Information Asymmetries, Transaction Cost, and the Pricing of Securities

Matthias Bank*

University of Innsbruck

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Abstract

I study a simple market microstructure model in a competitive setting where rational risk neutral investors anticipate becoming liquidity sellers (they are forced to sell with a certain probability) and paying transaction costs (adverse selection costs as well as fixed and/or proportional cost) at some future date. To buy stocks in the IPO they must be compensated for expected future trading losses due to adverse selection risk. The insights of the model are the follows. First, investor’s distribution of liquidity selling needs affects adverse selection cost and hence the IPO price. Second, the marginal investor receives, in equilibrium, an excess return that covers his expected transaction costs. Third, anticipated dissemination of information to the public, just before secondary market trading takes place, lowers uniformly the adverse selection costs, and, as a consequence, the cost of capital. Fourth, the model helps to explain the observed return differences for growth and value stocks in terms of transaction costs. Fifth, the IPO price depends on the specific allocation of stocks to investors with different liquidity selling needs.

Key words: adverse selection cost, liquidity trading, transaction cost, IPO, growth stocks, value stocks, cross-section of expected returns

JEL Classification:

* Department of Banking and Finance, University of Innsbruck, Universitätsstrasse 15, A-6020 Innsbruck, email: Matthias.bank@uibk.ac.at
I argue that the return differences of stocks are mainly driven by different transaction costs.\footnote{Risk aversion and the correlation between some utility measure or pricing factors and excess returns as in traditional asset pricing models may also be are important. But the focus here in this paper is solely on transaction cost.} This paper tries to fill the gap between traditional asset pricing models and market microstructure models, by incorporating adverse selection costs as an important part of the overall transaction costs. Adverse selection risk is a systematic risk, because uninformed investors are not able to diversify it away.\footnote{To quote Easley, Hvidkjaer, and O'Hara (2002, p. 2218) on that point: "A natural objection to all candidates put forward to explain asset returns is that, with the exception of systematic risk, the actions of arbitrageurs should remove any such proposed influence on the market. While this may be accurate for some factors, we do not believe that it is accurate with respect to asymmetric information. In a world with asymmetric information, an uninformed investor is always at a disadvantage relative to traders with better information. In bad times, this disadvantage can result in the uninformed trader's portfolio holding too much of the stock; in good times, the trader's portfolio has too little of the stock. Holding many stocks cannot remove this effect because the uninformed do not know the proper weights of each asset to hold. In this sense, asymmetric information risk is systematic because, like market risk, it cannot be diversified away."} Thus, the observed return differences of stocks may nothing else than the rational response of investors facing information asymmetries and systematic adverse selection costs.

The market microstructure model used in this paper follows the broad lines of John and Narayanan (1997). But instead of modelling the behaviour of market makers, the model is used to analyze the reservation prices of rational but uninformed investors, providing liquidity to the market by using limit orders. In nearly all theoretical microstructure models (e.g. Kyle, 1985) liquidity traders are assumed to bear the whole transaction cost due to adverse selection, that is, they lose money on average. Moreover, the likelihood to buy or sell of liquidity traders in these models is symmetric. While both assumptions are very helpful to get closed-form solutions or solutions at all, they are theoretically not fully convincing. First, because nobody can be forced to buy securities, rational investors will buy only when they can expect at least their opportunity return. This return should include expected losses due to selling for liquidity reasons. Second, it is hard to see why many investors should seek immediacy by buying securities for primarily other than for
information related reasons (e.g. to take advantage of private information). Especially for stocks, (strategic) portfolio rebalancing may be conducted rather through limit orders (supply liquidity) than through market orders (demand liquidity).³

The term transaction costs means both in this paper, fixed and/or proportional trading costs (brokerage fees, etc.) and - most importantly - adverse selection costs.⁴ The main idea is that rational marginal buyers in the stock market expect a perhaps significant transaction costs when they eventually has to sell immediately at some future time. Thus, to bring them into the market today, they must be compensated today for expected losses from trading tomorrow. Potential buyers always have a choice in allocating cash, which is not needed immediately. They can enter the market and buy stocks (when the price is 'reasonable'), they may choose to buy risk-free assets with virtually no transaction costs or they can simply do nothing. Most important, they cannot be forced to buy a certain stock.⁵

Therefore, there is a significant asymmetry between the urgent need for immediate buying and selling. In any case, buyers with cash at hand have some bargaining power, at least more then sellers, which are facing a potential hold-up problem.⁶

³ Hedging, as another potential source to liquidity driven buying, is mainly done through derivatives. Here, the most liquid derivative should be used, as long as this derivative is correlated with the position to be hedged.

⁴ To be sure, transaction costs in a broader sense means that opportunity cost of trading should also be included. For example, many people allocate a lot of their time in trading securities. It is at least questionable if they are able to recover this additional opportunity cost from trading. Perhaps they derive utility from trading, offsetting the extra cost in equilibrium.

⁵ Allen and Gorton (1992, p. 625) are very clear on that point by criticizing a main assumption in standard market microstructure models: "It is difficult to understand what the motivation is for traders who have pressing needs to buy securities. Traders wishing to buy securities can more freely choose the time to buy and thus minimize losses to insiders. For example, liquidity buyers could trade immediately following earnings or other important announcements when there is a lower probability of informed insiders profiting at their expense. This flexibility is in sharp contrast to traders who need to sell because of an immediate need for cash."

⁶ Consider a 20-year old residential house, which is on average relatively illiquid due to informational asymmetries. When the owner is forced to sell the house for any reason, he must accept the adverse selection-adjusted reservation price of a potential buyer. Thus, the seller faces a severe hold-up problem. Every owner is good advised to account for a potential loss when selling before deciding to buy. It is safe to say that nearly every buyer of a residential house will at least think about the consequences of an exogenously triggered fire sale for themselves. For stocks the situation is quite similar. Stocks are also subject to informational asymmetries and adverse selection, even if the average informational
I study a simple market microstructure model in a competitive setting where rational risk neutral investors anticipate becoming liquidity sellers (they are forced to sell with a certain probability) and paying transaction costs (adverse selection costs as well as fixed and/or proportional cost) at some future date.\textsuperscript{7} To buy stocks in the IPO they must be compensated for expected future trading losses due to adverse selection risk. The insights of the model are the follows. First, investor’s distribution of liquidity selling needs affects adverse selection cost and hence the IPO price. Second, the marginal investor receives, in equilibrium, an excess return that covers his expected transaction costs. Third, anticipated dissemination of information to the public, just before secondary market trading takes place, lowers uniformly the adverse selection costs, and, as a consequence, the cost of capital. Fourth, the model helps to explain the observed return differences for growth and value stocks in terms of transaction costs. Fifth, the IPO price depends on the specific allocation of stocks to investors with different liquidity selling needs.

