Information Asymmetry and Asset Prices: Evidence from the China Foreign Share Discount

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Abstract

We examine the effect of information asymmetry on equity prices in the local A- and foreign B-share market in China. We construct measures of information asymmetry based on market microstructure models, and find that they explain a significant portion of cross-sectional variation in B-share discounts, even after controlling for other factors. On a univariate basis, the price impact measure and the adverse selection component of the bid-ask spread in the A- and B-share markets explains 44% and 46% of the variation in B-share discounts. On a multivariate basis, both measures are far more statistically significant than any of the control variables. We also examine the behavior of B-share discounts after the B-share market was partially opened up to domestic investors after March 2001. Not only do we observe that B-share discounts decline from an average of 72% to 43%, but we also find that the differences in the adverse selection components across the markets shrink.

Keywords: information asymmetry, asset prices, microstructure, market segmentation, spread decomposition, PIN, China.

JEL Codes: G1, G15, G14, G12.

The extent of information asymmetry in the international equity market has become a very important topic. The question of whether domestic investors have better information than foreign investors has also become increasingly controversial. Although a few papers argue that domestic investors have a linguistic and cultural advantage (Brennan and Cao (1997), Choe, Kho and Stulz (2001), and Hau (2001)), others argue that foreign investors have an informational advantage because they possess a significant amount of investment experience and expertise (Seasholes (2000), Grinblatt and Keloharju (2000), and Froot and Ramadorai (2001)). Despite this controversy, it is more commonly accepted that the informational disadvantage of foreign investors is responsible for their reluctance to invest in foreign securities (Kang and Stulz (1997), Brennan and Cao (1997), and Grinblatt and Keloharju (2001)).

Although there is much evidence on informational asymmetry in international equity markets, very few studies examine whether informational asymmetry affects equity prices. The only exceptions are Bailey and Jagtiani (1994) and Domowitz, Glen and Madhavan (1997), who find that foreign investors in Thailand and Mexico seem to prefer to invest in larger companies that display greater financial disclosure and less information asymmetry, and that therefore the price premiums of foreign shares over domestic shares are higher for larger market capitalization firms. However, market capitalization might capture some other firm attributes. For example, firm size might measure share liquidity. Larger firms might have a more liquid foreign market, which would result in larger foreign share premiums. Furthermore, foreign institutional investors might have a mandate to invest only in larger companies, and would thus be willing to pay higher prices.

In this paper, we borrow from the literature on market microstructure to construct measures of information asymmetry, and examine whether these measures can explain asset prices in the Chinese A- and B-share market. Before 2001, the Chinese stock market was a perfect example of market segmentation, in which domestic investors could only trade A (local) shares, and foreign investors were restricted to trading B (foreign) shares.[1] Although the two share classes are identical

[1] In March 2001, the Chinese government opened up the B-share market to domestic investors.

with respect to shareholder rights, such as voting and profit sharing rights, B-shares are traded at a discount relative to A-shares. As with other emerging markets, foreign investors find it difficult to acquire and access information on Chinese firms compared with domestic investors. In fact, information asymmetry may be more severe in China, as share manipulation and insider trading is widespread and investor protection rights are not legally codified (Chakravarty, Sarkar and Wu (1998)).

We first develop a simple model of information asymmetry for the China A- and B-share market, in which the private information is possessed by some domestic investors but not any foreign investors. Basically, an increase in the proportion of informed domestic investors will have an impact on the market depth through two effects. The first is the adverse information effect, whereby uninformed investors will adjust their demand in response to unexpected changes in share supply (the reciprocal of order flows). The second is the risk bearing capacity whereby informed investors will require a smaller risk premium if they have less information uncertainty. An increase in the proportion of informed domestic investors will have different effects on the share prices and market depth in the A- and B- share market. We show that the B-share discount is a function of the proportion of domestic informed investors, although in a non-monotonic fashion. The proportion of domestic informed investors in the A-share market, which measures the information asymmetry between the two markets, influences the market depth or the price impact parameter. Because of that, the model illustrates that even without liquidity consideration, there could exist a relationship between the B-share discount and relative market depth in the two markets.

Based on the transactions dataset for firms in mainland China from 2000 to 2001, we estimate several information asymmetry measures, including the price impact coefficient, the adverse selection component of the bid-ask spread and the probability of informed trading (PIN) measure, and examine whether they can explain B-share discounts in China. As we are also aware of other explanations for foreign share discounts, such as liquidity (Chen and Xiong (2001)), market momentum (Karolyi and Li (2003)), and speculative behavior (Mei, Scheinkman and

Xiong (2003)), we also control for the influence of these variables when analyzing the impact of informational asymmetry measures.

Our results indicate that the information asymmetry measures explain a significant portion of the variation in B-share discounts. On a univariate basis, the difference between the price impact parameters and the difference between the adverse selection components in the A- and B-share markets explain 44% and 46% of the variation in B-share discounts. On a multivariate basis, these two components are far more statistically significant than any of the control variables in explaining B-share discounts. We also examine the behavior of B-share discounts after the B-share market was partially opened up to domestic investors after March 2001. Not only do we observe that B-share discounts declined from an average of 72% to 43%, but we also find that the difference in adverse selection component between the two markets shrank. Therefore, by allowing domestic investors to trade in the B-share market, there is less of an information disadvantage, and the B-share discount becomes smaller.

By showing that our information asymmetry measures can explain variation in B-share discounts, our paper contributes to the literature in demonstrating that information asymmetry is priced in international equity markets. It should be mentioned that the information asymmetry problem in China is distinct from the illiquidity, which has been shown to be able to explain the B-share discounts as well (for example, Chen and Xiong (2001)). In general, the information asymmetry is associated with illiquidity, as a greater degree of informed trading will increase the adverse selection cost which deters liquidity. But in China, the A-share market, which has more informed trading, is also much more actively traded than the B-share market. Furthermore, our regression results that the information asymmetry measures are much more important than other control variables, including trading activity measures, indicate that the information asymmetry is far more important than illiquidity in explaining the B-share discount. Nevertheless, we want to emphasize that the explanatory power of information asymmetry is on the cross-sectional variation of B-share discount, rather than on the absolute level.

The rest of the paper is organized as follows. Section I contains a brief overview of the Chinese equity markets and related literature. Section II presents a simple framework of information asymmetry for the A- and B-share market. Section III discusses the methodology for the construction of information asymmetry measures and control variables. Section IV introduces the data, provides preliminary statistics, and discusses the empirical results. Section V summarizes the main findings of the paper.

I. Overview of Chinese Equity Markets and Related Literature

China's two securities markets, the Shanghai Securities Exchange (SHSE) and the Shenzhen Stock Exchange (SZSE), were established in November 1990 and July 1991, respectively. The shares that were initially listed on the SHSE and the SZSE were called A-shares, and could only be traded by Chinese citizens. Starting in early 1992, another category of shares, known as B-shares, was introduced exclusively for foreign investors. A-shares are domestic ordinary shares that are denominated and traded in yuan by Chinese citizens. The majority of A-shares are issued by state-owned enterprises and can be classified as: (i) state shares, which are held by the government through a designated government agency; (ii) legal shares, which are held by "legal persons," i.e. enterprises or other economic entities, but not individuals; and (iii) public shares, which are owned by ordinary Chinese citizens. B-shares are ordinary shares offered to foreign investors, and are legally identical to A-shares, enjoying the same voting rights and dividends. The main difference is that all transactions, dividend payments, trades, and quotes, are conducted in foreign currency – U.S. dollars for the Shanghai B-shares and Hong Kong dollars for the Shenzhen B-shares.

Before 2001, the Chinese stock market was a unique example of market segmentation. A-shares were restricted to domestic residents, whereas foreigners could hold only B-shares. However, after March 2001, domestic residents could also purchase B-shares with foreign currency.

The fact that B-shares in China trade at a discount is a puzzle. According to Bailey, Chung, and Kang (1999), except for China, foreign shares exhibit price premiums in all other segmented markets.[2] In theory, foreign investors can diversify part of the risk that is inherent in B-shares through non-Chinese stocks, whereas domestic investors cannot. The required rate of return should therefore be lower for B-shares, which would result in a B-share premium instead of a discount. However, Fernald and Rogers (2002) attribute the fact that Chinese investors accept lower rates of return primarily to the lack of alternative investment opportunities. Because of the underdevelopment of financial markets and capital controls, it is difficult for Chinese investors to invest overseas, and the main investment alternative is bank deposits. However, bank deposits tend to pay interest rates that are below international levels, and thus Chinese investors face a lower opportunity cost of capital and may demand lower expected rates of return. Although the lack of alternative investment can explain why A-shares are sold at a premium relative to B-shares, it cannot explain the cross-sectional variation in A-share premiums. A few other explanations have been offered.

