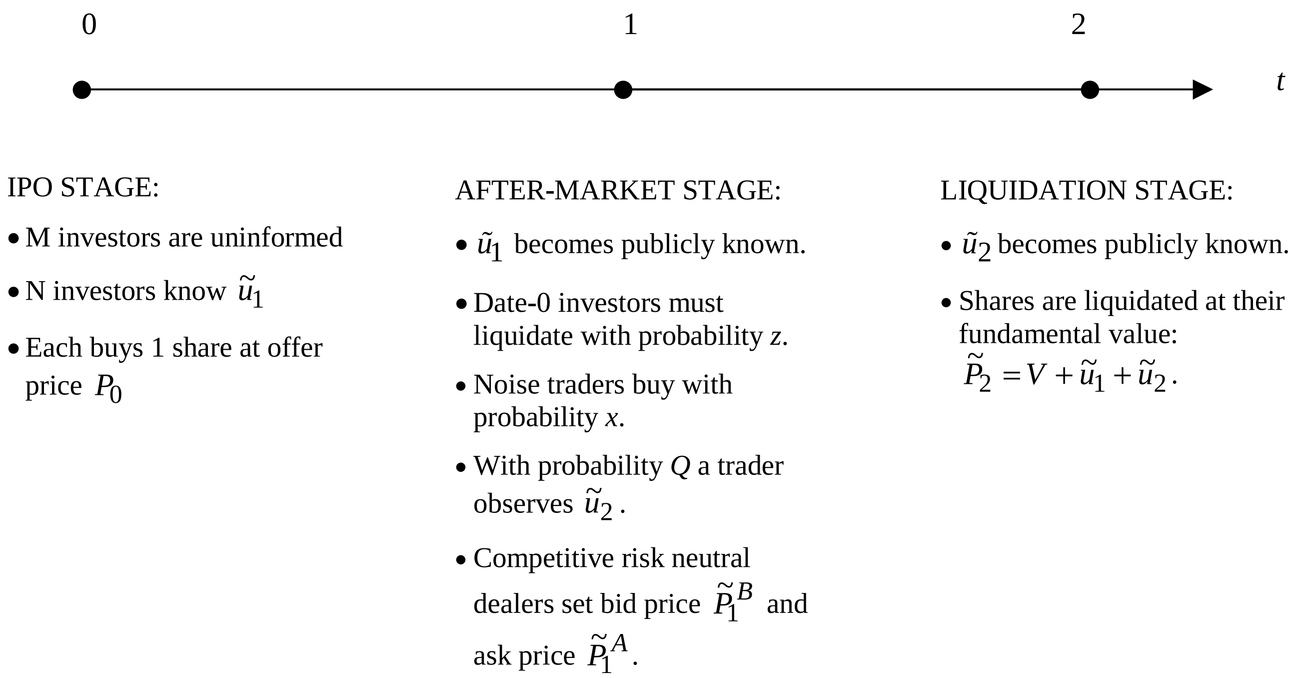

Figure 1. Time Line of the Model

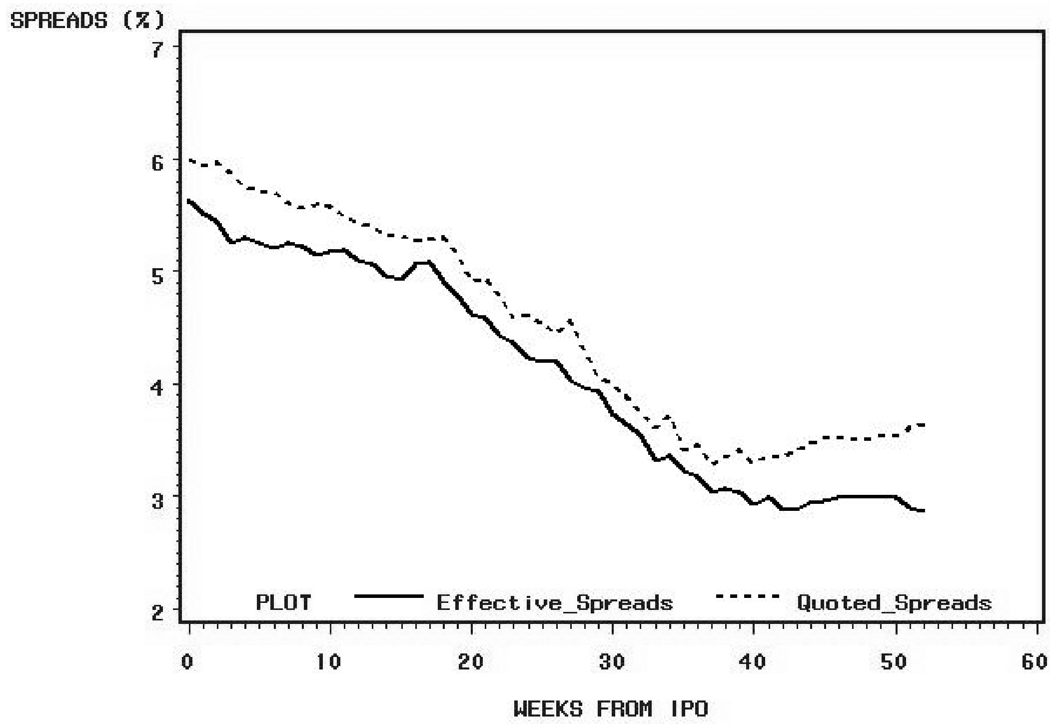

Figure 2. Average Quoted and Effective Bid-Ask Spread in the Year After the IPO

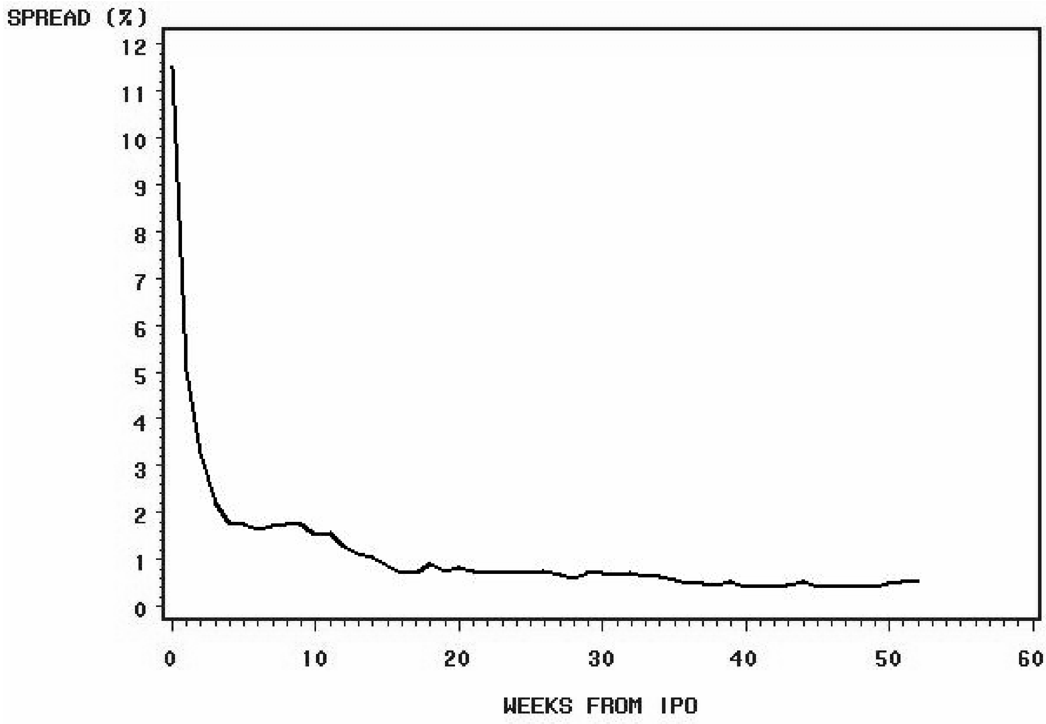

Figure 3. Average Amortized Spread in the Year After the IPO

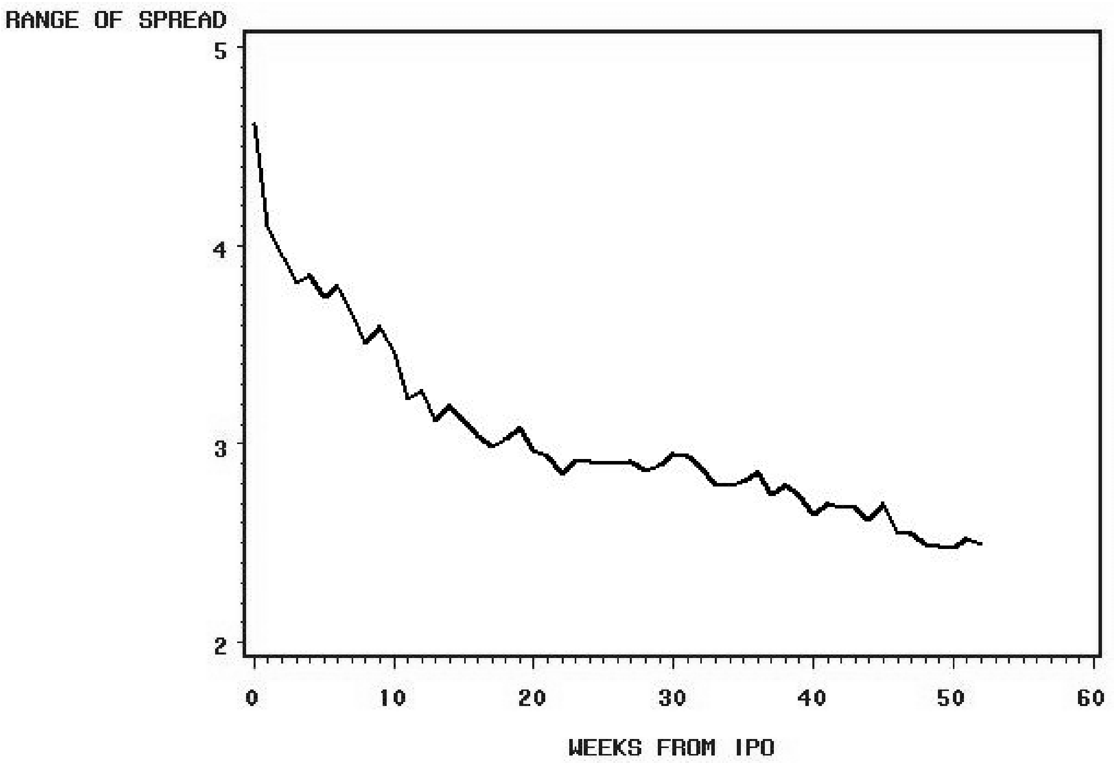

Figure 4. Variability of the Effective Spread in the Year After the IPO

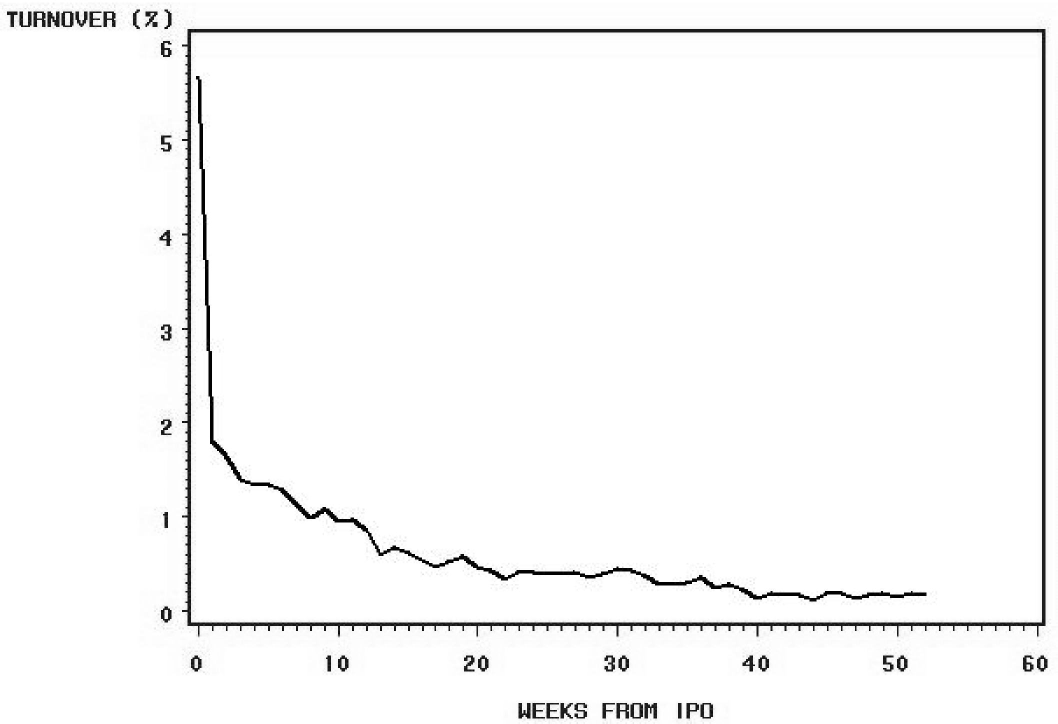

Figure 5. Turnover Ratio in the Year After the IPO

