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RESEARCH ARTICLE

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Adverse Selection Costs: A Study on the Chinese Stock Market

Abstract Employing a bid-ask spread model applicable for order-driven market, this paper decomposes the bid-ask spread of Shanghai Stock Exchange (SSE) into adverse selection and order processing cost components to investigate the relationship between the components of bid-ask spread and order size. It examines the impacts of firm size, price, trading activeness, and volatility on adverse selection cost, and explores the intraday pattern of adverse selection costs and informative trading. Results show that adverse selection costs increase with trade scale. However, order processing costs do not exhibit the economies of scale. Stocks of large firms, which are high-priced and actively traded, have relatively low adverse selection costs; stocks with large volatility have relatively high adverse selection costs. Moreover, this paper finds that the adverse selection component of bid-ask spread in the Chinese stock market exhibits an L-shaped intraday pattern, which implies that heavy trading around market opening is

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dominated by informative trading, while heavy trading near market closing is dominated by liquidity trading.

Keywords liquidity, bid-ask spread, adverse selection costs, order processing costs, informative trading

1 Introduction

Liquidity is vital to stock market and is normally measured by bid-ask spread. The narrower the spread, which implies lower order processing costs, the higher the liquidity. The constitution or the structure of bid-ask spreads has always been the core issue in the theory of market microstructure. It is the prerequisite for further theoretical research on liquidity issues; and also very useful in trading mechanism design, trading system arrangements and securities market supervision.

Early studies of bid-ask spread mainly focused on the quote-driven market. The spread quoted is a kind of compensation to market dealers for liquidating their positions passively. Stoll (1989) decomposed bid-ask spread into three parts: order processing costs, inventory holding costs and adverse information costs. The order processing costs are associated with providing market making services, which include items like security trading and liquidation costs, bookkeeping and office expenses, the opportunity of market makers' time and effort, etc. Market makers/dealers charge a commission on all transactions through the difference between the ask price and the bid price, thus the bid-ask spread is used to compensate order processing costs as well as to obtain economic rent based on its market power. Inventory holding costs refer to market makers' inventory management costs. For example, market makers may carry positions acquired in supplying investors with immediacy of exchange (liquidity). A dealer's actual inventory of a common stock may differ from the desired level. Due to stock price volatility, market makers bear the risk that the inventory value may change adversely as a result of price fluctuation. Consequently, market makers require a compensation for holding the inventory. Normally, it is agreed that inventory holding costs are positively related to the order processing size and the price volatility (Ho and Stoll, 1981). According to the microstructure theory, order processing costs and inventory holding costs are not related to the intrinsic value of the securities, and have no persistent impact on the price of securities. These two components are usually referred to as the temporary components of the bid-ask spread.

Based on information asymmetry and informed trading, Bagehot (1971), Copeland and Galai (1983) and Glosten and Milgrom (1985) proposed a third component of bid-ask spread—the averse selection costs. Informed traders can make profit by trading on insider information against market makers, while the latter could incur losses by liquidating corresponding positions passively. Rational market makers will increase the bid-ask spread further to obtain larger profit from the investor's trading with liquidation purpose, in order to compensate the losses from dealing with informed traders. This part of the bid-ask spread is called the adverse selection costs. Considering that the insider information implicated in the informed traders' orders has long lasting impact on security prices, the adverse selection costs are referred to as the persistent cost component of bid-ask spread.

Based on an understanding of cost components in bid-ask spread, various models and methods have been developed to quantitatively study the spread. These models include the bid-ask structure models developed, respectively, by Glosten and Harris (1988, hereinafter referred to as GH), Lin, Sanger and Booth (LSB, 1995), De Jong, Nijman and Roell (DNR, 1996), Huang and Stoll (HS, 1997) and Madhavan, Richardson and Roomans (MRR, 1997) as well as the model based on VAR by Hasbrouck (VAR, 1991a,1991b). With regard to the relationship between bid-ask spread components and trading order size, our main finding is that the adverse selection costs increase with the increase of order size, which is subject to the economies of scale. The intra-day trading of bid-ask spread, adverse selection costs decrease as order processing costs increase gradually in the New York Stock Exchange. However, both of these two costs exhibit a U-shape pattern in Tokyo Stock Exchange (Ahn, Cai, Hamao and Ho, 2002).

Stoll (2000) summarized and commented on the cross-sectional factors affecting bid-ask components, including company size, price, trading volume and volatility. The main findings of the existing literature are: adverse selection costs are negatively related to company size and trading volume, but positively related to price volatility. Further studies have confirmed these results (Ahn, Cai, Hamao and Yo, 2002; Ahn, Cai, Hamao and Ho, 2005).

Studies on the liquidity of Chinese stock market only started recently since 2002. For example, Qu and Wu (2002) investigated the daily and weekly bid-ask spread patterns in Shenzhen Stock Exchange and the factors affecting bid-ask spread. Some other researchers empirically studied the components of bid-ask spread. For instance, Yang, Sun and Shi (2002), Wang and Chen (2006), Han, Wang and Yue (2006) employed the LSB model to determine the components of bid-ask spread in the Chinese stock market; Su (2004) followed the method of George, Kaul and Nimalendran (1991) to estimate the proportion of bid-ask spread related to informative trading; Mu, Wu and Liu (2004), by using the MRR method, detected the components of bid-ask spread in Shenzhen Stock Exchange. Cao, Liu and Qiu (2006) estimated the bid-ask spread of the stocks in Shanghai 50 Component Index following the methodology of Chan (2000). Particularly, they pointed out that inventory holding costs exist in order-driven market as well. More recently, following the regulation change in 2003 that the disclosure of best bid-ask quotes increased from 3 to 5, Dong and Han (2006) investigated the impact of such change and the resulted increase of market transparency on market liquidity, trading cost and price volatility of Shenzhen A-shares. However, how such changes affect information asymmetry and adverse selection costs were not discussed in their study.