It is widely acknowledged that information asymmetries are important for pricing assets. Since the seminal paper by Akerlof (1970), literature has focused on how to overcome or how to cope optimally with frictions, meaning that information asymmetries are in the center of academic interest. While the theoretical literature on financial intermediation, market microstructure, corporate finance or even on efficient markets focus on adverse selection and/or agency problems, traditional asset pricing theory implicitly assumes information asymmetries away by relying on representative consumer economies, factor

\textsuperscript{7} Allen and Gorton (1992) show that when liquidity buying and selling is not equally likely, there may be room for profitable stock price manipulation. Why this can be true in sequential learning models (e.g. the Glosten and Milgrom (1985)-model), manipulation of this kind is not possible in the model presented here.
models and the belief that smart investors/arbitrageurs are able to efficiently mitigate negative consequences.⁸

There is a large literature considering the impact of transaction costs for asset pricing.⁹ Amihud and Mendelson (1986) are the first who provide a rigorous model. They consider the effect of exogenous transaction costs on asset prices and show that the price of an asset is reduced by the present value of the future trading cost. The result is driven by the assumption that investors have different investment horizons and therefore different portfolio turnover rates. There is a clientele effect in such a way that in equilibrium the excess gross return of an asset is a piecewise linear concave function of the relative bid-ask spread. Investors with longer investment horizons investing - ceteris paribus - in stocks with higher bid-ask spreads. While the story is intriguing there is only mixed support in empirical studies. On the one hand, Amihud and Mendelson (1986, 1989), Eleswarapu (1997) present convincing evidence based on the bid-ask spread that liquidity is priced. Other supporting evidence which uses other measures of trading costs or liquidity is found in Brennan and Subrahmanyam (1996), Datar, Naik, and Ratcliffe (1998), Amihud (2002), Easley, Hvidkjaer, and O’Hara (2002), and Pastor and Stambaugh (2003). The probability of information-based trading measure (PIN) used in Easley, Hvidkjaer, and O’Hara (2002) and Aslan, Easley, Hvidkjaer, and O’Hara (2008) as a proxy for information risk is highly significant even when all other variables of the Fama and French (1992) asset-pricing framework are included. In Easley et al. (2002) a difference of 10 percentage points in the PIN measure (which ranges from 0 to 0.53 with a mean of 0.19) between two stocks leads to a difference in their expected returns of 2.5 percent per year. Aslan et al. (2008) show that smaller, younger firms, firms with more insider

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⁸ See Easley and O’Hara (2004) for a similar reasoning.
⁹ This large literature is reviewed in detail by Amihud, Mendelson, and Pedersen (2005).
holdings, firms with greater institutional holdings, and firms followed by few analysts are more likely to have higher information risk. On the other hand, Eleswarapu and Reinganum (1993) provide evidence that trading costs, measured by the bid-ask spreads, are only priced in January. Chalmers and Kadlec (1998) find that the amortized spreads are priced but that these spreads are quite low in magnitude.

Related theoretical literature on market microstructure, adverse selection, and liquidity issues include, among others, Kyle (1985), Glosten and Milgrom (1985), and Admati and Pfleiderer (1988). Kyle (1985) described the optimal trading rule of a monopolistic insider in a market where competitive market makers set the price. While the insider expects a positive profit at the expense of liquidity traders, the market makers break even on average. Kyle (1985) shows that the expected profit of an insider is larger when the pay-off variance or the exogenous liquidity trading is increasing. Moreover, Admati and Pfleiderer (1988) show that when more insiders are active in one stock when the level of the precision of information is lower, the trading costs of liquidity traders as a group are reduced. When liquidity traders are able to time and coordinate their demand, trading cost may decrease further. Glosten and Milgrom (1985) show how the bid-ask spread is efficiently adjusted by a market marker learning from the incoming orders in an adverse selection setting. From adverse selection risk a bid-ask spread arises. More recently, Garleanu and Pedersen (2004) argue that the bid-ask spread need not to be a transaction cost measure. This is because agents are symmetric ex ante in their model, means that they may win (when they are informed) and lose (when they are uninformed) in a situation with asymmetric information. They do find that information asymmetries affect the required return via trading decision distortions implying allocation costs, but these costs may be rather small.

10 See O'Hara (1995) for an overview.
In the related theoretical paper, Diamond and Verrecchia (1991) show that revealing public information may reduce information asymmetries and, as a consequence the cost of capital for firms. In contrast to the model used in this paper where all investors are assumed to be risk neutral, Diamond and Verrecchia (1991) model risk averse market maker with a limited risk bearing capacity. There are other theoretical papers which try to explain asset returns in terms of trading costs, adverse selection, or liquidity. One group of models focus on transaction cost caused by private information. Easley and O'Hara (2004) show that comparing two otherwise identical stocks, the stock with more private information and less public information will have a larger expected excess return. They use a rational expectations model which leads to a partially revealing rational equilibrium. Of course, a risk premium in their model only emerges if investors are risk averse. Wang (1993) shows in an inter-temporal asset-pricing model that due to adverse selection risk uninformed investors demand a higher expected return. But informed trader makes the prices more informative, what in turn decreases uncertainty. Because the two effects offset each other, the net effect on asset returns is ambiguous.

One common finding in the empirical literature on asset pricing is that value stocks, i.e. stocks with a low price-to-book ratio, earn a substantial higher average return as growth stock, i.e. stocks with a high price-to-book ratio. On the other hand, small stocks, i.e. stocks with a low market value, have a significantly higher average return compared with mid or large caps. In this paper it is argued, that the observed return differences may be explained by differences in transaction cost due to adverse selection risk.