One common explanation for the B-share discount is that foreign investors find it more difficult to acquire and access information on local Chinese firms relative to domestic investors. There is much international finance literature that documents information asymmetry between foreign and domestic investors (Kang and Stulz (1997) and Portes and Rey (1999)). Information asymmetry arises from differences in accounting standards, disclosure requirements, and regulatory environments across countries. Information asymmetry is also a common explanation for home bias. Information asymmetry is particularly severe in China. For example, many Chinese firms do not fully disclose material changes in their business conditions, and published statements are not always prepared according to international accounting standards. Furthermore, share manipulation and insider trading are widespread, and there is a lack of codes to protect investors. Because of information costs, foreign investors avoid holding stocks that they do not know (Merton (1987)), which results in discounts for foreign B-shares in China.[3]

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[2] These markets include Indonesia, South Korea, Malaysia, Mexico, Norway, the Philippines, Singapore, Switzerland, Taiwan, and Thailand.

[3] A couple of papers provide evidence on information asymmetry between foreign and domestic investors. Based on transaction data, Chan, Menkveld and Yang (2003) show that A-shares lead B-shares rather than the opposite, which

Other explanations are offered for the B-share discount. The first alternative explanation is the liquidity hypothesis, which states that the discounts are to compensate foreign investors for lower liquidity and higher trading costs. This is because the A-share market is generally much more liquid than the B-share market. According to Amihud and Mendelson (1986), the illiquid B-shares should have a higher expected return and are priced lower to compensate investors for increased trading costs. Supporting evidence is provided by Chen, Lee and Rui (2001), who find that the relative trading volume of B-shares to A-shares is strongly negatively related to the discount. Chen and Xiong (2001) find additional support for the liquidity hypothesis in the Chinese market by showing that restricted institutional shares have an average discount of 78% to 86% compared with their unrestricted counterparts.

The second alternative hypothesis is that A-share premiums are a reflection of the speculative bubbles that are created by domestic investors (Mei, Sheinkman and Xiong (2003)). This hypothesis is based on the theoretical model of Scheinkman and Xiong (2003), which illustrates a resulting speculative component in asset prices, and predicts that there is a positive relationship among the volume of speculative trading, the size of the speculative component, and the volatility in stock prices. In their empirical test, Mei, Sheinkman and Xiong (2003) assume that the A-share price, but not B-share price, contains a speculative component. Consistent with their explanation, they find that the A-share turnover rate, which proxies for the amount of speculative trading, explains 20% of the cross-sectional variation in A-share premiums.

The third hypothesis is the differential risk hypothesis, which states that domestic and foreign investors face different investment opportunity sets. Due to capital controls, Chinese investors cannot diversify overseas. Thus, there is a divergence in risk exposure between domestic and foreign investors, as the risk of A- and B-shares is evaluated based on different investment benchmarks (Chinese market and world market returns). There is, however, little or weak

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provides indirect evidence that foreign investors in the B-share market are less informed than domestic investors in the A-share market. Using the number of company citations in the Wall Street Journal index as a proxy for information asymmetry, Chakravarty, Sarkar and Wu (1998) demonstrate empirically that this proxy explains a significant portion of the cross-sectional variation in B-share discounts.

empirical evidence to support this hypothesis. Eun, Janakiramanan and Lee (2001) find that the B-share discount is positively related to the covariance risk of B-shares with the Morgan Stanley world market index, but find no evidence of a negative relationship with the covariance risk of A-shares with the Chinese market index. Fernald and Rogers (2002) also find no evidence that the B-share discount is related to either B-share or A-share covariance risks.

II. A Model of Information Asymmetry for the China A- and B-Share Market

In this section, we develop a model of information asymmetry for the China A- and B-share market. While the model is simple, it serves to illustrate the effect of information asymmetry on the B-share discount and derives some implications on the relationship between the two. The model is based on Grossman and Stiglitz (1980), who introduce informational asymmetries into a noisy rational expectations model of asset pricing. We extend the model to two segmented markets, whereby domestic and foreign investors trade in the A-share and B-market separately, although uninformed investors in both markets could infer partial private information of informed domestic investors based on the A-share price.

We assume the domestic investors in the A-share market fall into two types: informed and uninformed, in a proportion of λ and $1-\lambda$. We further assume that all foreign investors in the B-share market are uninformed. This assumption that all foreign investors are uninformed is for convenience of analysis and could be relaxed without changing the key implications of the model as long as a smaller proportion of foreign investors is informed. All investors have CARA utility functions with a risk aversion coefficient ρ or a risk tolerance parameter η (i.e. $\eta = 1/\rho$). For the A- and B-share security issued on the same company, the future payoff (v) is the same but uncertain, with $v \sim N(\bar{v},\sigma_v^2)$). We assume that the domestic investors who are informed get a noisy private signal (S) about the future payoff such that $S = v + \varepsilon_S$ with $\varepsilon_S \sim N(0,\sigma_\varepsilon^2)$. The uninformed domestic investors and foreign investors do not observe the private signal, but attempt to extract information on the signal based on the A-share price (P_A). They are at an informational disadvantage, however, as noisy asset supply prevents the A-share price from being perfectly revealing. A-share asset supply is denoted $y \sim N(\bar{y},\sigma_y^2)$; B-share supply is denoted $z \sim N(\bar{z},\sigma_z^2)$. For convenience, we express all variance parameters in precision terms: $\tau_v = 1/\sigma_v^2,\ \tau_\varepsilon = 1/\sigma_\varepsilon^2,\ \tau_y = 1/\sigma_y^2,\ \tau_z = 1/\sigma_z^2$.

A. Price equilibrium in the A-share market

We denote demand of informed domestic investors as $x_A^I(P_A,S)$ and demand of uninformed domestic investors as $x_A^U(P_A)$. The market clearing condition implies that: $\lambda\ x_A^I(P_A,S) + (1-\lambda)\ x_A^U(P_A) = y$. To derive the equilibrium, we conjecture that the equilibrium price in the A-share market is linear in the private signal and the market supply. For ease of exposition, we specify the A-share price as a function of the surprise in signal ($\Delta S = S - \bar{S}$) and the unexpected change in A-share supply ($\Delta y = y - \bar{y}$), as ΔS and Δy contain the same information as S and y . The following is the functional form for the A-share equilibrium price:

$$P_A = \beta_0^A + \beta_S^A \Delta S + \beta_y^A \Delta y \tag{1}$$

It could be shown that the parameters in equation (1) are:

$$\beta_0^A = \frac{1}{(1+r)}\bar{v} - \frac{1}{(1+r)(\omega^I + \omega^U)}\bar{y} \tag{2}$$

$$\beta_S^A = \frac{1}{(1+r)(\omega^I + \omega^U)}\{\ \omega^I \frac{\tau_\varepsilon}{\tau_v + \tau_\varepsilon} + \omega^U \frac{\phi\tau_\varepsilon}{\tau_v + \phi\tau_\varepsilon}\} \tag{3}$$

$$\beta_y^A = \frac{1}{\Delta_A} = \frac{1}{(1+r)(\omega^I + \omega^U)}\{1 + (\omega^U \frac{\phi\tau_\varepsilon}{\tau_v + \phi\tau_\varepsilon})/(\omega^I \frac{\tau_\varepsilon}{\tau_v + \tau_\varepsilon})\} \tag{4}$$

where $\phi = \frac{\lambda^2\eta^2\tau_y\tau_\varepsilon}{1+\lambda^2\eta^2\tau_y\tau_\varepsilon}$, $\omega^I = \lambda\eta(\tau_v + \tau_\varepsilon)$, $\omega^U = (1-\lambda)\eta(\tau_v + \phi\tau_\varepsilon)$.