This paper employs the DNR and GH models to empirically investigate the components of bid-ask spread of the stocks in Shanghai 180 Component Index and their relationships with order size. Meanwhile, this paper also explores the impact of company size, stock price, trading activeness and volatility on the adverse selection costs, and studies the intra-day pattern as well as the causes of adverse selection costs and informed trading. It is found that adverse selection costs increase with the increase of order size. However, there are no obvious economies of scale in orders processing. We also find that adverse selection costs decrease with the increase of company size, stock price and stock activity, while increase with the increase of stock volatility. Additionally, it is also found that intra-day adverse selection costs exhibit an "L-shaped" pattern. The relative heavy trading around market opening is due to informative trading and the relative heavy trading around market closing is because of liquidity trading.

This paper differs from the existing literature in many ways: First, we use the DNR model, which is appropriate for the order-driven market, to investigate the bid-ask spread in China's stock market. To the best of our knowledge, this is the first study that employs the DNR model to study China's stock market. It is known that China's stock market is an order-driven rather than quote-driven market. As most existing models are based on quote-driven market, the use of DNR model in this paper to empirically study the bid-ask spread structure in Chinese stock market might generate some reliable results. Second, this paper is also the first to use the GH model to study the bid-ask spread in Chinese stock market. The using of both DNR and GH models might increase the solidness of our results. Meanwhile, in the two models, the bid-ask spread is, to some extent, sensitive to the size of trading order. Thus the use of the two models provides an opportunity to study the relationship between bid-ask spread components and size of trading order. Third, this paper investigates the reason why there is no obvious presence of economies of scale in order processing in SSE. Fourth, we aim to thoroughly analyze the cross-sectional factors that affect adverse selection costs, using trading volume, trading density and the depth of trading as indicators for trading activeness. We also discuss the cause of trading activity and the intraday bid-ask spread pattern, based on the existing study on intraday adverse selection costs.

The remainder of the paper is structured as follows. Section 2 describes the

DNR and GH models. Data description, data pre-processing and basic statistical analysis are given in Section 3. Section 4 analyzes the results from the bid-ask spread models and investigates the relationship between the components and order size. Section 5 studies cross-sectional impacts of company size, stock price, and trading activeness on adverse selection costs. Section 6 investigates the intraday relationships and cause between adverse selection costs and informed trade. Conclusion and policy implications are provided in Section 7.

2 Research Model of Bid-Ask Spread

We use the DNR (De Jone et al., 1996) and GH (Glosten and Harris, 1988) models to empirically study the bid-ask spread structure of SSE. Particularly, the DNR model is appropriate for order-driven market.

2.1 The DNR Bid-Ask Spread Model

For exemplification purpose, we assume that tradings are driven by buyers. $R(q)$ is the net profit of the trading driven by buyers and q is the order size . The total cost of order processing is $C(q)$. According to the marginal utility rule (Glosten, 1994), the marginal net revenue $R'(q)$ should be equal to the marginal cost of order processing $C'(q)$ plus the expected value of order size $E_z[e(z) \mid z \geqslant q]$ when an order is placed. E_z is the expected value of order size distribution z and $e(z)$ indicate the adjustment of public expectation of the order size z. Given that $e(z)$ is a linear function of z , $e(z) = e_0 + e_1 z$, the order size z is distributed as $F_z = 1 - e^{-q/a}$, $E_z[e(z) \mid z \geqslant q] = e_0 + e_1(q + \alpha)$, where α is the median of trading order divided by log(2).[1] Therefore,

$$R'(q) = C'(q) + e_0 + e_1(q + \alpha). \quad (1)$$

When averaging the order processing costs $C(q)/q = c_0 + c_1 q$, we first integrate both sides of Equation (1), and then divide the Equation by q. We therefore obtain the average premium per unit of the buyer driven trading order, which is,

$$R(q)/q = c_0 + c_1 q + (e_0 + e_1\alpha) + 1/2 e_1 q = R_0 + R_1 q, \quad (2)$$

Where $R_0 = c_0 + e_0 + e_1\alpha$, and $R_1 = c_1 + (1/2)e_1$. The costs of adverse selection and order processing are $(e_0 + e_1\alpha) + (1/2)e_1 q$ and $c_0 + c_1 q$, respectively.

We assume that stock price is $P_t = y_t + (R_0 + R_1 q_t)Q_t + u_t$, which implies that

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1 Because $F_z(q_{med}) = 1 - e^{-q_{med}/a} = 1/2$, where q_{med} is the median of q.

the price is equal to the expected value of stock price one period before, y_t, plus the average premium. u_t is used to capture the price dispersion effects. q_t is the order size measured by the minimum trading unit and Q_t the transaction driven variable (Q_t=1 when the trading is driven by buyer and $Q_t = -1$ when the transaction is driven by seller). t is the time of trade, therefore,

$$\begin{aligned}\Delta P_{t+1} &= P_{t+1} - P_t \\ &= [y_{t+1} + (R_0 + R_1 q_{t+1})Q_{t+1} + u_{t+1}] - [y_t + (R_0 + R_1 q_t)Q_t + u_t] \\ &= \{[y_t + (e_0 + e_1 q_t)Q_t + \varepsilon_{t+1}] + (R_0 + R_1 q_{t+1})Q_{t+1} + u_{t+1}\} \\ &\quad - [y_t + (R_0 + R_1 q_t)Q_t + u_t] \\ &= \Delta(R_0 + R_1 q_{t+1})Q_{t+1} + (e_0 + e_1 q_t)Q_t + e_{t+1}. \end{aligned} \tag{3}$$

Equation 3 reflects the effect of stock expected value adjustment on the realized stock price. The public expectation of stock price after the order q_t has been placed on the market is $y_{t+1} = y_t + (e_0 + e_1 q_t)Q_t + \varepsilon_{t+1}$, where ε_{t+1} represents the public information innovation between t and $t+1$, which is not related to the currency trading size. From the above equations, we can get $e_{t+1} = \varepsilon_{t+1} + \Delta u_{t+1}$, and then we obtain the fourth equation as follows

Therefore, DNR method is to estimate the following equation:[2]

$$\Delta P_t = \mu + R_0 \Delta Q_t + R_1 \Delta(q_t Q_t) + e_0 Q_{t-1} + e_1 q_t Q_{t-1} + u_t. \tag{4}$$

Based on this, the order processing costs are $c_0 + c_1 q_t$, where $c_0 = R_0 - e_0 - e_1 \alpha$ 、 $c_1 = R_1 - (1/2)e_1$; and the adverse selection costs are $(R_0 - c_0) + (R_1 - c_1)q_t$.