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12 See Banz (1991). In addition, Arbel and Strebel (1982) document a neglected firm effect. Less researched companies have higher average returns, even when size is taken into account. Bhushan (1989) shows that analyst covering is strongly correlated with firm size.
Finally, this paper has a connection to the large literature of initial public offerings. This literature shows that initial public offerings are fairly underpriced on average and that cumulative abnormal risk-adjusted or style-adjusted returns of newly issued firms are negative in the long run. In this paper, different allocations of IPO shares are considered. Among the articles concerning the allocation of IPO shares, the paper of Booth and Chua (1996) is most related. They argue that underpricing allows for a broad initial ownership, which in turn increases secondary market liquidity, leading to a lower required return to investors. In fact, they find supporting evidence for the hypothesis that ownership dispersion affects IPO underpricing. For an extensive overview over this literature see Ritter and Welch (2002).

The rest of the paper is organized as follows. Section A presents a simple microstructure model, combining the initial public offering of stocks with adverse selection problems in a later trading round. In section B the effects of the dissemination of information to the public is analyzed. Section C explores the implications of the model for the cross-section of expected returns. Section D discusses the implications of the model for the allocation of shares in the initial public offerings. Section E concludes the paper.

A. The model

In this section a very simple stylized model is studied. Consider a firm who wants to go public. The economy last 3 dates. At time 0 the firm sell their stocks to risk neutral investors who differ in their liquidity needs at time 1. The expected pay-off (or liquidation value) of the firm at time 2 is common knowledge to all investors at time 0. At time 1 there is the opportunity for trading. Here it will be a information asymmetry among

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13 Because all investors are assumed to be risk neutral, there is no need for portfolio rebalancing or hedging.
investors. Some investors are informed (insiders), some are not. At time 1 a random fraction of the investors is forced to sell their stocks because of urgent liquidity needs. Finally, at time 2 the uncertainty about the firm value is resolved and final values are distributed.

**Figure 1:** Timeline of the events

<table>
<thead>
<tr>
<th>time 0</th>
<th>time 1</th>
<th>time 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPO (no informational asymmetry)</td>
<td>Trading (risk of adverse selection)</td>
<td>Liquidation</td>
</tr>
</tbody>
</table>

The interest rate is set to zero. At time 2 the firm value may be high or low: \( v_H \) and \( v_L \). The corresponding unconditional probabilities are \( p_H \) and \( p_L \), leading to an expected value of \( v_0 \). At time 1 some of the investors learn which final state will come up, so it may be adverse selection.

The market is organized as follows. Every investor is restricted to buy (or to sell) one stock at one time. Why this assumption seems very restrictive it is standard in the literature following Glosten and Milgrom (1985).\(^{14}\) Buying or selling one stock entails a fixed cost \( c > 0 \).\(^{15}\) Both, market orders and limit orders are allowed. The order book is transparent in the sense that limit orders are visible to all investors. Once a limit order is placed, it can not be deleted. All market orders are queued randomly and executed one after one.

There are \( N > 0 \) investors in the market who are potential liquidity providers. At time 0 the firm sells \( M < N \) stocks to the public, so there is rationing among investors. At time 0

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14 Informed investors may want to buy or sell more than only one stock. But that would probably signal that they are informed. See, e.g., Easley and O'Hara (1987).

15 The fixed cost covers the order handling cost, etc.
investors differs with respect to their liquidity needs at time 1. There are only two groups of investors. Every investors belonging to group $A$ must sell his share at time 1 with probability $\lambda_A$. Every investors belonging to group $B$ has selling probability $\lambda_B > \lambda_A$. The probabilities are common knowledge. Assume that $A < N$. Therefore $N - A$ investors are belonging to group $B$. Let $M > A$, so some stocks must be sold to investors belonging to group $B$. All investors belonging to group $A$ and $B$ are assumed to be uninformed at time 1. In addition, at time 1 there are $Q$ informed traders active.¹⁶

What prices are the two groups willing to pay in the initial public offering? To illustrate this point, assume that the selling probability for both groups is zero, that is, they hold the stocks until the final pay-off. In this case, because the discount rate is zero, a risk neutral investor would pay the expected value. There would be no need for trading at time 1 at all, as long as all investors are rational.¹⁷ But with a positive probability to sell, investors expect trading costs at time 1, which must be taken into account at time 0.

At time 1, uninformed investors without selling needs providing liquidity to the market using limit buy orders. Informed traders will either buy or (short) sell one stock according to his information. When an informed trader knows that the high state will come up he has in principal two opportunities to act: (1) to place a market buy order or (2) a limit buy order. But when all potential buyers using market orders are informed (i.e. there are no forced buyers in the market), the only reasonable price for liquidity providing sellers is $v_H + c$. But this price would not be accepted by informed traders, so there is no trading at all in equilibrium.¹⁸ This result, established in many papers, is summarized as follows:

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¹⁶ The number of informed investors’ maybe also a random variable with a commonly known distribution. The assumption of a fixed number is only to keep the model as simple as possible.

¹⁷ In a sense, the no-trade theorem of Milgrom and Stockey (1982) will apply.

¹⁸ Moreover, when informed buyers are different in the precision of their information, the least best informed buyer would lose money, so he refrains from trading. This leads to a complete market breakdown in the sense of Akerlof (1970).
Under the assumptions of the model there is no trading at the only reasonable ask price of \( v_H + c \) at time 1. Informed investors never place market buy orders seeking liquidity, because they would lose money with probability one. Thus, when the upcoming state is high, informed investors only can mimic uninformed liquidity providers, using a limit buy order.

At time 1 some liquidity seeking sellers arrive in the market: (1) A fraction of investors from groups \( A \) and \( B \) who must sell their stocks and, eventually, (2) informed traders who know that the liquidation value will be low.

The expected profit of uninformed liquidity providing investors must be zero in equilibrium. The expected uninformed liquidity demand is \( \Phi = \lambda_A A + \lambda_B (M - A) \).

Moreover, \( Q \) informed traders are in the market, which is common knowledge. When \( N \) is small relative to \( M \) there is a probability that not all market orders can be executed. By chance, the maximum realization of \( \Phi \) is \( \Phi^{\text{max}} = M \), that is all shares are sold for liquidity reasons. To ensure that all markets orders are executed at time 1, the condition \( N > 2M + Q \) must be fulfilled. It is assumed that this condition holds.