(Proof: see Appendix A. 1)

B. Price Equilibrium in the B-share market

The derivation of price equilibrium in the B-share market is more straightforward. Since there is no informed foreign investor, all demand comes from uninformed foreign investors. This demand, denoted $x_B^U(P_A)$, is a function of A-share price as foreign investors also infer the private information of informed domestic investors from the A-share price. As a result, the market clearing condition implies that: $x_B^U(P_A) = z$. We also specify the B-share price as a function of the unexpected change in B-share supply ($\Delta z = z - \bar{z}$), and the functional form for the B-share equilibrium price is:

$$P_B = \alpha_0 + \alpha_B P_A + \alpha_Z \Delta z \qquad (5)$$

Since $P_A = \beta_0 + \beta_S \Delta S + \beta_y \Delta y$, equation (5) could be further specified as:

$$P_B = \beta_0^B + \beta_S^B \Delta S + \beta_y^B \Delta y + \beta_Z^B \Delta z \qquad (6)$$

It could be shown that the parameters in equation (6) are:

$$\beta_0^B = \frac{1}{(1+r)}\bar{v} - \frac{1}{(1+r)\omega^B}\bar{z} \qquad (7)$$

$$\beta_S^B = \frac{1}{(1+r)}\left(\frac{\phi\tau_\varepsilon}{\tau_v + \phi\tau_\varepsilon}\right) \qquad (8)$$

$$\beta_y^B = \frac{1}{(1+r)}\left(\frac{\phi\tau_\varepsilon}{\tau_v + \phi\tau_\varepsilon}\right) / \left(\omega^I \frac{\tau_\varepsilon}{\tau_v + \tau_\varepsilon}\right) \qquad (9)$$

$$\beta_z^B = \frac{1}{\Delta_B} = \frac{1}{(1+r)\omega^B} \qquad (10)$$

where $\omega^B = \eta(\tau_v + \phi\tau_\varepsilon)$.

(Proof: see Appendix A. 2)

C. Analysis on B-share Discount and Market Depth

The theoretical analysis shows that the A- and B-share prices are determined by a number of parameters. Our primary focus is how it is affected by the degree of information asymmetry, which is measured by the proportion of informed domestic in the A-share market (λ). We perform numerical analysis to examine the effect of λ on the A-share and B-share prices. As a benchmark case, we assume there is no surprise in signal ($\Delta S = 0$), and no unexpected change in supply in the A- and B-share market ($\Delta y = \Delta z = 0$). A key parameter of the model is the quality of the information signal received by informed investors. We assume that $\tau_v = 5$ and $\tau_\varepsilon = 5$, implying a signal-to-noise ratio of 1. The investor risk tolerance parameter (η) is assumed to be 0.5, and the interest rate (r) is fixed at 2%. For other parameters, we assume that $\tau_y = \tau_z = 5$, $\bar{v} = 3$ and $\bar{y} = \bar{z} = 6$. It should be noted that a change of the parameter values does not have a qualitative effect on the relationship between λ and the share prices in the two markets.

Figure 1 plots the values of P_A and P_B against λ. It shows that both the A- and B-share prices are positively related to the proportion of informed domestic investors in the A-share market. It should be noted that an increase in the proportion of informed domestic investors in the A-share market has two effects. First, the informed investors will have a larger demand for A-shares because of the private signal they possess. Second, the uninformed investors in the A- and B-share markets will have less uncertainty about the payoffs because they can infer some of the private information based on the A-share price. As a result, an increase in the proportion of informed investors will reduce the risk premium for information uncertainty, resulting in higher share prices in both markets. This result in consistent with Easley and O'Hara (2004) that a higher fraction of traders who receive the private information will make the stock less risky for both the informed and uninformed investors, thus decreasing the cost of capital.[4] Figure 1 also plots the difference between P_A and P_B , or effectively the B-share discount, against λ. The discount is non-negative for all values of λ. Holding the share supply in the two markets the same, since the aggregate investor in the A-share market is more informed than in the B-share market, the demand for A-shares will be larger than the demand for B-shares, resulting in the A-share premium or B-share discount. Figure 1 shows the B-share discount first increases with λ, reaching a peak around the value of 0.2 for λ, and then decreases with λ. The reasoning is as follows. When λ increases initially, informed domestic investors who have less uncertainty about the stock's payoff will have bigger demand than uninformed foreign investors so that the B-share discount will increase with the proportion of informed investors in the A-share market. But once the proportion of informed investors grows "significantly," the A-share price becomes very informative and the uninformed investors in the B-share market have less information disadvantage, so that the price differential between the two markets declines.

We also examine the two parameters in equations (4) and (10): $\frac{1}{\Delta_A}$ and $\frac{1}{\Delta_B}$, which measure the impact of unexpected changes of share supply (Δy and Δz) on the prices in the A- and B- share markets, respectively. The unexpected changes of share supply are reciprocal to the noise trading in Kyle (1985), although the former reflects supply shocks while the latter reflects demand shocks. Similar to Kyle's model, $\frac{1}{\Delta_A}$ and $\frac{1}{\Delta_B}$ reflect the (inverse) market depth, as the deeper the market gets, the lower the two parameters are. These two parameters are also analogous to the price impact coefficients in the market microstructure literature that measure the price impact of unexpected order flows.

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[4] Easley and O'Hara also show that the risk premium is affected by the stock's information structure. For two stocks that are otherwise identical, the stock with more private and less public information will have a larger expected excess return. This occurs because when information is private, rather than public, uninformed investors cannot perfectly infer the information from prices, and consequently require a higher risk premium. The effect of the ratio of private to public information is beyond the scope of our discussion.

Figure 2 plots the values of $\frac{1}{\Delta_A}$ and $\frac{1}{\Delta_B}$ against λ. The price impact parameter in the A-share market ($\frac{1}{\Delta_A}$) first increases with λ, reaching a peak around the value of 0.2 for λ , and then declines with λ. On the other hand, the price impact parameter in the B-share market ($\frac{1}{\Delta_B}$) is monotonically declining in λ. The intuition is as follows. An increase in the proportion of informed domestic investors has two effects on market depth – the <u>risk bearing capacity</u> and the <u>adverse selection</u> effect. When there are more informed investors, the risk bearing capacity in the market increases as both informed and uninformed investors have less information uncertainty. This effect, labeled as the risk bearing capacity effect, causes a negative relationship between the proportion of informed investors and the price impact (or inverse market depth). On the other hand, the uninformed investors will also take into account the presence of informed investors when determining their demand elasticity. When there are more informed investors, an unexpected price decrease (increase) is more likely to originate from unfavorable (favorable) price signals of informed investors, so that uninformed investors will be more aggressive in adjusting their demand downward (upward). Therefore, when the proportion of informed investors is higher, an unexpected positive (negative) supply shock will cause a larger decrease (increase) in the stock price, thus lowering market depth. This effect, labeled as the adverse selection effect, causes a positive relationship between the proportion of informed investors and the price impact.

In the A-share market, the relationship between $\frac{1}{\Delta_A}$ and λ depends on which effect dominates. When λ is small, the adverse selection effect dominates so that the price impact increases when the proportion of informed investors increases. When λ is large, A-share prices are more revealing, the risk bearing capacity effect dominates so that the price impact decreases when the proportion of informed investors increases. In the B-share market, since uninformed foreign investors are not trading directly with informed domestic investors, only the risk bearing capacity effect prevails. Consequently, there is a negative relationship between $\frac{1}{\Delta_B}$ and λ.

Figure 2 also plots the difference between $\frac{1}{\Delta_A}$ and $\frac{1}{\Delta_B}$ against λ. When λ is small, the difference between $\frac{1}{\Delta_A}$ and $\frac{1}{\Delta_B}$ is positively related to λ. This is because the adverse selection effect increases $\frac{1}{\Delta_A}$ while the risk bearing capacity effect decreases $\frac{1}{\Delta_B}$. When λ is large, the difference between $\frac{1}{\Delta_A}$ and $\frac{1}{\Delta_B}$ is negatively related to λ. In this instance, the risk bearing capacity effect dominates and it has a larger effect on the price impact in the A-share market than in the B-share market.

It should be noted that the differential of price impact parameters ($\frac{1}{\Delta_A}$ and $\frac{1}{\Delta_B}$) in the two markets is not due to the exogenous liquidity factor, as trading volume does not play a role in our model. Instead, the reason for the relative market depth to vary is related to information asymmetry between the two markets. Given that the information asymmetry between the two markets also affects the B-share discount, as depicted in Figure 1, we also examine the relationship between the differential of price impact parameters and the B-share discount, which is plotted in Figure 3. For most values of λ, there is a positive relationship between the differential of price impact and the B-share discount, except when we come to the neighborhood of the turning point whereby the differential reaches the maximum value.