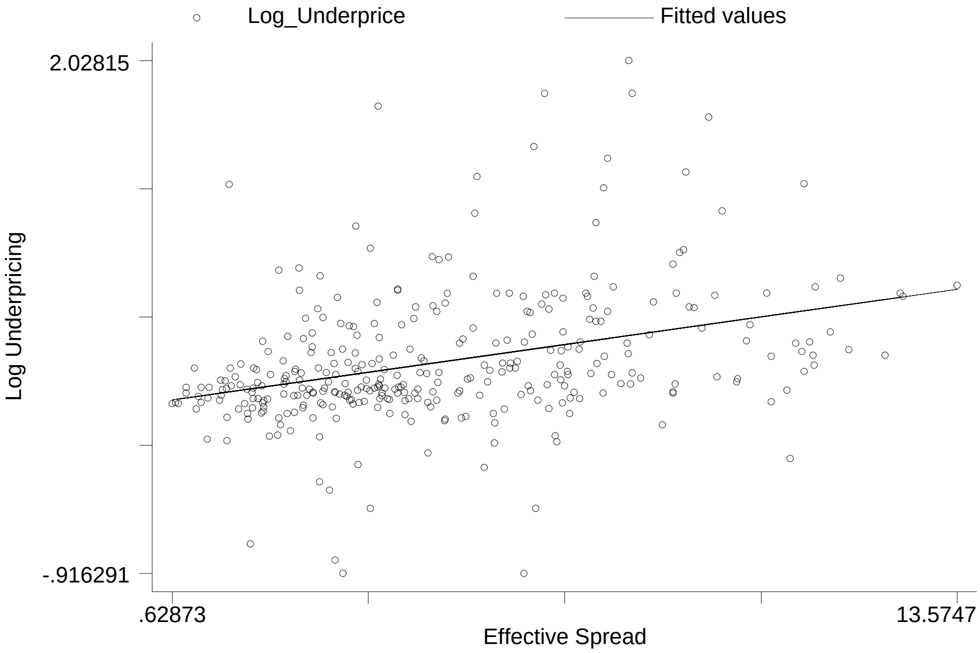

Figure 6. Log Underpricing and the Effective Bid-Ask Spread

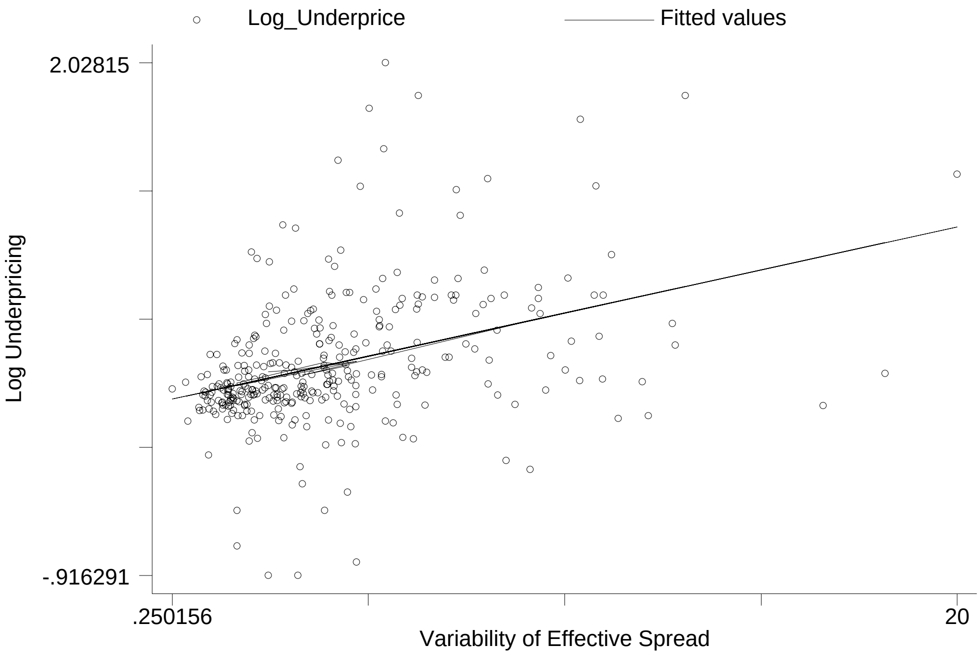

Figure 7. Log Underpricing and the Variability of the Effective Spread

Description of the Figures

Figure 2: The figure shows the average Quoted Bid-Ask Spread and the Effective Bid-Ask Spread in the first year after the inception of trading for a sample of 97 IPOs carried out in the period June 1998-December 1999.

Figure 3: The figure shows the Amortized Spread in the first year after the inception of