The expected number of uninformed liquidity providing buyers is therefore \( N - \Phi \). In the case of the high state, the expected value of being informed may be quite limited. Depending on the parameters, there may be only a small probability, that the limit buy orders will be executed. But indeed, informed investors always expect a positive excess return, provided \( N - \Phi \) is not too large to cover the fixed transaction cost. When the upcoming state is low informed investors can hide among the forced sellers and uses a market sell order. Define \( \varepsilon_H = v_H - v_0 \) and \( \varepsilon_L = v_0 - v_L \) such that \( p_L \varepsilon_L = (1 - p_L) \varepsilon_H \).
Then, the expected profit of a liquidity providing buyer, ready to buy one share at time 1, can be expressed as

\[
E[\Pi] = p_L [v_0 - \varepsilon_L - c - P_1] \left( \frac{\Phi + Q}{N - \Phi} \right) + (1 - p_L) [v_0 + \varepsilon_H - c - P_1] \left( \frac{\Phi}{N - \Phi + Q} \right).
\]

When the upcoming state is low, informed investors use a market sell order. The expected number of market sell orders arriving in the market in that state is \(\Phi + Q\). Otherwise, in the high state the liquidity demand is only \(\Phi\) and the informed investors submit limit buy orders. Define \(a \equiv \frac{N - \Phi}{\Phi}\) and \(b \equiv \frac{Q}{\Phi}\). \(a\) has the interpretation of the ratio of uninformed liquidity providing investors to uninformed liquidity demanding investors. \(b\) is the ratio of informed traders to uninformed liquidity demanding investors. Given the number of expected limit orders in each state, the term \(\frac{\Phi + Q}{N - \Phi} = \frac{1 + b}{a}\) may be interpreted as the average probability that the single limit buy order of a liquidity providing investor is executed in the low state. Similarly, the term \(\frac{\Phi}{N - \Phi + Q} = \frac{1}{a + b}\) denotes the average probability that a single buy order is executed in the high state. It can be easily checked (provided \(Q > 0\)) that

\[
\frac{\Phi + Q}{N - \Phi} > \frac{\Phi}{N - \Phi + Q},
\]

meaning that a limited buy order is more likely to be executed when the true state is low, reflecting adverse selection risk. Setting \(E[\Pi]\) to zero and solving for \(P_1\), the expected price, leads to
\[
\begin{align*}
    P_1 &= v_0 - \left( \frac{p_L Q \left( \frac{N + Q}{N - \Phi} \right)}{\Phi + p_L Q \left( \frac{N + Q}{N - \Phi} \right)} \right) \varepsilon_L - c, \\
    &= \text{adverse selection cost}
\end{align*}
\]

provided that \( N > 2\Phi^{\text{max}} + Q \) to ensure that the weights \( \frac{\Phi + Q}{N - \Phi} \) and \( \frac{\Phi}{N - \Phi + Q} \) can indeed be interpreted as probabilities. \( P_1 \) is the expected secondary market price, when the expectation is taken at time 0. This price consists of the unconditional value \( v_0 \), the fixed cost \( c \) and the adverse selection cost

\[
ASC = \left( \frac{p_L Q \left( \frac{N + Q}{N - \Phi} \right)}{\Phi + p_L Q \left( \frac{N + Q}{N - \Phi} \right)} \right) \varepsilon_L.
\]

It is shown in the appendix that the equilibrium price will, all other things equal and given that \( N > 2\Phi^{\text{max}} + Q \), decrease (i) if the business risk of the stock, measured by an mean preserving spread over \( \varepsilon_L \), is increasing, (ii) if the number of informed investors \( Q \) is increasing, (iii) if the expected liquidity demand \( \Phi \) is decreasing, and (iv) if the fixed cost \( c \) is increasing.

Observe that the price is also related to \( N \). \( N \) may be interpreted as the investor base or the a pool of potential liquidity providers. When \( N \) is decreasing the average probability of the execution of a limit order is increasing (see appendix for the proof that the adverse selection cost and \( N \) are inversely related). When \( N \) grows to infinity, the adverse selection cost decreases steadily and approaches the minimum value of

\[
ASC(N \rightarrow \infty) = \left( \frac{p_L Q}{\Phi + p_L Q} \right) \varepsilon_L.
\]
The inspection of the simple pricing function (1) reveals a systematic relationship between the composition of the different investor groups, measured by \( \Phi \), and the adverse selection cost. Therefore, the composition of the investor base should be a major concern for firms, issuing equity. Attracting investors with a high propensity to sell in later secondary market trading rounds lowers the average adverse selection cost.

To fully place the stocks in the IPO, some stocks must be sold at time 0 to investors belonging to group \( B \). Thus, group \( B \) investors can be considered as the marginal investors in the model. The equilibrium IPO-price is therefore exactly the price, group \( B \) investors are willing to pay to be indifferent between investing or taking the outside option. Investors from group \( B \) break even if the following condition is fulfilled:

\[
P_0 = \lambda_B P_1 + (1 - \lambda_B) v_0 - c.
\]

Thus, the IPO-price is a weighted average consisting of the unconditional value \( v_0 \) and the expected secondary market price \( P_1 \). Observe that investors belonging to group \( A \) expect a positive excess return, provided that in the rationing process the highest bidder will be served first.\(^{19}\) The excess return has a straightforward interpretation as a consumer rent.

**Numerical example:** For illustration of the model, assume the following parameters:

\[
p_L = 0.5, \; v_H = 150, \; v_L = 50, \; N = 5000, \; A = 1000, \; B = 4000, \; M = 2000, \; \lambda_A = 0.1, \; \lambda_B = 0.5, \; Q = 100, \; c = 0.5.
\]

The expected unconditional pay-off is \( v_0 = 100 \) with \( \varepsilon_H = \varepsilon_L = 50 \).