2.2 GH Bid-Ask Spread Model

The GH model (Glosten and Harris, 1988) is developed to model the quote-driven market. It decomposes bid-ask spread into temporary and persistent components, which are used to indicate order processing and adverse selection costs, respectively.[3] The model is described as:[4]

$$\Delta P_t = \mu + c_0 \Delta Q_t + c_1 \Delta(q_t Q_t) + z_0 Q_t + z_1 q_t Q_t + u_t, \tag{5}$$

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[2] The estimation equation is an adjusted equation developed by Ahn et al. (2002). There are a few divergences from the model in De Jone et al. (1996).

[3] Assume that in the order driven market, investors who submit limited order are regarded as implicated market makers, bid-ask spread models developed to describe the quote-driven market are applicable to a certain extent. A pure order driven market does not have market maker, thus no inventory holding costs. As a result, the temporary and persistent components of bid-ask spread are the order processing costs and adverse selection costs respectively.

[4] For a more detailed explanation about the model, please see Glosten and Harris (1988).

where P_t, Q_t and q_t have the same meaning as in the DNR model. In the GH model, adverse selection costs are $z_0+z_1q_t$ order processing costs are $c_0 + c_1q_t$, and the implicated spread is $2(c_0 + c_1q_t) + (z_0 + z_1q_t)$.

When estimating the above models, we exclude the transactions in the top 1% of all transactions ranking according to their order size so as to eliminate the interference of larger transactions on the estimation results (Hausman, Lo and Mackinlay, 1992).

3 Data Description, Data Pre-Processing and Basic Statistical Analysis

3.1 Data Description and Pre-Processing

Sample stocks used in this paper are those in Shanghai 180 Component Index. Data range from March 1, 2005 to May 31, 2005, including 61 trading days in total. All data were obtained from the High-Frequency Trading Database developed by Shenzhen Guotai Industrial Co., Ltd. The database has a detailed record of 35 indicators since 2005, including stock code, trading date, trading time, price, turnover, volume and trading mark (buyer-driven transaction is denoted by "*B*" and seller-driven transaction by "*S*"), bid price, ask price, bid volume, ask volume, and bid-ask spread, etc. The number of floating shares of each stock is from CSMAR Database.

We first filter the raw data by excluding: (1) data with system records outside the market trading time (i.e., 09:30 to 11:30 and 13:00 to 15:00); (2) data with negative trading price, turnover and bid/ask quote; and (3) data with negative bid-ask spread.

3.2 Basic Statistical Analyses

Table 1 illustrates the descriptive statistics of company size, stock price, trading activeness, volatility and bid-ask spread.[5] The trading activeness is described by turnover, trading density and depth. Price is the average trading price in all trading days, and free floating share volume is the one after the last stock ownership reform in 2005. Market value is price times the number of floating shares. Daily turnover is calculated as the average turnover of all trading days; trading density as the average number of daily transactions, and trading depth as the average order size of all trading days. Volatility is the standard deviation of stock price. To facilitate the understanding of the cross-sectional relationships between these variables, we divide the samples into three sub-samples, according

[5] The maximum and minimum value and some other descriptive statistics are not reported to save the space, but available upon request.

Table 1 Descriptive Statistics

Variables	Whole sample ($N = 180$)			Small companies ($N = 45$)			Medium companies ($N = 108$)			Large companies ($N = 18$)		
	Median	Mean	S.D.	Median	Mean	S.D.	Median	Mean	S.D.	Median	Mean	S.D.
Price (yuan)	5.072	6.401	5.084	4.213	4.291	1.665	5.423	6.65	4.198	7.046	10.06	10.88
No. of floating shares (million shares)	207.1	366.9	595.2	122.4	127.6	52.65	244.8	287.7	169.7	976.6	1480	1421
Market capitalization (million yuan)	1 119	1 985	2 662	485.9	499.7	144.9	1 323	1 598	796.9	6 674	8 218	4 712
Volatility	0.195	0.200 7	0.055 8	0.216 3	0.229 6	0.058	0.191 6	0.196 9	0.051 97	0.153 3	0.152 8	0.031 1
Daily turnover (million yuan)	1 087	1 978	2 583	688.4	949.2	851.3	1 103	1 688	1 958	5 230	6 435	4 221
Daily volume (million lots)	1.99	3.488	5.534	1.801	2.159	1.596	1.914	2.809	3.916	8.253	11.22	11.83
Trading density (times)	488.4	545.6	267.4	444.5	457.5	207	488.5	527.5	248.1	923.4	883.4	279.9
Trading depth (thousand lots)	3.889	4.871	3.902	3.817	4.221	1.81	3.674	4.248	2.697	7.833	10.55	8.022
Absolute bid-ask spread (yuan)	0.012 4	0.015 1	0.009 6	0.012	0.012 6	0.002 6	0.013	0.015 5	0.007 9	0.011 3	0.019 3	0.022 2
Relative bid-ask spread (%)	0.256 6	0.275 4	0.095 9	0.310 7	0.33	0.102 6	0.247 1	0.265 2	0.087 5	0.195 6	0.205 3	0.059 5

to their market values based on floating shares with 25% and 90% of market value as the band. To be more specific, the companies in our sample are ranked based on their market value. We group the top 25% companies to form the large company group and the bottom 10% to form the small company group. The rest of the companies are located in the medium company group.

