

Pricing Dynamics and Risk Taking in Partially Segmented Incomplete Markets

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Abstract

I examine the dynamic pricing of multi-listed equity shares from the universe of Chinese companies traded in mainland China (A-shares) and Hong Kong (H-shares). Even though each equity pair represents the identical claims to the residual earnings of a single entity, which the investors are entitled to same dividends and voting rights from either share class, persistent and time-varying differences are priced in the majority of such shares.

In this paper, I provide a review of the extant literature, and subsequently I describe and analyze how different local market environments affect the cross-market A-H share price disparity. Differing from the theory proposed in Heaton and Lucas (1994), I argue the contrary and empirically test whether market incompleteness, notably evidenced by the lack of financial innovations and the capital account restrictions in mainland China, *lowers* the equity risk premia in the mainland market on an aggregate level. Drawing from the conjecture in Fernald and Rogers (2002), I show that the variation in the aggregate A-H share premia can be explained by the risk profiles of alternative investment vehicles in mainland China. Finally, using a unique account-level brokerage data-set, I extrapolate the contributions of noise-driven investors to idiosyncratic mis-pricing through event-driven studies.

Keywords: China, emerging markets, empirical asset pricing, equity risk premium, market incompleteness, noise trading, portfolio optimization, and twin shares.

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1 Introduction

1.1 Theory of Arbitrage

Classical finance theory states that multi-listed shares issued by a single corporate entity, which entitle shareholders to identical cash flow and voting rights, should trade at the same price in the equilibrium. Ideally, arbitrageurs can effectively take risk-less profits through correcting the “spread” of those mis-priced securities, and during such risk-neutral processes the price disparity among multiple shares will disappear quickly. Even in the absence of arbitrage opportunities, activist investors and controlling shareholders are incentivized to drive up the demand for the discounted shares, and consequently they push the multi-listed share prices to converge in the long run. Financial innovations, such as the emergence of high-frequency trading, help facilitate faster convergence and likely improve the informational efficiency of the financial markets.

Recent literature has focused on examining the applicability of “the law of one price” to the financial markets worldwide, particularly to those that are not fully internationally integrated. Empirical evidence shows that arbitrage in segmented markets is often difficult, hence resulting in identical shares having different prices. Lamont and Thaler (2003) document that the ADR of Infosys, an Indian information technology corporation, once traded at a 136 percent premium to its local Indian counterpart. American depositary receipts (ADRs) are essentially certificates traded in the U.S. that represent the foreign shares purchased by U.S. banking institutions. To increase their exposure in specific foreign equities, U.S. investors primarily hold ADRs (and foreign ETFs or index funds traded in the local exchanges) since investing directly in foreign markets is normally cumbersome. Due to the limited supply of comparable Indian equities in the U.S. during that stage, a significant premia for Indian shares were priced in the U.S. market as the choice set and risk appetite of a representative investor in the U.S. was very different from those of an ordinary Indian investor. Indian investors could easily find substitutes or create instruments to replicate the risk payoffs of Infosys, whereas American investors could not do so. The “exotic” nature of an Indian company also provided desirable risk diversification for U.S. portfolios because of its low or even negative correlation with the overall U.S. market.

In addition to the aforementioned case of heterogeneous supply and demand in segmented markets, many other exogenous frictions in the financial markets can hamper arbitrage. Examples from previous literature have delved into analyzing the effects of transaction costs, short-selling limit, etc on the behavior of stock prices. Rosenthal and Young (1990) examine the mis-pricing of twin shares, specifically Royal Dutch/ Shell and Unilever N.V./Unilever PLC. After factoring in the cost of financing and country-specific tax obligations, inter-market pairs-trade became profitless. Mei, Scheinkman and Xiong (2009) analyze the joint effect of short-sales constraints and heterogeneous beliefs on the Chinese A-B shares discount. Because of the short-selling restriction in mainland China, the marginal buyer in the domestic A-shares market had a tendency to be overconfident. The theory of resale option in Harrison and Kreps (1978) implies that under such environment, the optimistic investors are incentivized to speculate, and hence they drive the stock price above the fundamental level, whereas pessimistic investors can only be bystanders, being unable to accurately price their views in the share price.

Absent the exogenous frictions in the financial markets, behavioral finance theory shows that arbitrage fails nevertheless. An agency model developed by Shleifer and Vishny (1997) argues that arbitrage is mostly conducted by professional performance-based institutional traders, who manage outside capital and are subject to idiosyncratic risks. A large deviation in the tail risks deter arbitrageurs from executing profitable strategies due to the prospect of position liquidations from potential widening of the gap, which can result in investors' ensuing redemption. Such setting is similar to a bank run, where one needs to consider an endogenous risk that grows within the system. To vindicate their reasoning, one can look at Long-Term Capital Management during the Russian and Asian financial crises. Once a successful long-short hedge fund, LTCM was forced to confront a large marginal call on its highly levered positions, and the situation exacerbated as the fund investors continued to retreat. As the two events happened simultaneously and positively interacted with each other, LTCM incurred tremendous losses and eventually went bankrupt.

1.2 China's Financial System

China's domestic stock market was unique for its segmented A-B twin shares structure during the last decade of the 20th century. Representing the same rights to a company and traded on the

same exchange, A-shares, denominated in CNY, could be bought and sold by mainland Chinese investors only, whereas B shares, denominated in USD or HKD, were available to foreign investors only. The tax treatment was more favorable for foreign investors, due to an effort to attract foreign capital investment during China's initial transition to a partially capitalist economy. In fact, foreign investors had been exempt from capital gains and dividend taxation for a very long period of time. Yet astoundingly, B-shares overall had traded at a persistent discount to A-shares, and at the same time B-shares were very illiquid, despite the preferential treatment status. This puzzle has been documented in various literature that aims to resolve the abnormal phenomenon.