The expected demand of liquidity traders is \( \Phi = 600 \). The 'probability' for the uninformed liquidity providers to buy when the true state is low is \( \frac{\Phi + Q}{N - \Phi} = 15.91\% \) and

\(^{19}\) In a subsection below a rational for a different rationing scheme is discussed which may explain the widely observed book-building process and, even more important, for underpricing.
\[ \frac{\Phi}{N - \Phi + Q} = 13.33\% \] when the true state is high. With these parameters, the price at time 1 is \( P_1(N = 5000) = 95.10 \). The implied adverse selection cost is \( ASC = 4.40 \). When \( N \to \infty \) the price approaches \( P_1^{\text{max}} = 95.65 \), lowering the adverse selection cost to \( ASC_{\text{min}} = 3.85 \). Finally, when \( N = 2M + Q \), the price is the lowest with \( P_1(N = 4100) = 94.95 \) and \( ASC(N = 4100) = 4.54 \). Given \( N = 5000 \), the IPO-price is \( P_0(N = 5000) = 97.05 \). See figure 2 for the whole range of prices at time 1 and time 0 as well as for \( ASC \) as a function of \( N \).

**Figure 2:**

Figure 3 below depicts the prices at time 0 and time 1 as well as the adverse selection cost as a function of the expected liquidity demand, when \( \lambda_A \) varies from 0.1 to 0.49. Here the selling probability of the marginal investors is fixed to \( \lambda_B = 0.5 \), and \( N = 5000 \).

**Figure 3:**
Because the IPO-price is determined by the marginal investors, increasing the selling probability of group A investors implies that both, the expected secondary market price and the IPO price are increasing. The reason is that a higher $\lambda_A$ implies a higher liquidity in the secondary market which in turn lowers the adverse selection risk for liquidity providers.

Figure 4 depicts the prices at time 0 and time 1 as well as the adverse selection cost as a function of the expected liquidity demand, when $\lambda_B$, the selling probability of the marginal investor, varies from 0.11 to 0.5. Here the selling probability of the investors belonging to group A is fixed to $\lambda_A = 0.1$, and $N = 5000$.

**Figure 4:**

Because of the lower secondary market liquidity the price at time 1 decreased as well. But on the other hand the IPO price is increasing, because with a lower propensity to sell, the higher adverse selection cost is less often incurred. Therefore, with a lower selling probability, the marginal investor is willing to pay a higher IPO price despite the higher adverse selection cost.
B. Public Information arrives prior to time 1

In this section, the implications of additional public observable information for the IPO price are analyzed. Suppose that prior to time 1 information about which final state will come up is revealed to the public. All investors receive the same signal which is correlated with the probability for a high (low) liquidation state. Assume the signal may again be high or low, that is $S = s_i$ with $i = H, L$. The likelihoods for signal $s_i$ when the true liquidation value is $v_i$ is common knowledge at time 0. Specifically,

$$\Pr(S = s_H | v = v_H) = q_H, \quad \Pr(S = s_H | v = v_L) = 1 - q_H, \quad \Pr(S = s_L | v = v_L) = q_L, \quad \text{and} \quad \Pr(S = s_L | v = v_H) = 1 - q_L.$$  

For the signal to be informative, $q_H, q_L > \frac{1}{2}$ is required. The conditional probability for the liquidation value to be low when the signal is $s_L$ is, according to Bayes rule,

$$\Pr(v = v_L | S = s_L) = \frac{\Pr(v = v_L) \Pr(S = s_L | v = v_L)}{\Pr(v = v_L) \Pr(S = s_L | v = v_L) + \Pr(v = v_H) \Pr(S = s_L | v = v_H)}$$

Let $p_L(s_L) = \Pr(v = v_L | S = s_L)$, then the updated conditional probability is

$$p_L(s_L) = \frac{p_L q_L}{p_L q_L + (1 - p_L)(1 - q_L)} > p_L$$

The remaining conditional probabilities are calculated in the same way leading to

$$p_H(s_L) = \frac{(1 - p_L)(1 - q_L)}{p_L q_L + (1 - p_L)(1 - q_L)} < p_H$$

$$p_L(s_H) = \frac{p_L(1 - q_H)}{(1 - p_L)q_H + p_L(1 - q_H)} < p_L$$

and
\[ p_H(s_H) = \frac{(1 - p_L) q_H}{(1 - p_L) q_H + p_L (1 - q_H)} > p_H \]

Along with the updated probabilities for the high and low state the parameters in the pricing formula changes as well. The updated expected pay-off \( v_i(s) \) can be found by solving

\[ v_i(s) = p_L(s) v_L + (1 - p_L(s)) v_H \]

Knowing \( v_i(s) \), the difference between the low pay-off and the expected pay-off can be calculated according to \( \varepsilon_L(s) = v_i(s) - v_L \). For notational convenience and without loss of generality only the case of a very large \( N \) is analyzed. \(^{20}\) The equilibrium price at time 1, after receiving signal \( S = s_i \), is therefore

\[ p_i(s_i) = v_i(s_i) - \left( \frac{p_L(s_i) Q}{\Phi + p_L(s_i) Q} \right) \varepsilon_L(s_i) - e. \]

The adverse selection premium \( ASP(p_i(s_i)) = \left( \frac{p_L(s_i) Q}{\Phi + p_L(s_i) Q} \right) \varepsilon_L(s_i) \) is a inverted U-form function with a maximum at \( p_L^* = \frac{1}{2Q} \left( -2\Phi + 2\sqrt{\Phi^2 + \Phi Q} \right) < 0.5 \). Observe that \( p_L^* \) depends not on the signal. The adverse selection premium is strictly concave in \( p_L \). In the special case where the prior probability \( p_L \) equals \( p_L^* \), a informative signal always lowers the adverse selection cost. When \( p_L > p_L^* \) a high signal always lowers the adverse selection cost, whereas a low signal may increase the cost for small \( q_L \). This result is consistent with earlier work, indicating that more public information will lower the cost of capital. \(^{21}\)

\(^{20}\) When \( N \) is low, the probability for execution of a single limit buy order is higher. Therefore, the adverse selection risk is pronounced, leading to a lower price.