trading for a sample of 97 IPOs carried out in the period June 1998-December 1999.

Figure 4: The figure shows the Range of Variation of the Effective Bid-Ask Spread in the first year after the inception of trading for a sample of 97 IPOs carried out in the period June 1998-December 1999.

Figure 5: The figure shows the average Turnover Ratio (number of shares traded divided by number of outstanding shares) in the first year after the inception of trading for a sample of 97 IPOs carried out in the period June 1998-December 1999.

Figure 6: The figure plots data for Log Underpricing and the average Effective Bid-Ask Spread. Log Underpricing is the natural log of the ratio between the closing price on the first day of trading and the IPO price. The effective spread is the average Effective Spread in the first four weeks in the after-market trading. The line in the figure shows the predicted values of an OLS regression of Log Underpricing on a constant and the Effective Bid-Ask Spread.

Figure 7: The figure plots data for Log Underpricing and the Variability of the Effective Bid-Ask Spread. Log Underpricing is the natural log of the ratio between the closing price on the first day of trading and the IPO price. The Variability of the Effective Bid-Ask Spread is measured as the average range of variation between the highest and lowest effective spread, calculated for each trading day over the first four weeks of trading. The line in the figure shows the predicted values of an OLS regression of Log Underpricing on a constant and the Variability of the Effective Bid-Ask Spread.