It should again be pointed out that the positive relationship between the differential of price impact and the B-share discount could not be explained by the liquidity explanation. According to the liquidity story, when the difference between $\frac{1}{\Delta_A}$ and $\frac{1}{\Delta_B}$,becomes smaller (or more negative), this indicates higher liquidity of the A-share market relative to the B-share market, which should be accompanied by higher B-share discounts in order to compensate foreign investors for their relatively illiquid market. Therefore, it is only under the information asymmetry explanation, rather than the liquidity explanation, that we observe a positive relationship between the differential of price impact and the B-share discount.

III. Information Asymmetry Measures and Control Variables

In this section, we discuss the methodologies that we use to construct the information asymmetry measures and the control variables. These will be used to explain the B-share discount in the next section. We first discuss three information asymmetry measures, the price impact measure (PI), adverse selection component (AS) of the spread decomposition and the probability of informed trading (PIN).

A. Price Impact Measure (PI)

This approach is based on the theoretical models of Glosten (1987), Kyle (1985), Easley and O'Hara (1987) and the empirical analysis of Glosten and Harris (1988), which suggest that the effects of asymmetric information are most likely to be captured by the price impact of a trade.

Let m_t denote the expected value of the security, conditional on the information set at time *t*, of a market maker who observes only the order flow ($V_t Q_t$, where V_t is trade size and Q_t is trade sign[5]), and a public information signal (e_t). According to Kyle (1985), it is assumed that m_t evolves as:

$$m_t = m_{t-1} + \gamma Q_t V_t + e_t \tag{11}$$

where γ is the price impact (or inverse market depth) parameter. Let φ denote the gross profit

[5] Trade sign is +1 for a buyer-initiated trade and -1 for a seller-initiated trade. Since not all trades occur at the bid or ask quotes, we follow the convention of Lee and Ready (1991) to classify trades as buyer- or seller-initiated: if a transaction occurs above the prevailing quote mid-point, it is regarded as a purchase and vice versa. If a transaction occurs exactly at the quote mid-point, it is signed using the previous transaction price according to the tick test (i.e. a purchase if the sign of the last nonzero price change is positive and vice versa).

component associated with an order, and assuming competitive risk-neutral market makers, the transaction price (m_t) can be written as:

$$P_t = m_t + \varphi Q_t \tag{12}$$

Substituting out m_t using (11), we have

$$P_t = m_{t-1} + \gamma Q_t V_t + \varphi Q_t + e_t \tag{13}$$

However, using $P_{t-1} = m_{t-1} + \varphi Q_{t-1}$, we find that the price change (ΔP_t) is given by

$$\Delta P_t = \gamma Q_t V_t + \varphi (Q_t - Q_{t-1}) + e_t \tag{14}$$

It should be noted that the price impact measure (γ) is directly related to the price impact parameters introduced in the theoretical model ($\frac{1}{\Delta_A}$ and $\frac{1}{\Delta_B}$). The empirical analysis will compare the price impact measures in the A- and B- share markets and investigate how they affect the B-share discount. It should, however, be pointed out that in our theoretical model, the difference between $\frac{1}{\Delta_A}$ and $\frac{1}{\Delta_B}$ is due to the difference in informed trading in the two markets. Our empirical price impact measure, on the other hand, might, besides information asymmetry, also be driven by market illiquidity. Therefore, in the empirical analysis we will introduce some other variables to control for the liquidity difference across the two markets. We will come back to this issue in the multivariate analysis.

B. Adverse Selection Component of the Bid-Ask Spread (AS)

This approach extends the price impact parameter as estimated in equation (14). Basically, the price impact coefficient (γ) is a measure of the extent of private information that is available in the market, as it reflects the adverse selection cost of trading with informed investors. On the other hand, the gross profit cost (φ) represents two components. The first is the order processing cost, which is the cost of conveying an order to the market, monitoring the order, searching for a counterpart, and clearing and settlement procedures. The second is the inventory holding cost, which arises from the sub-optimal inventory position that a risk-averse market maker must hold to supply immediacy (see, for example, Stoll (1978) and Ho and Stoll (1981, 1983)).

A number of studies have suggested that the adverse selection and gross profit costs consist of a fixed and a variable component. For the adverse selection cost, Easley and O'Hara (1987), Kyle (1985), and Glosten (1987) provide theoretical models that suggest that this component should increase with the quantity traded, as well-informed traders try to trade more to maximize the return on perishing information. This has since been confirmed by several empirical studies (see, for example, Glosten and Harris (1988), and Lin, Sanger and Booth (1995)). The gross profit component consists of the order processing and inventory holding costs. The order processing costs "represent the clerical costs of carrying out a transaction, the cost of a market maker's time, and the cost of the physical communications and office equipment necessary to carry out the transaction" (Copeland and Stoll (1990)). To a considerable degree, the order processing costs are fixed with respect to any particular transaction. However, we expect the inventory holding costs to increase with the quantity traded, as larger orders force liquidity providers to deviate further from their optimal inventory.

As a result, we assume that the adverse selection and the gross profit components vary over time and are linearly related to order size (V_t) as follows:

$$\gamma_t = z_0 + z_1 V_t \quad \textit{(adverse selection component)}, \tag{15}$$

$$\varphi_t = c_0 + c_1 V_t \quad \textit{(gross profit component)},$$

where z_0, z_1, c_0, and c_1 are constants. Equation (15) can therefore be re-written as:

$$\Delta P_t = c_0 (Q_t - Q_{t-1}) + c_1 (Q_t V_t - Q_{t-1} V_{t-1}) + z_0 Q_t + z_1 Q_t V_t + e_t. \tag{16}$$

The adverse selection cost will be measured by $z_0 + z_1 V_t^*$, where V_t^* is the median order size. To incorporate the idea that market participants revise their beliefs according to the *innovation* in signed volume rather than signed volume itself (see, for example, Madhavan, Richardsen and Roomans (1997)), we use an ARMA (*p,q*) model to extract this innovation:

$$Q_t V_t = \xi_1 Q_{t-1} V_{t-1} + \ldots \xi_p Q_{t-p} V_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} \ldots\ldots - \theta_q \varepsilon_{t-q} . \qquad (17)$$

After specifying and estimating this model with conventional ARIMA techniques, the residual, $\hat{\varepsilon}_t$, is interpreted as the innovation in signed volume. In addition, we also introduce the rounding error due to price discreteness (η_t), and the new model becomes:

$$\begin{aligned} &\Delta P_t = c_0 (Q_t - Q_{t-1}) + c_1 (Q_t V_t - Q_{t-1} V_{t-1}) + z_0 Q_t + z_1 \hat{\varepsilon}_t + u_t \\ &\text{with } u_t = e_t + \eta_t - \eta_{t-1}. \end{aligned} \qquad (18)$$

To estimate the model efficiently, we have to account for the dynamic structure in the (unobserved) error term u_t. This is achieved by estimating equation (18) with an MA (1) structure for the error term.

C. Probability of Informed Trading (PIN)

The probability of informed trading (PIN) measure is developed by Easley, Kiefer and O'Hara (1996, 1997a, 1997b). Similar to the adverse selection component in the spread decomposition, the PIN is a measure of the amount of private information that is available in the market.

In the model of Easley, Kiefer and O'Hara, it is assumed that there is a probability α that informed traders receive a private signal on the value of an asset at the start of a trading day. Conditional on the arrival of this signal, bad news arrives with probability δ and good news with probability $(1-\delta)$. Furthermore, buy (sell) orders from liquidity traders arrive at rate ε_b (ε_s) and, conditional on the arrival of new information, orders from informed traders arrive at rate μ.

Informed traders buy when they receive a positive signal and sell when they receive a negative signal.