As shown in Table 1, in the sample period, the median of Shanghai 180 Component Index is 5.072 Yuan; the average price 6.401 Yuan; the median of the number of floating shares 207.1 million shares (with an average of 366.9 million shares); the median of market capitalization based on the floating shares is 1.119 billion Yuan (with an average of 1.985 billion Yuan); the daily turnover and trading volume of sampled shares is 3.488 million shares and 19.78 million Yuan, respectively; the average trading density, average trading depth and price volatility is 546, 4.871, and 0.2007 respectively; the average absolute bid-ask spread 0.0151 Yuan, and relative bid-ask spread 0.2754%.[6]

By comparison, large companies have higher stock price and heavier trading activity, whereas small companies have larger price volatility. Specifically, for large, medium and small listed companies, the average market capitalization based on the floating shares is 8.218, 1.598 and 0.499 7 billion Yuan, respectively; the average numbers of floating shares are 1 480, 287.7 and 127.6 million; the average prices per share are 10.06, 6.65 and 4.291 Yuan; and the average volatilities are 0.152 8, 0.196 9 and 0.229 6, respectively. The statistics show that large companies have higher stock price and small companies have higher volatility. Moreover, the average daily turnovers for large, medium and small companies are 64.35, 16.88 and 9.492 million Yuan; average trading volumes are 11.22, 2.809 and 2.159 million lots; median trading densities are 923, 489 and 445 times; and the median trading depth are 7 833, 3 674 and 3 817 shares, respectively. These statistics show that the divergence of trading activities between large companies and medium and small companies are obvious: large companies have the most active trading activities, whereas the difference between small and medium companies in trading activeness is little.

The absolute bid-ask spread for large companies is larger than that of for medium and small companies. However, the relative bid-ask spread is smaller. For example, in Table 1, the absolute average bid-ask spreads for large, medium and small companies are 0.019 3, 0.015 5 and 0.012 6 Yuan, respectively, while the relative average bid-ask spreads are 0.205 3%, 0.265 2% and 0.33%, respectively. Absolute bid-ask spread is used to measure the number of shares involved, while relative bid-ask spread is used to measure the amount of money involved. The latter is therefore more useful from the investors' angle. To summarize, large companies have high stock price, low volatility, and low

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[6] Absolute bid-ask spread = bid price-ask price; relative bid-ask spread = (bid price – ask price)/[(bid price – ask price)]/2.

relative bid-ask spread.

The intraday statistics for stock activities, price, volatility and bid-ask spread are reported in Table 2, showing that the trading volume is large around market opening, and even larger around market closing. During the day, the trading volume exhibits a “U” shaped pattern, so as the trading density and depth, particularly the trading density. By comparison, volatility follows an “L” shaped pattern because there is no obvious upward sloping towards market closing. Stock price, absolute and relative bid-ask spreads also exhibit typical “L” shaped pattern.

Table 2 Intraday Trading Activities, Price and Volatility

Time	9:30–10:00	10:00–10:30	10:30–11:00	11:00–11:30	13:00–13:30	13:30–14:00	14:00–14:30	14:30–15:00
Price (Yuan)	6.407	6.404	6.4	6.399	6.398	6.4	6.401	6.397
Market capitalization (million Yuan)	1 987	1 986	1 985	1 985	1 984	1 985	1 985	1 984
Volatility	0.253 6	0.191	0.185 6	0.181 9	0.180 2	0.177 6	0.173 5	0.182 3
Turnover (million Yuan)	252.6	267.1	237.8	199.1	204.5	238.1	244	333.7
Trading volume (million lots)	0.459 1	0.474 9	0.420 2	0.343 7	0.354 5	0.415 2	0.424 4	0.597 4
Trading density (times)	74.5	72.78	65.96	58.16	56.14	64.37	66.17	85.84
Trading depth (thousand lots)	4.219	4.671	4.63	4.375	4.554	4.722	4.76	5.361
Absolute bid-ask spread (Yuan)	0.020 31	0.015 59	0.014 99	0.014 92	0.014 66	0.014 34	0.014 09	0.014 06
Relatively bid-ask spread (%)	0.345 2	0.278 9	0.273	0.271 7	0.268 4	0.264	0.260 1	0.259 1

Now, we employ the DNR and GH models to empirically decompose the bid-ask spread into order processing costs and adverse selection costs, investigate the relationship between adverse selection and order size, discover the cross-sectional mpacts of company size, price, trading activeness and volatility on adverse selection costs and to study the relationship between adverse selection and informed trading and its causes.

4 The Components of Bid-Ask Spread and Estimation Results

Table 3 shows the estimation results of the parameters in the DNR and GH models, as well as the estimated adverse selection costs, order processing costs