But most important, the IPO-price at time 0 depends on the two public signals. When the low signal with likelihood \( q_L \) is received, the conditional price at time 1 is

\[
P_1(s_L(q_L)) = v_1(s_L(q_L)) - \left( \frac{p_L q_L}{p_L q_L + (1 - p_L)(1 - q_L)} \right) \Phi + \left( \frac{p_L (1 - q_L)}{(1 - p_L)q_H + p_L (1 - q_H)} \right) q_L (s_L(q_L)) - c
\]

The same holds for the high signal with likelihood \( q_H \):

\[
P_1(s_H(q_H)) = v_1(s_H(q_H)) - \left( \frac{p_L (1 - q_H)}{(1 - p_L)q_H + p_L (1 - q_H)} \right) \Phi + \left( \frac{p_L (1 - q_H)}{(1 - p_L)q_H + p_L (1 - q_H)} \right) q_H (s_H(q_H)) - c
\]

Thus, the best estimation at time 0 for the price at time 1, given \( q_L \) and \( q_H \), is

\[
E_0[P_1(q_L,q_H)] = (1 - \Pr(S = s_L))P_1(s_L(q_L)) + \Pr(S = s_H)P_1(s_H(q_H)).
\]

Here, the conditional prices at time 1 are weighted with the probabilities for the low or high signal. Using Bayes rule once again (see appendix) and solving for the unconditional probability of a high signal is given by

\[
\Pr(S = s_H) = \frac{q_H p_H(s_H)}{p_H(s_H)(1 - q_H) + q_H p_H(s_L)}.
\]

Because the adverse selection cost is strictly concave in \( p_L \), informative signals just before time 1 always lower the expected adverse selection cost, when the expectation is taken at time 0. Thus, firms should care about the information policy as well as the analyst and media coverage at the time of the IPO. A higher and credible commitment of a firm to provide public information will reduce the cost of capital.
Example (continued): For the same data as before, the adverse selection cost depending on the probability of the low state is depicted in figure 5.

Figure 5:

\[
\text{ASP}(p_L) = 3.852 - 0.5 \times (p_L - 0.5)^2
\]

The adverse selection cost-function has its maximum at \( p_L^* = 0.481 \), slightly below 0.5. For every combination of \( q_H \) and \( q_L \) the expected adverse selection cost is a convex combination. Once a informative signal is received, given that the prior probability is close to \( p_L^* \), the adverse selection cost is lowered.

C. Implications for the cross-section of expected returns

At time 0 investors form expectations about how informative the signals about the true state will be. The precision of public available information may depend on how interesting the business of the firm is for the public and therefore how large the analyst coverage will be. Assume that the analyst coverage just before time 1 may be high or low, that is \( AC = ac_j \), with \( j = H,L \). Moreover, assume that in the high state the signal is always more informative then in the low state. The reason may simply be the observation, that firms and analyst are more reluctant to disseminate bad news.\(^{22}\)

\(^{22}\) Hong, Lim, and Stein (2000) argue that bad new “travel slowly” compared to good news. They provide empirical results which are consistent with that hypothesis. Specifically, they show that low-coverage stocks react more sluggishly to bad news than to good news. In addition, Brennan, Jegadeesh, and Swaminathan (1993) find faster adjustment to new information for stocks with wider analyst following.
At time 1 there are four possible likelihoods. The probability for a high signal, given that the true state is $v_H$ and that the analyst coverage is $ac_H$ is defined as

$$\text{Pr}(S = s_H | v = v_H, AC = ac_H) = q_{H,H}. \text{ Similarly, the probability for a high signal when the true state is } v_H \text{ and the analyst coverage is } ac_L \text{ is } \text{Pr}(S = s_H | v = v_H, AC = ac_L) = q_{H,L}. \text{ The same hold for the low signal, given the low state and a high or low analyst coverage. Specifically, assume that } q_{H,H} > q_{H,L} > q_{L,H} > q_{L,L} > 0.5. \text{ From the perspective of time 0 the expected price at time 1 is a weighted average of four conditional prices who reflecting the corresponding likelihoods.}

Just before time 1 the uncertainty about the quality of the signals is resolved. The conditional prices are set by the liquidity providing investors. Given these conditional prices, the expected excess returns are lowest for stocks with a high and most informative signal, because the adverse selection risk is lowest. But because of the high signal, the stock price move up and exceeds the IPO price. The IPO price can be interpreted as the book value of equity. Thus, at time 1 one would term this stock as a “growth stock”, because the price-to-book ratio is high. The low expected excess return is consistent with the empirical observations.

The same token can be used for a low signal with is less informative. Here the adverse selection cost is highest, compared to all other cases. Due to the bad signal the price change from time 0 to time 1 is negative, indicating a low price-to-book ratio. Thus, the stock would be termed “value stock”. The expected excess return is highest in this case, which is consistent with the empirical data.²³

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²³ Brennan and Subrahmanyam (1995) find that firms with higher analyst coverage face a smaller adverse selection cost than do firms with fewer analysts.

²³ To stretch the implications of the model a little bit, assume that two identical stocks go public at time 0. But just before time 1 good information is received only for one stock, whereas for the other stock the
When the ratio of informed trading to expected liquidity trading is high, the probability which maximizes the adverse selection cost, \( p_L^* \), can be much lower than 0.5. Given that the initial, unconditional probability of the low state is 0.5, a relatively uninformative low signal may push the updated probability closer to \( p_L^* \), increasing the adverse selection cost. In this case the expected excess return of the value stock will be even higher.

The analysis shows that more precise public available information reduces the adverse selection cost more strongly. When the precision of the signal in the case of good news is higher the adverse selection cost should be lower compared with the case of bad news. Thus, stocks who had received good (bad) news in the past should have a high (low) realized return and a low (high) expected return due to systematic changes in the adverse selection cost.

Finally, when the analyst or media coverage for large or mid cap stocks is higher, as empirical evidence suggests, the adverse selection cost should be larger for smaller stocks on average, linking the results of the model to the size effect.\(^{24}\)

**D. Allocation of stocks in the IPO**

In section A it was assumed the highest bidder is served first in the allocation of stocks to investors and all investors pay the same IPO price. While such an auction is highly recommended by theoretic arguments, in real markets other rationing schemes (e.g. information is bad. Assume further that liquidity seller have some discretion about which stocks they sell at time 1. When they prefer the stock with the good news for selling, more liquidity trading is directed to this stock, meaning that the adverse selection cost of this stock is getting lower. Of course, the adverse selection cost of the other stock will increase. This reinforces the implications for growth and value stocks. Moreover, the stock turnover in the stock with good information should then be higher, compared to the stock with bad information.