The PIN model allows us to use observable trade and quote data on the number of buys and sells to make inferences about unobservable information events and the frequency of informed and uninformed trades. In the implementation, each day is considered as a trading period and the normal level of buys (sells) in a stock is used to identify ε_b (ε_s). Abnormal buys or sells indicate information based transactions, which are used to identify μ. The number of days for which there are abnormal buys or sells is used to identify α and δ. A maximum likelihood estimation procedure is employed here. Assuming a POISSION arrival process for the informed and uninformed traders, the likelihood function for a single day is:

$$L(\vartheta \mid B,S) = (1-\alpha)e^{-\varepsilon_b}\frac{\varepsilon_b^B}{B!}e^{-\varepsilon_s}\frac{\varepsilon_s^S}{S!} + \alpha\delta e^{-\varepsilon_b}\frac{\varepsilon_b^B}{B!}e^{-(\mu+\varepsilon_s)}\frac{(\mu+\varepsilon_s)^S}{S!} + \alpha(1-\delta)e^{-(\mu+\varepsilon_b)}\frac{(\mu+\varepsilon_b)^B}{B!}e^{-\varepsilon_s}\frac{\varepsilon_s^S}{S!}, \tag{19}$$

where *B* and *S* indicate the total number of buys and sells respectively, and $\vartheta=(\alpha, \delta, \mu, \varepsilon_b, \varepsilon_s)$ is the parameter vector. The likelihood is a mixture of distributions, for which the trade outcomes are weighted by the probability of a "good news day" $(\alpha(1-\delta))$, a "bad news day" ($\alpha\delta$), or a "no news day" ($1-\alpha$). Using the parameter estimates, the (unconditional) probability of an informed trade (PIN) is:

$$PIN = \frac{\alpha\mu}{\alpha\mu + \varepsilon_b + \varepsilon_s}. \tag{20}$$

Based on the PIN measure, Easley, Hividjaer and O'Hara (2002) find that the amount of private information affects asset returns. Using a sample of individual NYSE-listed stocks from 1983 to 1988, they find that a difference of 10 percentage points in the PIN measure between two stocks leads to a difference in their expected returns of 2.5 percent per year.

D. Control Variables

As previous studies offer some hypotheses that may account for B-share discounts, we also construct a few control variables to examine the incremental explanatory powers of our information asymmetry measures.[6]

The first set of control variables is the turnover ratios of A- and B-shares. Turnover is often used as a proxy for market liquidity and transaction costs. All things being equal, an investor requires a higher return or a lower price for holding an illiquid stock. Therefore, the B-share discount will be higher if A-share trading volume increases and B-share trading volume decreases. An alternative interpretation of turnover is that it is a proxy for speculative trading. Mei, Scheinkman and Xiong (2003)) view the A-share premium as a reflection of the speculative bubbles that are caused by overconfident domestic investors. The higher the turnover of the A-share market, the bigger the speculative bubble. As speculative bubbles arise only in the A-share market, the B-share discount (or A-share premium) is positively related to the turnover of A-shares, but has no relationship with the turnover of B-shares. Besides turnover, we also measure liquidity based on the number of trades as the order sizes are different between the two markets.

The second set of control variables is the market capitalization of outstanding A- and B-shares. Market capitalization could also be another measure of information asymmetry, as the information cost is typically lower for large firms. In that case, the B-share discount should be negatively related to the market capitalization of either A- or B-shares.

The last control variable is the cumulative A-share return or cumulative B-share return. Cumulative return proxies for stock momentum and, according to Karolyi and Li (2003), momentum may also be associated with risk. If stocks with high momentum are riskier stocks, and if Chinese investors are more risk tolerant than foreign investors, then we would expect the

[6] It should be noted that we do not consider control variables that are related to the risk exposures of A- and B-shares, such as their betas and volatilities, as previous studies (e.g. Karolyi and Li (2003)) find little evidence to show that they can explain B-share discounts on a consistent basis.

discount to be positively related to past returns. Another interpretation of the relationship between discounts and past returns is that domestic and foreign investors have different trading strategies. For example, Choe, Kho and Stulz (1999) find strong evidence of positive feedback trading among foreign investors. If that is the case, then we would expect foreign investors to purchase more B-shares when share prices increase, and thus the foreign share discount would be negatively related to past returns.

IV. Empirical Analysis

In this section, we discuss the data, present some summary statistics, and discuss the empirical results. We start with a brief description of the trading process and the data that we have available for our tests.

A. Data and Preliminary Statistics

The trading process for A- (local) and B- (foreign) shares on the Shanghai Stock Exchange (SHSE) and Shenzhen Stock Exchange (SZSE) is similar. Both exchanges run order-driven, automated markets. Neither exchange has designated market makers. Traders can only submit limit orders, which arrive at an electronic consolidated open limit order book (COLOB). An incoming order is automatically matched against the best standing limit order in the COLOB, according to the price-time priority principle. If it cannot be matched, then it is added to the COLOB. There is no block trading system to allow liquidity traders to trade large volumes in an upstairs market. Off-exchange trading and insider trading are both forbidden, but this is not tightly monitored. The minimum trade size is 100 for local shares and 1,000 for foreign shares.

Our data consist of all time-stamped trades and quotes from January 2000 to November 2001 for all stocks that were traded on the SZSE and SHSE.[7] We apply a number of filters to our data. First, we limit the sample to firms that traded A- and B-shares throughout the sample period,

[7] The data are collected by the Department of Economics of the School of Economics and Management of Tsinghua University.

thereby reducing the number of firms from over 1,000 to 84. Second, we remove eight firms, because these firms had a few days with non-zero volume in the B-share market. Third, for the remaining 76 firms we remove, for exogenous reasons, days for which there was no or very limited trading in either the A- or the B-share market.[8] Fourth, we remove stale quotes, which are easily recognized through zero depth. Fifth, the first and last fifteen minutes of each trading session are removed from the sample.

Table I provides trading statistics for the A- and B-shares from January to December 2000, a period during which both markets were fully segmented. The table presents the cross-sectional mean, standard deviation, minimum, and maximum based on the 76 stocks in the sample. For comparison, the trade and quote data for the B-shares (in Hong Kong dollars for SZSE and in US dollars for the SHSE) are converted to yuan using the (fixed) official exchange rate for the sample period. The average trade price in this period is 14.29 yuan ($1.73) for A-shares and 3.10 yuan ($0.37) for B-shares. This corresponds to an average B-share discount of 72%, which is in line with previous evidence (see, e.g., Bailey, Chung and Kang (1999)).

In terms of volume, the B-share market is about half the size of the A-share market – an average of 854,000 versus 1,684,000 shares per day. The A-share market is, as expected, more liquid, but significant trading in the B-share market is at odds with its supposed illiquidity. Furthermore, we find that the trading frequency is higher in the A-share market, but that the transaction size is lower. This highlights the importance of controlling for trade size in our spread decomposition analysis. Although the average quoted spread is 0.027 yuan for A-shares and 0.035 yuan for B-shares, this difference is not significant at conventional confidence levels. The effective spreads in the two markets are both equal to 0.035 yuan.

[8] Examples include days when trading was halted, because the price limit of a 10% change with respect to the previous day's close was reached.

B. Preliminary Analysis of Information Asymmetry Measures

In this subsection, we estimate the price impact coefficients (PI), adverse selection components (AS) and the probability of informed trading (PIN) measures, and study whether these information asymmetry measures agree, cross-sectionally, as to which securities exhibit the highest information asymmetry. We then relate them to the foreign share discount.

In preparing the data for the estimation of PI and AS, we follow Glosten and Harris (1988) and truncate the trade size to 100,000 shares to avoid giving too much weight to large trades. The median truncation frequency is 0.28% and 1.55% for the A- and B-share market. This is most likely the result of more institutional investors in the B-share market, who trade in larger sizes. We have also truncated the trade size to 200,000 and 400,000 shares, and find the results are generally similar. [9]

Panel A of Table II contains estimates of the price impact coefficients (PI) for the 76 A- and B-shares. The mean estimates of γ and ϕ are 9.66 x 10^{-7} yuan per share and 8.58 x 10^{-3} yuan for the A-share market, and 2.61 x 10^{-7} and 6.35 x 10^{-3} for the B-share market. The higher A-share impacts (γ) are, *prima facie*, not consistent with lower quoted spreads and much more volume in the A-share market (see Table 1). The larger impacts are, however, preliminary evidence of more private information in the A-share market. That is, after a market buy order of size *X,* liquidity suppliers seem to revise their estimate of the efficient price up to much larger degree in the A-share market than in the B-share market, all else equal. These results are consistent with a much lower depth at the best quotes in the A-share market (4,679 vs. 26,720 shares in the A- and B-share market, respectively, see Table 1).

Panel B of Table II contains cross-sectional statistics on the fixed and variable adverse selection component (AS) of the spread and on gross profit for the 76 A- and B-shares. The AS component coefficients, z_0 and z_1, are significant, and carry the right sign for all of the 76

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[9] The median truncation frequency are 0.06% and 0.30% for the A- and B-share market using 200,000 shares, and 0.01% and 0.04% using 400,00 shares.

securities in the A-share market and for almost all (66 and 61, respectively) of the securities in the B-share market. This evidence is consistent with previous literature in that the cost of adverse selection is a significant component of the spread, and increases with the size of the transaction. The fixed gross profit coefficients, c_0, are significant, and carry the right sign for all of the securities in the A-share market and for 67 of the securities in the B-share market. The variable gross profit coefficients, c_1, are significant for 55 of the securities in the A-share market and for only 4 of the securities in the B-share market. The last column in Panel B reports the AS component for a median-size trade. Consistent with the PI estimate, we find that the average AS component is larger in the A-share market than in the B-share market, with values of 56.4 x 10^{-4} and 46.8 x 10^{-4} yuan, respectively.