Table 3 Estimation Results of Bid-ask Spread Model

		Part A Parameters estimation							
		DNR model				**GH model**			
		$R_0 - c_0$	$R_1 - c_1$	c_0	c_1	z_0	z_1	c_0	c_1
	Small companies ($N = 45$)	0.160 8 (0.016 9)	0.058 2 (0.003 8)	0.290 9 (0.013 7)	0.068 2 (0.006 8)	0.086 2 (0.012 0)	0.116 5 (0.007 5)	0.365 6 (0.016 4)	0.009 9 (0.003 7)
	Medium companies ($N = 117$)	0.149 7 (0.013)	0.061 1 (0.003 3)	0.381 (0.014 5)	0.070 6 (0.005 5)	0.085 5 (0.009 6)	0.122 2 (0.006 6)	0.445 1 (0.016 4)	0.009 5 (0.002 6)
	Large Companies ($N = 18$)	0.123 8 (0.056 6)	0.057 4 (0.018 7)	0.544 5 (0.114 7)	0.048 8 (0.019 1)	0.079 3 (0.0452)	0.114 9 (0.037 4)	0.589 (0.125 2)	–0.008 5 (0.003 7)
		Part B Adverse selection, order processing costs and the implied bid-ask spread							
		$q = 1$	$q = 5$	q = median	$q = 99\%$	$q = 1$	$q = 5$	q = median	$q = 99\%$
Small company group	Adverse selection	0.219 1	0.452	0.743 1	1.034	0.202 7	0.668 5	1.251	1.833
	Order processing	0.359 1	0.631 9	0.972 9	1.314	0.375 5	0.415 4	0.465 3	0.515 1
	Adverse selection (%)	0.048 1	0.103	0.171 7	0.240 3	0.044 4	0.154 3	0.291 5	0.428 8
	Order processing (%)	0.090 2	0.147 8	0.219 8	0.291 8	0.093 9	0.096 6	0.099 9	0.103 3
	The weight of adverse selection	0.359 7	0.408 5	0.435 9	0.450 9	0.332 2	0.611 3	0.741 1	0.805 7
	Implied bid-ask spread	0.937 4	1.716	2.689	3.662	0.953 8	1.499	2.181	2.863
	Implied bid-ask spread (%)	0.228 6	0.398 7	0.611 3	0.823 9	0.232 3	0.347 5	0.491 5	0.635 4
Medium company group	Adverse selection	0.210 8	0.455 2	0.760 7	1.066	0.207 8	0.696 6	1.308	1.919
	Order processing	0.451 7	0.734 3	1.088	1.441	0.454 7	0.492 9	0.540 6	0.588 4
	Adverse selection (%)	0.030 4	0.068 9	0.116 9	0.165	0.029 7	0.106 6	0.202 7	0.298 7

(*To be continued*)

(*Continued*)

Part B Adverse selection, order processing costs and the implied bid-ask spread

		$q = 1$	$q = 5$	q = median	q = 99%	$q = 1$	$q = 5$	q = median	q = 99%
Medium company group	Order processing (%)	0.078 6	0.118	0.167 1	0.216 3	0.079 3	0.0802	0.081 4	0.082 5
	The weight of adverse selection	0.292 9	0.3681	0.411 1	0.434 8	0.286 6	0.571	0.714 7	0.789 5
	Implied bid-ask spread	1.114	1.924	2.936	3.948	1.117	1.682	2.389	3.096
	Implied bid-ask spread (%)	0.187 7	0.3048	0.451 2	0.597 6	0.188 4	0.2671	0.365 5	0.463 8
Large company group	Adverse selection	0.1812	0.4109	0.698	0.9851	0.1942	0.6536	1.228	1.802
	Order processing	0.5934	0.7888	1.033	1.277	0.5804	0.5461	0.5032	0.4604
	Adverse selection (%)	0.01603	0.0404	0.071	0.1016	0.0168	0.0657	0.1269	0.1881
	Order processing (%)	0.0806	0.0967	0.1169	0.1371	0.0797	0.0714	0.061	0.0506
	The weight of adverse selection	0.1792	0.2932	0.3719	0.4217	0.1894	0.4791	0.6686	0.7852
	Implied bid-ask spread	1.368	1.988	2.764	3.54	1.355	1.746	2.234	2.723
	Implied bid-ask spread (%)	0.1773	0.234	0.3049	0.3758	0.1764	0.2087	0.249	0.2893

Note: In part A, the standard deviations of the parameters are reported in parentheses. In part B, the unit for adverse selection costs and bid-ask spread is 0.01 Yuan. The weight of adverse selection costs are the percentage of implied bid-ask spread (adverse selection costs plus order processing selection costs). The minimum trading size q is 100 shares.

and the implied bid-ask spread. We use the same sub-samples as in Table 1. Part A of Table 3 reports the estimation results of the parameters with standard deviation in the brackets. Part B of Table 3 presents the calculated adverse selection costs, order processing costs and the implied bid-ask spread using the values obtained from model estimation. In order to study the relationship between order size and adverse selection and order processing costs, we calculate adverse selection costs, order processing costs and implied bid-ask spread for the stocks by assuming *q* equals 1, 5, the median of order size, and 99% of the order size, respectively. The results are shown in Table 3, Part B.

First, adverse selection costs increase with the increase of order size. In the medium companies group, when order size *q* is equal to 1, 5 and the median respectively, the adverse selection costs $(R_0 - c_0) + (R_1 - c_1)q_t$ from the DNR model are 0.210 8, 0.455 2 and 0.760 7 respectively; relative adverse selection costs are 0.030 4%, 0.068 9% and 0.116 9% (with the weight equal to 0.292 9, 0.368 1 and 0.411 1), respectively. Similar patterns can also be found in the groups of small and large companies, and in the estimated results of GH model. We thus infer that adverse selection costs (absolute or relative) are positively related to order size.

The above findings are consistent with Easley and O'Hara's (1987) assumption: Informed traders make profit by trading on the private information; their order size is normally bigger than non-informed investors. As a result, large orders are more likely to contain more private information. These findings are consistent with the previous studies on stock markets in New York (Lin et al., 1995), Paris (De Jong et al., 1996) and Tokyo (Ahn et al., 2002).

Second, order processing costs are not characterized by economies of scale. Our study only finds that there exists some degree of economies of scale in the large company group. For the large company group, when *q* is equal to 1, 5 or the median, order processing costs $c_0 + c_1 q_t$ are 0.580 4, 0.546 1 and 0.503 2 and the corresponding relative costs of order processing are 0.079 7%, 0.071 4% and 0.061% respectively. The order processing costs increase as the order size decrease. In other cases, the order processing costs increase as the order size increases. These are different from the findings of Glosten and Harris (1988), De Jong et al. (1996) and Ahn et al. (2002).[7]

There are mainly two reasons behind the order processing costs in SHSE not exhibiting economies of scale: first, according to the trading rule in stock market, commissions (fees) are calculated based on the volume of realized turnover. If the commission/fee charged is a fixed proportion applicable to each transaction, then order processing costs typically have the feature of economies of scale. In

[7] Evidence can be found in their study showing that order processing costs do not demonstrate economies of scale. However, such a view is only of minority.