\(^{24}\) Stocks with a high ratio of informed trading to liquidity trading have a high information risk in the sense of Aslan et al. (2008). They show that especially smaller firms have a high information risk. The model used here would therefore imply that small value firms should have the highest expected excess return, which is consistent with empirical data provided, e.g., by Fama and French (2007a, 2007b).
bookbuilding) are used. In this section a simple rationale for not using a common price auction with a fixed stock supply is presented.

With all assumption of section A still in place, assume now that all shares will be sold to investors belonging to group $B$ (marginal investors), provided that $B > M$. Notice that the reservation price of investors belonging to group $A$ is still higher. Despite this fact, no shares are allocated to group $A$.

Because group $B$ investors are the marginal investors, the IPO price should be the same on the first sight. But now are more stocks allocated to investors of group $B$, so the expected number of liquidity sales at time 1 is higher on average, leading to a higher expected price at time 1. Thus, type $B$ investors are willing to pay a higher IPO-price at time 0, because they expect better trading conditions which in turn decrease the adverse selection cost at time 1. That is,

$$P_0(\text{allocating all stocks to B investors}) = \lambda_b v_0 - \left( \frac{p_L Q}{\lambda_b M + p_L Q} \right) e_L - c + (1 - \lambda_b) v_0 - c > P_0.$$ 

The proof follows from the fact that $\lambda_b M > \lambda_B B + \lambda_A (M - B)$ because $\lambda_b > \lambda_A$.

This basically means that the allocation of stocks only to marginal investors with the highest propensity to sell at time 1 reduces the expected adverse selection costs at time 1. But this result strongly depends on the assumption, that trading between time 0 and time 1 is not possible or even forbidden.

Therefore, assume that just after time 0 (say at time $0'$) stocks may be traded. Suppose that at time $0'$ the same information set as at time 0 applies. Thus, at time $0'$ is no adverse

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selection risk at all. But indeed, the fixed transaction costs must be paid when transacting.

The new timeline of events is depicted in Figure 6.

**Figure 6:** New timeline of the events

![Timeline diagram]

Because investors belonging to group $A$ did not get shares at time 0, they are willing to buy shares for their own reservation at time 0’ in the secondary market. Observe that this price is higher than the IPO-price. Investors belonging to group $B$ are eager to sell, because they will expect to make an excess return. But in equilibrium, knowing that they will get a slightly higher price at time 0’, type $B$ investors bid up the IPO-price to a point when their expected excess return is just zero (after fixed transaction cost). Thus, the firm going public is indeed able to skim parts of the consumer rent.

The reservation price of type $A$ investors at time 0’ depends on how large the group is:

$$P_{0'}^A = \lambda_A \left[ v_0 - \left( \frac{p_i Q}{\tilde{\lambda}_A + \tilde{\lambda}_B(M - A) + \tilde{p}_i Q} \right) e_L - c \right] + (1 - \lambda_A) v_0 - c$$

When more stocks change hands at time 0’ from type $B$ investors to type $A$ investors, this increases the adverse selection cost at time 1, reducing the reservation price. Thus, the IPO price, the group $B$ investors are willing to pay depends on the how many stocks are traded at time 0’. The IPO price is therefore a function of the size of group $A$ investors:
\[
P_0^b(A) = \left[ \lambda_B v_0 - \frac{p_L Q}{\lambda_A A + \lambda_B(M - A) + p_L Q} \right] \varepsilon_L - c + (1 - \lambda_B) v_0 - c \left[ \frac{M - A}{M} \right] + P_0^a\left( \frac{A}{M} \right)
\]

This price is a weighted average consisting of the two reservation prices at time 0’, weighted by the probability that an investor B will or will not trade at time 0’, that is \( A/M \) or \((M - A)/M \) respectively.

Thus, when stocks in an IPO are predominately allocated to investors with a short holding horizon and provided that there are only few investors with a long holding horizon, underpricing may be the common result the first trading day. The theory implies that underpricing should be negatively related to trading volume.

The model produces a remarkably price pattern for IPO’s. At time 0’, the first trading day after the IPO, one would expect underpricing as long as \( A < M \). Observe that only the allocation of shares among different types of investors with different investment horizons matters to produce this outcome. Moreover, the expected price change from time 0’ to time 1 should be negative on average, because information asymmetries come into play.

When IPO-stocks are predominately small, high risky and getting more and more out of focus of the public after the IPO, one would expect average prices to decrease slowly due to an increasing adverse selection premium.

Ritter and Welch (2002) report that for the years 1980 to 2001 the equally weighted average first day return of IPO’s is 18.8%. It seems fair to say that the model presented here can not account for that huge first day return. The mechanics of the model may only help to explain partially the amount of underpricing seen in real markets. But is adds to the understanding why the allocation of stocks to different investor groups may be important.
Example (continued): With the same data as before, figure 7 depicts the prices for three different allocations of stocks to the two investor groups.

Figure 7:

P0 stands for the price, where group A investors receive full allocation (A = 2000) and the price is set by marginal investors belonging to group B, receiving M – A shares. In this example, \( N \to \infty \). The corresponding price is \( P_0 = 97.33 \). PB is the price, when all stocks are allocated to group B investors and if there is no trading before time 1. The price is \( P_0(\text{allocating all stocks to B investors}) = 98.06 \). P(A) is the IPO price group B investors are willing to pay, when the amount of A-stocks can be sold to investors belonging to group A at time 0’. This price varies from \( P_0^B(0) = 98.06 \) to \( P_0^B(2000) = 98.45 \).