A problem in estimating PI and the AS component for the two markets is that there is a lower trade frequency for B-shares as compared to A-shares Instead of estimating the AS component based on trade-by-trade data, we have also estimated based on fixed-length intervals, say every 15-minutes. In that case, price change from *t-1* to *t* is measured as the price change over the 15-minute interval, *V(t)* is defined as the absolute value of net order flow in the 15-minute interval *t*, and *Q(t)* is defined as 1 or -1 depending on whether the net order flow is positive or negative in the 15-minute interval t. In general, we find that our subsequent regression analysis using alternative estimates of PI and the AS component produce qualitatively similar results.

Panel C of Table II presents cross-sectional statistics on the parameter estimates of the PIN model. Again, we find considerable evidence for privately informed traders in the A-share market, as the average arrival rate of these types of traders, μ, is 0.38, which is of the same level of magnitude as the arrival rates of uninformed buyers (0.44) and sellers (0.51). The arrival rate of informed traders in the B-share market is lower at 0.11, and again is of the same level of magnitude as the arrival rates of uninformed buyers (0.06) and sellers (0.07) in this market. The probability of an information event on a specific day, α, is higher in the A-share market than in the

B-share market, with rates of 0.30 versus 0.28, respectively. This is consistent with the existence of more information in the A-share market. However, the average level of the PIN measure is higher in the B-share market, because this market exhibits a relatively low number of uninformed trades. All parameters are significant for the majority of the securities except for the parameter δ, which is the probability of the news being bad news.

We compare our measures of information asymmetry by verifying whether they agree cross-sectionally as to which securities exhibit the most information asymmetry. Figure 4 contains the scatterplots of the AS component of the spread (for a median-sized trade) against PI and the PIN for both the A- and B-share markets. These plots suggest a stronger relationship between the measures in the A-share market, with correlations of 89% and 59%, respectively. The relationship in the B-share market is much weaker.

Finally, a scatterplot analysis reveals that the B-share discount appears to be explained by the proposed information asymmetry measures. Figure 5 plots foreign share discounts against the differentials of the information asymmetry measures in the A-share market relative to the B-share market, as measured by PI, the AS component, or the PIN. For all measures, we find that stocks with a relatively higher information asymmetry appear to command higher B-share discounts. The correlations between the three information asymmetry measures and the discounts are 66% for PI, 67% for AS, and 28% for PIN, and are statistically significant at either 1% or 5% level.

C. Regressions of Foreign Share Discount on Information Asymmetry and Controls

In this subsection, we examine whether the relatively greater quantity of private information in the A-share market will result in a higher A-share premium (or B-share discount), and check the robustness of our results by controlling for alternative explanations.

We start with a correlation analysis of information asymmetry and competing explanatory variables to check whether our explanation can be discriminated from these alternatives. Results in Table III show stocks that exhibit higher information asymmetry between A- and B-share market (higher differentials of PI, AS, and PIN) also enjoy a higher turnover in both the A- and B-share markets, have a smaller A-share market capitalization,[10] and exhibit high momentum. It is therefore imperative to control for these competing explanatory variables when relating our information asymmetry measures to the B-share discount.

Regression analysis of the foreign share discount on the candidate explanatory variables generate further support for the information asymmetry hypothesis, even after controlling for alternative explanations. Table IV summarizes the results of the univariate regressions with one of the information asymmetry variables and multivariate regressions using a subset of explanatory variables. The first three univariate regressions show that all three information asymmetry measures are significant. The PI and AS measures are the strongest, explaining 44% and 46% of the cross-sectional variation in the discounts, as compared to only 8% for the PIN measure. The slight increase in the explanatory power of the AS measure over the PI measure indicates that the order size information, which is used in computing the AS measure, is marginally important in capturing the information asymmetry. The fourth regression finds that the A-share turnover is significantly positive, which is consistent with the explanation of Mei, Scheinkman and Xiong (2003) that a premium is paid for shares that carry opportunities for speculative trading. The turnover of B-shares is also significant, albeit to a lesser extent, but its positive sign is not consistent with the B-share illiquidity explanation for the discount. The fifth regression finds that A-share number of trades is statistically significant though bearing the wrong sign, while the B-share number of trades is insignificant. The sixth regression shows that A-share market capitalization is significantly negative, which indicates that larger firms exhibit smaller discounts. This can be interpreted as support for our information asymmetry explanation, as the information cost for larger firms is typically lower. The seventh regression finds that momentum is significantly positive, which is consistent with the findings of Karolyi and Li (2003). They

[10] A-share market capitalization can be interpreted as total market capitalization, as B-share market capitalization is relatively small because the B-share price is lower, but also the number of outstanding shares is lower.

attribute this effect to high momentum stocks being riskier and Chinese investors being more risk tolerant.[11]

In the regressions 8, 9, and 10, we find that the PI and AS measures remain significant even after all control variables are included, while the PIN measure becomes insignificant. The explanatory power of PI and AS appears pervasive, as their coefficients are more statistically significant than all other control variables, including the proxies for B-share illiquidity (turnover and number of trades). This also indicates that the information asymmetry effect that PI and AS capture are distinct from the liquidity effect. In the final regression, 11, we include both AS and PIN and all control variables to establish the robustness of the result that AS (or PI for that matter[12]) is the most significant explanatory variable and that PIN is insignificant.

D. Changes After the B-Share Market Was Opened Up to Local Investors

We use the event of March 2001, when regulators opened up the B-share market to domestic investors, to further test our information asymmetry hypothesis in two ways. First, we expect B-share discounts to shrink or vanish, and, more importantly, we expect our information asymmetry measures to increase for the B-share market after this event, because better-informed domestic investors are now allowed to participate in this market. Second, we repeat our cross-sectional regressions for the new sample period as a robustness test. We analyze the same 76 stocks for the sample period of April to November 2001.

We find that, consistent with our hypothesis, the discount levels decrease from an average of 72% to 43%, and the level of informed trading in the B-share market increases compared with the model estimates for the pre-event period. The main reason for this gradual, instead of sudden, decline in discounts is the lack of foreign currency among domestic investors. Panel A in Table V presents the pre- and post-entry estimates of PI, which show that it almost doubles (+81%) for the

[11] We have also tried the cumulative B-share return with qualitatively similar results.
[12] We do not include both PI and AS, as these proxies are highly collinear (correlation is 0.84, see Table III). If, instead of AS, we include PI we get similar results.

B-share market from 2.6 pre-entry to 4.7 post-entry. This increase is larger than the 21% increase in the A-share market and it is, therefore, consistent with the arrival of better-informed domestic investors in the B-share market. Panel B reconfirms these results based on the AS component of the spread. We find, for both the fixed (z_0) and the variable (z_1) AS component, considerable increases in the B-share market of 52% and 101%, respectively, after domestic investors were allowed entry into this market. We find that the AS component for median-sized trades increases by 44% from 46.8 cents to 67.4 cents. This increase is again larger than the increase in the A-share market and thus consistent with the PI findings. Panel C of Table V reveals that the arrival rate of informed investors in the B-share market increases by 164%. This rate actually decreases by 29% in the A-share market. Further evidence of increased information in the B-share market is that the probability of an information event increases from 0.31 to 0.42, whereas in the A-share market the probability increases only from 0.36 to 0.38. Nevertheless, the level of the PIN measure does not change much in either market, because the changes in the arrival rate of uninformed traders roughly match those of informed traders.

The regressions of the foreign share discount on the information asymmetry measures and controls in the post-event period are consistent with earlier findings. Table VI presents the results for PI, AS, and the PIN including and excluding the control variables. In all of the regressions, the information asymmetry measures are significantly positive, with the PI and AS component measures explaining 61% and 71% of the variation in foreign share discounts, respectively.

E. Discussion and Interpretation of the Results

Overall, our results provide strong evidence that the information asymmetry measures, especially the adverse selection component of the bid-ask spread, are far more important than any of the control variables in explaining the cross-sectional variation in B-share discounts. Our interpretation is that the information asymmetry measures reflect the extent of private information available to domestic investors. When there is a higher degree of information asymmetry, as measured by a higher price impact coefficient or adverse selection component in the A-share market than in the B-share market, domestic investors are more willing to pay a higher price than foreign investors, resulting in B-share discounts. There are, however, several issues that are worthy of discussion.