China's stock market, stock trading commission/fee is usually calculated as a proportion of the turnover, which partly explains China's stock market does not have the economies of scale feature. For example, in the whole sample period, the stamp duty of stock trading is 1‰, and the commission is roughly 2‰.

Most microstructure theories agree that market maker's inventory holding costs increase as order size and price volatility increase. In an order-driven market, market makers do not incur inventory holding costs. However, an investor who submitted limit orders acts as an implied market maker. Hence, in an order-driven market, there also exist similar inventory holding costs as in the quote-driven market. Previous studies have noticed such possibilities that if investors who submit market orders are treated as liquidity demanders and investors who submit limit orders as liquidity providers, the theory of inventory holding costs can be used in order-driven market, based on the view that limited orders absorb the inventory passively according to the instructions (orders) from the market in exchange for price reverse (De Jong et al., 1995). When bid-ask spread reflects inventory holding costs, the price quoted will be negatively related to stock prices because liquidity provider will adjust bid and ask quote to facilitate a deal and to balance inventory. For example, when liquidity providers face a market sell order, both bid and ask price is trending downward to prevent further sell and to encourage buy in the stock market, in order to make sure the price will go back to the original level when the balance inventory is achieved (Stoll, 1989). When there are no inventory holding costs, quote does not have negative correlation with stock price even though the latter changes.[8] Therefore, for investors who submitted limited orders, if limited orders can not be processed to reverse price, inventory holding costs for such investors will increase. Essentially, in this study, order processing costs, to a certain extent, include such kind of inventory holding costs. Based on this, if most individual investors are lack of experience and tend to follow other investors (i.e., "herd behavior"), inventory holding costs will stand out, which will in turn lead to the fact that economies of scale feature of the order processing costs is not being observed.

Last but not least, adverse selection costs and order processing costs components in bid-ask spread are sensitive to model setting. For example, when $q = 1$, the small company group has smaller absolute and relative adverse selection costs when the GH model rather than DNR model is adopted, so do the weight of averse selection costs. However, the opposite can be found when q is equal to the median. Our findings are consistent with the findings of De Jong et al. (1996), who discussed the relationship between the two models. De Jong et al. (1996) also pointed out that when order size is small, the GH model tends to

[8] Chan's (2002) study included inventory holding costs in the bid-ask spread model under the context of order driven market.

underestimate adverse selection costs and overestimated the costs when order size is large.[9]

5 Impacts of Company Size, Price, Trading Activeness and Volatility on Adverse Selection Costs

Table 4 reports the estimation results using the DNR and GH model, respectively, when the stocks are re-sampled based on the cross-sectional actors, including company size, price, activeness and volatility. Company size is measured by market capitalization using only the floating portion of total stocks and by the number of floating shares. The trading activeness is measured by trading volume, density, and depth.

First, stocks with larger trading volume have lower adverse selection costs. The estimates for the DNR model show that the adverse selection costs for large, medium and small company group are 0.014 9, 0.082 and 0.022 58 respectively; and the corresponding relative adverse selection costs are 0.004 2%, 0.015 1% and 0.035 7%. Stocks with larger trading volume have lower absolute and relative adverse selection costs. The GH model produces similar results.

Moreover, stocks with larger trading density and trading depth have larger adverse selection costs. Dufour and Engle (2000) and Pascual, Escribano and Tapia (2004) found that order size and trading intervals can all reveal, to a certain extent, private information. This paper further decomposes trading activeness into trading density and depth, and finds both of which are negatively related to adverse selection cost. Trading density can somewhat reflect the extent to which the market pays attention to a certain stock. In this sense, our finding that stocks with higher trading density have lower adverse selection costs is consistent with the findings of Ahn et al. (2005), namely stocks having more brokers tend to have lower information asymmetry and adverse selection costs. This is because the larger the number of the brokers, the more the information an investor can get from utilizing the brokerage service, and thus the less the adverse selection costs. The number of brokers in a stock market is therefore an important indicator for market focus.

Another finding is that stocks with higher price volatility have higher adverse selection costs. From the DNR model estimation results, we can see that adverse selection costs are 0.304 6, 0.215 0 and 0.158 6, and the relative adverse selection costs are 0.059 1%, 0.034 2% and 0.021 2% for the large, medium and small company group respectively,. Their weights are 0.355, 0.304, and 0.261. Both the GH model and DNR models produce the similar results. In summary, stocks with higher price volatility have larger absolute and relative adverse selection costs.

[9] Please see De Jone et al. (1996) for detailed discussion.

Table 4 Relationship between Adverse Selection Costs and Company Size, Price, Activeness and Volatility