Underpricing in figure 7 is measured by the difference between \( \text{PA}(A) \), the reservation price of the group A investors at time 0’, and P(A), the IPO price group B investors are willing to pay, i.e. \( P_0^A(A) - P_0^B(A) \). Underpricing is highest when only very few group A investors are in the market, i.e. for \( A = 1 \) the difference is \( P_0^A(1) - P_0^B(1) = 1.15 \).
E. Concluding remarks

In this paper a simple stylized market microstructure model in an asymmetric information framework is studied. Contrary to existing market microstructure models, in this model liquidity traders only have the need to sell stocks immediately. As a consequence no bid-ask-spread arises and the whole trading takes place at the bid price. It is shown, that properly anticipated future transaction costs should be reflected in the stock price. Whereas the magnitude of direct trading cost (brokerage fee, etc) is rather low, the adverse selection cost of future liquidity trading can be quite high. Rational investors should demand a premium as a compensation for the total expected transaction cost before entering the market at all. It is argued that the adverse selection cost depends on various market microstructure parameters, such the number of informed traders, the expected liquidity demand, the potential investor base and the business risk of the firm. Thus, firms with different market microstructure characteristics should have different expected returns. Moreover, the dynamics of the adverse selection cost is driven by information related factors, such as the information policy of the firm or analyst or media coverage as well as changing selling needs of liquidity traders. Specifically, it is shown that systematic differences in adverse selection risk could help to explain observed return differences for value and growth stocks, without relying in behavioural finance models. The book-to-market factor as well as the size factor in the Fama and French (1993) asset pricing model may simply be interpreted as noisy proxies for adverse selection risk.

Further research could focus on the interaction of the adverse selection cost with endogenous noise trading, which is not rational but information related. Suppose noise trading demand is triggered only when salient positive, public observable signals arrive in
the market. Then, trading volume would go up and the adverse selection cost would decrease, reinforcing the results of this paper. As long as noise trading only affects prices systematically but indirectly through a changing expose of rational liquidity provider to adverse selection, markets are informational efficient in the sense of Grossman and Stiglitz (1980). A theory of endogenous noise trading along that lines may help to explain the momentum effect, the interaction between momentum and turnover, and the observation that expected returns are lower when turnover volatility is high, via systematically changing adverse selection costs and without relying on behavioural biases influencing prices directly.

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26 See Bagehot (1971) or Black (1986) for the notion that noise traders may react to public available information which is already incorporated in security prices.


28 See Lee and Swaminatham (2000).

Appendix

A. Comparative statics for the price at time 1

Given $P_1 = v_0 - \left( \frac{-p_l Q_N - p_l Q^2}{-p_l Q_N - p_l Q^2 - N - \Phi^2} \right) \epsilon_L - c$.

(i) $\frac{\partial P_1}{\partial \epsilon_L} = -\left( \frac{-p_l Q_N - p_l Q^2}{-p_l Q_N - p_l Q^2 - N + \Phi^2} \right) < 0$

Proof: For $\frac{\partial P_1}{\partial \epsilon_L} < 0$, $(\Phi^2 - \Phi N) < 0$. This implies $N > \Phi$. This condition is fulfilled by assumption.

(ii) $\frac{\partial P_1}{\partial Q} = -\left( \frac{-p_l Q_N - p_l Q^2}{-p_l Q_N - p_l Q^2 - N + \Phi^2} \right) \epsilon_L + \frac{\left( -p_l Q_N - p_l Q^2 \right)}{\left( -p_l Q_N - p_l Q^2 - N + \Phi^2 \right)} \epsilon_L (-p_l N - 2p_l Q) < 0$

Proof: This is equivalent to $-\epsilon_L + \frac{\left( -p_l Q_N - p_l Q^2 \right)}{\left( -p_l Q_N - p_l Q^2 - N + \Phi^2 \right)} \epsilon_L < 0$. It remains to show that

$\frac{\left( -p_l Q_N - p_l Q^2 \right)}{\left( -p_l Q_N - p_l Q^2 - N + \Phi^2 \right)} < 1$. If $\Phi^2 - \Phi N = 0$, the term is 1. Therefore, $\Phi^2 - \Phi N < 0$ or $N > \Phi$, which is fulfilled by assumption.

(iii) $\frac{\partial P_1}{\partial \Phi} = \frac{-p_l Q_N - p_l Q^2}{\left( -p_l Q_N - p_l Q^2 - N + \Phi^2 \right)} \epsilon_L (2\Phi - N) > 0$

Proof: Because $2\Phi - N < 0$ by assumption and the nominator is negative, the derivative must be negative since the denominator is always positive.
(iv) \( \frac{\partial P}{\partial c} = -1 < 0 \). The proof is obvious.

**B. Proof that the adverse selection cost decreases when \( N \) is increasing.**

The derivative of the adverse selection cost with respect to \( N \) is

\[
\frac{\partial \text{ASC}}{\partial N} = -\frac{p_i Q}{-p_i Q N - p_i Q^2 - \Phi N + \Phi^2} + \frac{-p_i Q N - p_i Q^2}{(-p_i Q N - p_i Q^2 - \Phi N + \Phi^2)^2} (p_i Q - \Phi) < 0.
\]

This is equivalent to \( 1 - \frac{-p_i Q N - p_i Q^2}{(-p_i Q N - p_i Q^2 - \Phi N + \Phi^2)} (1 + \Phi) < 0 \). When \( \Phi > 1 \) and \( N > \Phi \), the adverse selection cost decreases as \( N \) increases. This is fulfilled by assumption.

**C. Calculation of the unconditional probability for signal \( S = s_H \).**

Bayes rule implies that

\[
\Pr(S = s_H | v = v_H) = \frac{\Pr(S = s_H) \Pr(v = v_H | S = s_H)}{\Pr(S = s_H) \Pr(v = v_H | S = s_H) + \Pr(S = s_L) \Pr(v = v_H | S = s_L)}
\]

Given the notation in the paper \( q_H = \Pr(S = s_H | v = v_H) \), \( p_H(s_H) = \Pr(v = v_H | S = s_H) \), and \( p_H(s_L) = \Pr(v = v_H | S = s_L) \), this can be written as

\[
q_H = \frac{\Pr(S = s_H) p_H(s_L)}{\Pr(S = s_H) p_H(s_H) + (1 - \Pr(S = s_H)) p_H(s_L)}
\]

Solving for \( \Pr(S = s_H) \) yields

\[
\Pr(S = s_H) = \frac{q_H p_H(s_L)}{p_H(s_H)(1 - q_H) + p_H(s_L) q_H}
\]

Observe that \( \Pr(S = s_L) = 1 - \Pr(S = s_H) \).
References