The first issue concerns the type of private information to which we refer. It is widely believed that Chinese investors trade on rumors rather than fundamentals. Furthermore, share manipulation is widespread, and pushes prices away from the intrinsic value for a relatively long time period. Mei, Sheinkman and Xiong (2003) opine that A-share prices are a reflection of speculative bubbles. Thus, it is not clear whether our information asymmetry measures reflect fundamental news. Although we agree with this view of the speculative behavior of investors, we do not think that it should disqualify our price impact coefficient or adverse selection component from being effective measures of information asymmetry. The differentiation between the adverse selection component and the gross profit component of the bid-ask spread is that the adverse selection component reflects a permanent price change, rather a temporary price change. Therefore, even for long-term investors, the adverse selection component is always important, regardless of whether it reflects fundamental news or rumors. Furthermore, our another paper (Chan, Menkveld, Yang (2003)) shows that A-share quote revision has a predictive ability for B-share quote revision, but not vice versa. Therefore, even though A-share prices are not necessarily reflecting fundamentals, it appears that foreign investors also react to the A-share price movement.

Second, if it is the case that the A-share market is dominated by speculation such that stock prices do not reflect fundamentals, then we must question why the differentials between A- and B-share prices are explained by some fundamental variables, such as our information asymmetry measures. Obviously, due to speculation, A-share prices might be more random, and thus do not reflect fundamentals. However, if B-shares are priced according to fundamentals by rational foreign investors, then the discounts will still correlate with information asymmetry measures., Our evidence demonstrates that foreign share discounts can be explained by fundamental components even if they become noisy due to randomness in A-share prices.

Third, a major reason for the PI or the AS component to be larger in the A-share market than in the B-share market might be that trades are more frequent in the former, so that it is easier for informed investors to camouflage in the A-share market. In other words, the observed larger AS component for the A-share market is not necessarily due to the A-share investors possessing "more information" than the B-share investors, but it is easier for the A-share informed investors to take advantage of it. We do not rule out this possibility because we could not trace the reason for observing a greater degree of informed trading in the A-share market than in the B-share market - whether it is due to the ability of domestic investors acquiring private information or due to the ability of hiding the trades. Nevertheless, since the empirical evidence shows that information asymmetry measures are much more important than number of trades in explaining the B-share discount, we think that this explanation, while plausible, is unlikely.

V. Conclusion

To conclude, the foreign share discount in China is a puzzle that many researchers have tried to solve. One common explanation for this puzzle is that foreign investors, who trade B-shares, have an informational disadvantage relative to domestic investors, who trade A-shares. In this paper, we construct a few measures of information asymmetry based on market microstructure models – the price impact coefficient (PI), the adverse selection component (AS) of the spread and the probability of informed trading (PIN) – and investigate whether they can explain the cross-sectional variation in foreign share discounts after controlling for the influence of other variables that proxy for the liquidity factor, speculative behavior, and stock momentum.

Based on a sample of 76 Chinese firms from 2000 to 2001, we find that all our measures of information asymmetry explain a significant portion of the cross-sectional variation in foreign share discounts. On a univariate basis, the PI and the AS component are particularly strong and explain 44% and 46% of the variation in B-share discounts, while the PIN explains 8%. On a multivariate basis, the PI and AS components are statistically more significant than any of the control variables in explaining B-share discounts. We do not claim that the information asymmetry measure is the only variable for explaining the B-share discount. In fact, we suspect that some other reasons, such as the liquidity consideration and lack of investment opportunities, might be more important in explaining the level of the B-share discount. Our paper does demonstrate, however, that the information asymmetry measures are very important in explaining the cross-sectional variation of the discount.

We also investigate the effect of the opening up of the B-share market to domestic investors after March 2001. The advent of supposedly better-informed domestic investors in the B-share market should lead to a higher PI and AS component of the spread, as market makers in the B-share market now also face order flow from the better-informed domestic investors. This is confirmed by the data. Not only do we observe that B-share discounts decline from an average of 72% to 43%, but we also find that the PI and AS component increase by 81% and 44%, respectively. We also see increases in the A-share market, which indicates that post-event trading is more informative, but the B-share increases far exceed the ones witnessed in the A-share market. These increases far exceed the increases we also see in the for the A-share market, Therefore, by allowing domestic investors to trade in the B-share market, there is less of an information disadvantage in this market, and thus B-share discounts become smaller.

There is extensive literature that documents information asymmetry in international equity markets, but very few studies investigate whether information asymmetry is priced in the market. Our work is one of the few studies to demonstrate the effect of information asymmetry on asset prices. Therefore, if we find that these two information asymmetry measures can explain the cross-sectional variation in foreign share discounts, then this will indicate that information asymmetry is priced in international equity markets.

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Appendix

The model is based on Grossman and Stiglitz (1980), who introduce informational asymmetries into a noisy rational expectations model of asset pricing. We extend the model to two segmented markets, whereby domestic and foreign investors trade in the A-share and B-market separately, although uninformed investors in both markets could infer partial private information of informed domestic investors based on the A-share price.

We assume the domestic investors in the A-share market fall into two types: informed and uninformed, in a proportion of λ and $1-\lambda$. We further assume that all foreign investors in the B-share market are uninformed. This assumption that all foreign investors are uninformed is for convenience of analysis and could be relaxed without changing the key implications of the model as long as a smaller proportion of foreign investors is informed. All investors have CARA utility functions with a risk aversion coefficient ρ or a risk tolerance parameter η (i.e. $\eta = 1/\rho$). For the A- and B-share security issued on the same company, the future payoff (v) is the same but uncertain, with $v \sim N(\bar{v},\sigma_v^2)$). We assume that the domestic investors who are informed get a noisy private signal (S) about the future payoff such that $S = v + \varepsilon_S$ with $\varepsilon_S \sim N(0,\sigma_\varepsilon^2)$. The uninformed domestic investors and foreign investors do not observe the private signal, but attempt to extract information on the signal based on the A-share price (P_A). They are at an informational disadvantage, however, as noisy asset supply prevents the A-share price from being perfectly revealing. A-share asset supply is denoted $y \sim N(\bar{y},\sigma_y^2)$; B-share supply is denoted $z \sim N(\bar{z},\sigma_z^2)$. For convenience, we express all variance parameters in precision terms: $\tau_v = 1/\sigma_v^2$, $\tau_\varepsilon = 1/\sigma_\varepsilon^2$, $\tau_y = 1/\sigma_y^2$, $\tau_z = 1/\sigma_z^2$.

A. 1 Price equilibrium in the A-share market

We conjecture that the equilibrium A-share price will be

$$P_A = \beta_0^A + \beta_S^A \Delta S - \beta_y^A \Delta y \quad \text{`} \tag{A.1}$$

The posterior mean ($E[v \mid S, P_A]$) and posterior precision ($\tau[v \mid S]$) of future payoff conditional on the private signal and the resulting demand of informed domestic investors ($x_A^I(P_A, S)$) in the A-share market are calculated as follows:

$$E[v \mid S] = E[v \mid S] = \bar{v} + \frac{\tau_\varepsilon}{\tau_v + \tau_\varepsilon} \Delta S \tag{A.2}$$

$$\tau[v \mid S] = \frac{1}{Var[v \mid S]} = \tau_v + \tau_\varepsilon \tag{A.3}$$

$$x_A^I(P_A, S) = \frac{E[v \mid S, P_A] - P_A(1+r)}{\rho Var[v \mid S]} = \eta(\tau_v + \tau_\varepsilon)\{\bar{v} + \frac{\tau_\varepsilon}{\tau_v + \tau_\varepsilon} \Delta S - P_A(1+r)\} \tag{A.4}$$