Sample		DNR Model					GH Model			
		No. of share	Adverse Selection (0.01 Yuan)	Adverse selection (%)	Order processing (%)	Weight	Adverse Selection	Adverse Selection (%)	Order Processing (%)	Weight
Price (Yuan)	<4	52	0.107 3	0.034 2	0.118 6	0.226	0.100 8	0.032 1	0.120 7	0.213
	4–10	110	0.203 3	0.033 7	0.069 2	0.321	0.196 1	0.032 4	0.070 5	0.310
	>10	18	0.546 5	0.029 4	0.050 1	0.366	0.561 3	0.030 2	0.049 4	0.375
No. of floating shares (million shares)	<100	28	0.390 9	0.046 9	0.065 2	0.421	0.372 7	0.044 1	0.067 9	0.398
	100–500	128	0.202 4	0.034 5	0.081 3	0.305	0.198 6	0.033 1	0.082 7	0.295
	>500	24	0.088 8	0.017	0.097 4	0.159	0.091 5	0.017 4	0.097 1	0.163
Market capitalization (million Yuan)	<600	29	0.212 6	0.050 5	0.093 2	0.365	0.195 8	0.046 5	0.097 2	0.336
	600–3 000	120	0.212 4	0.032 4	0.079 7	0.301	0.206 3	0.031 2	0.080 9	0.291
	>3000	31	0.196 6	0.019 5	0.077 4	0.212	0.210 1	0.020 6	0.076 3	0.224
Volatility	<25% quartile	45	0.158 6	0.021 2	0.064 4	0.261	0.156	0.020 9	0.064 7	0.257
	25%–90% quartile	117	0.215 0	0.034 2	0.083 1	0.304	0.211 6	0.032 9	0.084 3	0.294
	>90% quartile	18	0.304 6	0.059 1	0.114 8	0.355	0.285 6	0.054 8	0.119 1	0.330
Trading volume (million lots)	<1	39	0.225 8	0.035 7	0.080 1	0.316	0.219 9	0.034 1	0.081 6	0.304
	1–5	115	0.082 2	0.015 1	0.088 7	0.158	0.087 2	0.016 01	0.087 8	0.168
	>5	26	0.014 9	0.004 2	0.141 3	0.032	0.019 4	0.005 4	0.14	0.042
Trading density (times)	<25% quartile	45	0.340 4	0.050 3	0.075 4	0.398	0.330 6	0.047 5	0.078 1	0.38
	25%–90% quartile	117	0.173 7	0.029 6	0.084 6	0.276	0.17	0.028 6	0.085 6	0.267
	>90% quartile	18	0.118 9	0.016 0	0.077 5	0.194	0.119 6	0.016 2	0.077 2	0.197
Trading depth (thousand lots)	< 2.5	29	0.369 5	0.044 1	0.064 3	0.401	0.357	0.041 5	0.067	0.380
	2.5–7	128	0.171 9	0.032 1	0.084 3	0.285	0.168 4	0.031	0.085 5	0.276
	>7	23	0.068 9	0.015 5	0.106 0	0.136	0.074 8	0.016 6	0.104 8	0.147

Note: The unit for adverse selection cost is 0.01 Yuan.

Adverse selection costs are negatively related to company size and stock price. Market capitalization is normally used as a measure of company size. When we re-divide sampled companies into high, medium and low groups according to their market value, we find that relative adverse selection costs from the DNR estimation are 0.019 5%, 0.032 4% and 0.050 5%, and from the GH estimation are 0.020 6%, 0.031 2% and 0.046 5%, respectively. Stocks with larger market value have relatively lower adverse selection costs. We then further divide market value into two factors—the number of floating shares and stock price. We find that stocks with large number of floating shares and higher price have relatively lower adverse selection costs. We thus conclude that stocks of large company and stocks with higher price have lower absolute and relative adverse selection costs.

One thing needs to be noticed is that, stocks with large market value, particularly those high-price stocks, may have relatively large adverse selection costs. For example, from the GH estimation results, the adverse selection costs for large, medium, and small companies (based on market value) are 0.561 3, 0.196 1 and 0.100 8, respectively. To sum up, absolute adverse selection costs are a measurement for single stock using standard prices (more precisely, the average of bid and ask prices) as the comparison criteria. In the sense to maximize investors' revenue, relative costs are more useful and more appropriate for comparison across stocks.[10] Take these into consideration, conclusion draw in this paper about the effects of market value and price on the adverse selection costs are based on their relative values. We find that when market size is measured by the number of floating shares, large companies have relatively lower absolute and relative adverse selection costs in terms of bid-ask spread.

The above findings about the relationship between adverse selection costs and company size, price and volume, volatility are consistent with previous findings (e.g., Merton, 1987; Stoll, 2000; Ahn et al., 2002 and Ahn et al., 2005). Merton (1987) pointed out that larger companies tend to have higher transparency and attract more attention from investors and brokers. As a result, their stock prices are contented with more information, which leads to less information asymmetry. Stoll (2000) also found that stocks of large companies with high prices have relatively low adverse selection costs, however, large company stocks with low price have relatively large adverse selection costs, due to the dispersion of prices

[10] For example, for two stocks with the price of 20 and 2 Yuan, respectively, if their adverse selection costs are 0.1 and 0.05 Yuan respectively, then the adverse selection cost for the 20-Yuan stock is larger than the 2-Yuan stock in absolute value. However, considering that the two stocks have different prices, the above comparison is not very useful for an investor who aims to maximize his investment returns. The relative adverse selection costs for the above two stocks are 0.5% and 2.5% respectively, thus, the 2-Yuan stock has larger (relative) adverse selection cost.

lead to higher volatility and risk and also due to the fact that information disclosure is relatively low. The stocks with larger trading volume have lower adverse selection costs, because the (absolute) adverse selection costs are measured by one unit of trading order. As a result, even if the information hidden does not change, larger trading volume could lead to low adverse selection costs per unit of order. The findings of Ahn et al. (2002) and Ahn et al. (2005) are supportive of the conclusion of Stoll (2000).

6 Pattern of Adverse Selection Costs and Informed Trading during the Day

The variable of adverse selection costs is used to measure the degree the information asymmetry or informed trading in a market. Table 5 demonstrates the estimation results of intraday adverse selection costs. Employing the DNR and GH models and based on the 30-minutes high frequency trading data, we

Table 5 Intraday Adverse Selection Costs and Informed Trade

Period	9:30–10:00	10:00–10:30	10:30–11:00	11:00–11:30	13:00–13:30	13:30–14:00	14:00–14:30	14:30–15:00
DNR Model								
Adverse selection	0.295	0.215 8	0.206 1	0.199	0.204 8	0.1985	0.189 6	0.172 5
Order processing	0.506 7	0.435 2	0.441 9	0.424 9	0.429 1	0.4203	0.419 6	0.446
Adverse selection (%)	0.046 4	0.034 1	0.033	0.031 9	0.032 5	0.0321	0.030 5	0.026 9
Order processing (%)	0.088 8	0.079 9	0.081 4	0.079	0.080 4	0.0785	0.078 9	0.083 2
The weight of adverse selection	0.343	0.308	0.297	0.296	0.299	0.301	0.290	0.254
Implied bid-ask spread	1.308	1.086	1.09	1.049	1.063	1.039	1.029	1.064
Implied bid-ask spread (%)	0.223 8	0.193 8	0.195 8	0.189 8	0.193 3	0.1891	0.188 2	0.193 3
GH Model								
Adverse selection	0.284 3	0.209 9	0.201	0.193 7	0.202 5	0.193 7	0.186 4	0.168 9
Order processing	0.517 3	0.441 1	0.446 9	0.430 2	0.431 4	0.425 1	0.422 7	0.449 6
Adverse selection (%)	0.044 2	0.032 6	0.031 7	0.030 4	0.031 7	0.030 7	0.029 5	0.025 8
Order processing (%)	0.090 9	0.081 4	0.082 7	0.080 5	0.081 3	0.079 9	0.079 9	0.084 3
The weight of adverse selection	0.328	0.296	0.287	0.284	0.292	0.29	0.282	0.245
Implied bid-ask spread	1.319	1.092	1.095	1.054	1.065	1.044	1.032	1.068
Implied bid-ask spread (%)	0.226	0.195 3	0.197 1	0.191 3	0.194 2	0.190 5	0.189 3	0.194 4

Note: The unit price is 0.01 Yuan for the adverse selection cost, order processing cost and implied bid-ask spread.

estimate the value of adverse selection costs, order processing costs and implied bid-ask spread, and try to discover the pattern of intraday adverse selection costs and their causes.

As shown above, the intraday adverse selection costs follow an “L” shaped curve. In the estimates of DNR and GH models, the absolute and relative adverse selection costs and their weights all have the largest value at the time of market opening, then decrease gradually. When divide daily trading into morning and afternoon sessions according to the market trading hours, we find adverse selection costs in both the morning and afternoon session also exhibit an “L” shape. Around the re-opening of the market in the afternoon at 13:00, adverse selection costs increase for a while, then decrease again. So in SSE, private information is mainly gathered in the non-trading hours. At market opening, there are vast informative tradings, but towards market closing, the informative trade is much lesser. At noon interval when the stock market stops trading, private information can also be obtained by some investors.

The intraday order processing costs exhibit a “U” shaped curve. From the estimation results using the NDR and GH models, we observe that the absolute and relative order processing costs are at their highest level during the opening of the market, followed by the period around market closing, hence forming a “U” shaped curve. Such results are similar to our earlier findings for the intraday trading volume, and intraday depth, which give more evidence that order processing costs do not strictly follow the economies of scale.

The “L” shape of adverse selection costs indicate that at the market opening, there are lots of informative trading in the market, while towards the closing of the market, informed trading is not as active. Meanwhile, trading activeness exhibits a “U” shaped in the day, with large trading activities around the opening and closing of the market. We therefore conclude that the heavy trading activities at the opening of the market is due to informative trading, while the heavy trading activities towards the market closing is due to liquidity trading.

The implied bid-ask spread exhibits an “L” pattern. From the estimation results, the absolute and percentage implied bid-ask spreads are at their highest level when market is just opened and then decreases to a lower level, forming the “L” shape. Such a finding is similar to the intraday pattern of daily bid-ask spread we has discussed in Section 2. Although the implied bid-ask spread exhibits the same pattern as the adverse selection costs, it differs greatly from the order processing costs pattern. This indicates that adverse selection costs and informative trading are critical determinative factors of the intraday bid-ask spread.

7 Conclusion and Policy Implication

Adopting the DNR and GH models, we decompose in this paper the bid-ask spread of Shanghai 180 Component Index to investigate the relationship between bid-ask spread components and order size, the impact of company size, price and trading activeness and price volatility on adverse selection costs, and the intraday pattern of adverse selection costs and informative trading as well as their causes. Our main findings are: adverse selection costs are positively related to order size, whereas order processing costs do not show obvious feature of economies of scale; large companies with higher share price have relatively lower adverse selection costs, and adverse selection costs are negatively related to trading activeness and positively related to price volatility; intraday adverse selection costs exhibit an "L" shape, with large trading volume at the opening of market caused by informative trading and large trading towards the closing of the market caused by liquidity trading.

Our findings have great implications on increasing the effectiveness and liquidity of China's stock market: (1) The larger the trading volume, density and depth, the more extensive the trading activity, and the lower the adverse selection costs. Hence, educating the institutional investors and attracting more individual investors to participate in securities trading could increase the trading volume, density and depth, reduce the asymmetric information and increase the effectiveness and volatility; (2) We shall increase the transparency of the information disclosure of the aggregate auction market opening mechanism. As noted, stock trading is usually more active at market opening and closing. The main reason behind active trading at market opening is informative trading, whereas the main reason behind active trading at market closing is liquidity trading. Private information is gathered in the non-trading hours. Following the aggregate action mechanism at market opening, SSE is almost completely closed to investors during the auction period. This is probably one of the main reasons for the active trading at the opening of the market. Increase in information disclosure can reduce the asymmetric information at the beginning of the trading and increase the effectiveness of the stock opening price; (3) Currently, SSE uses 0.01 Yuan as a minimum price per unit quote. Due to the fixed tick size, dispersion of stock price and other reasons, the stocks with lower price tend to bear more risk, which will lead to low liquidity and high adverse selection costs of these stocks. We can refer to the practice in Hong Kong and Japan stock market to set different unit quote prices according to stock prices, so as to enhance the efficiency of market information; (4) To widen the channels of information flow and strengthen the information disclosure mechanism. Another reason for the low price stocks have relatively high adverse selection costs is that investors pay less attention to these stocks and there are lack of disclosure of these companies. Therefore, enhancing the supervision of information disclosure is of paramount importance.

Deficiencies are also included in this study. For example, we do not calculate the inventory holding costs in bid-ask spread, nor do we discuss the dynamic relationships between the components of bid-ask spread and the factors affecting them. Both need to be further improved in studies of the future.

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