The uninformed investors in the A-share market do not observe the private signal and, therefore, form expectation of future payoff based only on the price change. The posterior mean ($E[v \mid P_A]$) and posterior precision ($\tau[v \mid P_A]$) and demand function of uninformed traders ($x_A^U(P_A)$) in the A-share market are:

$$E[v \mid P_A] = \bar{v} + \frac{\beta_S^A \sigma_v^2}{(\beta_S^A)^2(\sigma_v^2 + \sigma_\varepsilon^2) + (\beta_y^A)^2 \sigma_y^2} \Delta P_A = \bar{v} + \frac{1}{\beta_S^A} \frac{\phi \tau_\varepsilon}{\tau_v + \phi \tau_\varepsilon} \Delta P_A, \tag{A.5}$$

$$Var[v \mid P_A] = \sigma_v^2 \left(1 - \frac{(\beta_S^A)^2 \sigma_v^2}{(\beta_S^A)^2(\sigma_v^2 + \sigma_y^2) + (\beta_y^A)^2 \sigma_y^2}\right)$$

$$\text{or } \tau[v \mid P_A] = \frac{1}{Var[v \mid P_A]} = \tau_v + \frac{\tau_y}{\tau_y + h^2 \tau_\varepsilon} \tau_\varepsilon \tag{A.6}$$

$$x_A^U(P_A) = \frac{E[v \mid P_A] - P_A(1+r)}{\rho Var[v \mid P_A]} = \eta(\tau_v + \phi \tau_\varepsilon)\{\bar{v} + \frac{1}{\beta_S^A} \frac{\phi \tau_\varepsilon}{\tau_v + \phi \tau_\varepsilon} \Delta P_A - P_A(1+r)\}$$

where $\phi = \frac{\tau_y}{\tau_y + h^2 \tau_\varepsilon}$ with $h = \frac{\beta_y^A}{\beta_S^A}$. (A.7)

Based on the market clearing condition, we get:

$$\lambda\ x_A^I(P_A,S)+(1-\lambda)\,x_A^U(P_A)=y \qquad \text{or}$$

$$\lambda\eta(\tau_v+\tau_\varepsilon)\{\bar{v}+\frac{\tau_\varepsilon}{\tau_v+\tau_\varepsilon}\Delta S-P_A(1+r)\}+(1-\lambda)\eta(\tau_v+\phi\tau_\varepsilon)\{\bar{v}+\frac{1}{\beta_S}\frac{\phi\tau_\varepsilon}{\tau_v+\phi\tau_\varepsilon}\Delta P_A-P_A(1+r)\}=y \tag{A.8}$$

Since $\Delta P_A = P_A - E(P_A) = P_A - \beta_0^A$, we could express the A-share price as follows:

$$P_A(S,y)=\frac{1}{\Delta_A}\{(\omega^I+\omega^U)\bar{v}-\frac{1}{\beta_S^A}\omega^U\frac{\phi\tau_\varepsilon}{\tau_v+\phi\tau_\varepsilon}\beta_0^A-\bar{y}+\omega^I\frac{\tau_\varepsilon}{\tau_v+\tau_\varepsilon}\Delta S-\Delta y\} \tag{A.9}$$

where $\frac{1}{\Delta_A}=\frac{1}{(1+r)(\omega^I+\omega^U)-\frac{1}{\beta_S^A}(\frac{\phi\tau_\varepsilon}{\tau_v+\phi\tau_\varepsilon})\omega^U}$,

$\omega^I=\lambda\eta(\tau_v+\tau_\varepsilon),\ \omega^U=(1-\lambda)\eta(\tau_v+\phi\tau_\varepsilon)$.

By imposing the rationality condition, comparing equation (A.1) with (A.9), we have

$$\beta_0^A=\frac{1}{\Delta_A}\{(\omega^I+\omega^U)\bar{v}-\frac{1}{\beta_S^A}\omega^U\frac{\phi\tau_\varepsilon}{\tau_v+\phi\tau_\varepsilon}\beta_0^A-\bar{y}\} \tag{A.10}$$

$$\beta_S^A=\frac{1}{\Delta_A}\{\omega^I\frac{\tau_\varepsilon}{\tau_v+\tau_\varepsilon}\} \tag{A.11}$$

$$\beta_y^A=\frac{1}{\Delta_A} \tag{A.12}$$

Based on equations A.10, A.11, and A.12, we solve for β_0^A, β_S^A and β_y^A as explicit functions of the exogenous parameters:

$$\beta_0^A=\frac{1}{(1+r)}\bar{v}-\frac{1}{(1+r)(\omega^I+\omega^U)}\bar{y} \tag{A.13}$$

$$\beta_S^A=\frac{1}{(1+r)(\omega^I+\omega^U)}\{\omega^I\frac{\tau_\varepsilon}{\tau_v+\tau_\varepsilon}+\omega^U\frac{\phi\tau_\varepsilon}{\tau_v+\phi\tau_\varepsilon}\} \tag{A.14}$$

$$\beta_y^A=\frac{1}{\Delta_A}=\frac{1}{(1+r)(\omega^I+\omega^U)}\{1+(\omega^U\frac{\phi\tau_\varepsilon}{\tau_v+\phi\tau_\varepsilon})/(\omega^I\frac{\tau_\varepsilon}{\tau_v+\tau_\varepsilon})\} \tag{A.15}$$

The solution to *h* in equation A.7 could be also found by dividing equation A.15 by equation A.14.

A. 2 Price equilibrium in the B-share market

The derivation of price equilibrium in the B-share market is more straightforward. Since there is no informed foreign investor, all the demand comes from uninformed foreign investors. The demand of foreign investors in the B-share market, denoted $x_B^U(P_A)$, is a function of A-share price as foreign investors also infer the private information of informed domestic investors from the A-share market:

$$x_B^U(P_A) = \frac{E[v|P_A] - P_B(1+r)}{\rho Var[v|P_A]} = \eta(\tau_v + \phi\tau_\varepsilon)\{\bar{v} + \frac{1}{\beta_S^A}\frac{\phi\tau_\varepsilon}{\tau_v + \phi\tau_\varepsilon}\Delta P_A - P_B(1+r)\} \tag{A.16}$$

By imposing the market clearing condition, we get:

$$\eta(\tau_v + \phi\tau_\varepsilon)\{\bar{v} + \frac{1}{\beta_S^A}\frac{\phi\tau_\varepsilon}{\tau_v + \phi\tau_\varepsilon}\Delta P_A - P_B(1+r)\} = z \tag{A.17}$$

Since $\Delta P_A = P_A - E(P_A) = P_A - \beta_0^A$ and $z = \bar{z} + \Delta z$, equation (A.17) could be rew ritten as:

$$\omega^B(\bar{v} - \frac{1}{\beta_S^A}\frac{\phi\tau_\varepsilon}{\tau_v + \phi\tau_\varepsilon}\beta_0^A) + \omega^B\frac{1}{\beta_S^A}\frac{\phi\tau_\varepsilon}{\tau_v + \phi\tau_\varepsilon}P_A - \omega^B P_B(1+r) = \bar{z} + \Delta z \tag{A.18}$$

where $\omega^B = \eta(\tau_v + \phi\tau_\varepsilon)$.

Therefore, the equilibrium B-share price is:

$$P_B(P_A, z) = \frac{1}{\Delta_B}\{\omega^B(\bar{v} - \frac{1}{\beta_S^A}\frac{\phi\tau_\varepsilon}{\tau_v + \phi\tau_\varepsilon}\beta_0^A) - \bar{z} + \omega^B\frac{1}{\beta_S^A}\frac{\phi\tau_\varepsilon}{\tau_v + \phi\tau_\varepsilon}P_A - \Delta z\} \tag{A.19}$$

where $\frac{1}{\Delta_B} = \frac{1}{(1+r)\omega^B}$.

The B-share equilibrium price now takes the following function form:

$$P_B = \alpha_0 + \alpha_B P_A + \alpha_Z \Delta z \quad \text{or}$$

$$P_B = \beta_0^B + \beta_S^B \Delta S - \beta_y^B \Delta y - \beta_Z^B \Delta z \quad \text{(A.20)}$$

By substituting for P_A in equation A.19, and substituting for the expressions in equations A.13 to A.15, and comparing the final expression with equation A.20, we obtain:

$$\beta_0^B = \frac{1}{(1+r)}\bar{v} - \frac{1}{(1+r)\omega^B}\bar{z} \quad \text{(A.21)}$$

$$\beta_S^B = \frac{1}{(1+r)}\left(\frac{\phi\tau_\varepsilon}{\tau_v + \phi\tau_\varepsilon}\right) \quad \text{(A.22)}$$

$$\beta_y^B = \frac{1}{(1+r)}\left(\frac{\phi\tau_\varepsilon}{\tau_v + \phi\tau_\varepsilon}\right)/\left(\omega^I \frac{\tau_\varepsilon}{\tau_v + \tau_\varepsilon}\right) \quad \text{(A.23)}$$

$$\beta_z^B = \frac{1}{\Delta_B} = \frac{1}{(1+r)\omega^B} \quad \text{(A.24)}$$