Other than issuing B-shares, the majority of which have now been delisted due to the lack of trading activity from market participants, blue-chip Chinese companies primarily list their shares overseas in Hong Kong (known as H-shares) to raise foreign capital. H-shares enjoy the same cash flow and voting rights as their A-shares counterparts, but the two different share classes are usually different in the timing, pricing and size of the equity offerings, and most notably, in the corporate actions such as share buyback and stock-split decisions. H-shares can be held by any individual investor with brokerage accounts in Hong Kong, as well as foreign institutional investors. Started in 2002, the introduction of Qualified Foreign Institutional Investors program allowed investors based outside of China to invest directly in A-shares, while under some quota restrictions. Hence, the A and H markets are partially segmented, and inter-market arbitrage is viable.

In terms of the rules for participants, Chinese mainland market employs more stringent requirements in trading arrangements. 1) Mainland securities regulators employ a circuit breaker that triggers a mandatory bound of accepted trades when price swings hit beyond 10% of the daily opening price. 2) In Hong Kong, dealers are allowed to engage in intraday trade for clients, whereas in mainland T+0 trades are not allowed, with the exception of exchange traded-funds. 3) In mainland, bans on short-selling and leverage have been recently lifted, but investors are faced with higher margin and settlement requirements. Such requirements are much more relaxed in Hong Kong. 4) Dividends in A-shares are always subject to a 10% withholding rate for mainland residents, who have long dominated the turnover in such shares, yet all investors in H-shares had been universally exempt from such requirement until the mid of 2011.

Comparing the market regulations, a rational person should be able to deduce that A-shares would trade at discounts to H-shares. Since the investors in China A-shares are exposed to various restrictions, on average they should demand premia in the asset returns to compensate the risk in holding such securities. In other words, the stocks should trade at lower prices in mainland China than in Hong Kong, *ceteris paribus*. On the contrary, A-shares have historically traded at premia, despite the unfavorable market conditions.

<Figure 1: AH Premium Index>

1.3 Incomplete Markets

Heaton and Lucas (1994) evaluate the effects of market incompleteness on equity risk premium. Specifically, they found that when the extent of trade is limited by large transaction costs such as short-sales/leverage constraints and the supply of tradable securities, agents require a higher equity risk premium. Behaviors of asset prices in many emerging markets tend to agree with their findings. Bailey, Chung and Kang (1999) document large price premia for foreign shares relative to identical domestic shares in developing economies with investment barriers. Thus, the phenomenon in China is distinctly different from other comparable economies and hence requires further investigation.

In my paper, I argue that under regulatory constraints and the existence of noise traders, equity risk premium can decrease with market incompleteness. Two opposing effects occur: the direct effect of market incompleteness, as the lack of financial innovations for hedging idiosyncratic risks and the existence of frictions in financial markets, makes agents demand a premium in the asset return, which would translate to a downward price pressure. However, when faced with limited investment opportunities in a noisy environment, agents in the economy tend to over-invest in risky assets, and indirectly they become risk-takers. Similar to a positive feedback loop as described in DeLong, Shleifer, Summers and Waldmann (JoF 1990), agents trade with each other even if the asset prices deviate from the fundamental risks. Therefore, the required rate of excess return drops, which equates to an upward price pressure.

In the following sections, I provide statistics on the Chinese A-H premium puzzle by using the universe of cross-listed A-H pairs that underwent initial public offering in both markets prior to 2007. Subsequently, I review the relevant literature and discuss whether the conventional wisdom would apply to our study. Then I derive a modified noise trader risk model in DeLong et al (JPE 1990), adding the implications of market incompleteness. The model provides additional insights on the relationship between asset prices, noise trading and market incompleteness in a long run steady equilibrium. Drawing from the conjecture in Fernald and Rogers (2002), I show that the variation in the aggregate A-H premium tracks the risk profile of alternative investment vehicles in mainland China. Specifically, I show empirically that the existence of market incompleteness greatly reduces the excess return of an optimal portfolio strategy for a mainland Chinese representative investor than that for a representative Hong Kong investor, after comparing the performance of a matched sample consisting of securities available in the two markets. Finally, using a unique account-level brokerage data-set, I extrapolate the contributions of noise-driven investors to idiosyncratic mispricing during the split share structure reform.

2 Twin Share Conjectures

Extant literature that focuses on the twin shares puzzle has culminated in various theoretical postulations with implementations of empirical analyses that aim to resolve the pricing dynamics in the cross-listed markets. Here I provide a non-exhaustive list of popular arguments and examine their applicability to our topic of study.

2.1 Information Percolation

Chan, Menkveld and Yang (2008) analyze the contribution of information asymmetry in the China A-B share setting. Using a micro-structure transaction data-set in a narrow time period from 2000 to 2001, during which the purchase of foreign B-shares by domestic residents were illegal, they construct several measures of informational asymmetry between the two perfectly segmented markets, and have found that the level of asymmetry serves as a strong predictor of the cross-sectional variation in the B-share discount, even when controlling for market factors. Setting the

foreign B-share investors as equally uninformed, the proportion of informed investors in domestic A-shares non-monotonically captures the dynamics of the B-share discount: at the initial stage when the privately informed investor base in China is small, the benefit of an increase in the informational advantage for the A-share investors translates to a lower required rate of return in A-shares than in B-shares, hence the B-share discount widens. As the informational efficiency disperses further, B-share investors adapt to the signals from the domestic investors, and such learning effectively dims the “home advantage”, which results in the B-share discount dropping towards the parity level.

The analytical framework applies to the A-H study, where the A-share investors enjoy an informational advantage against the Hong Kong-based investors. However, as we have discussed previously, A-H markets are not strictly segmented, since both Chinese residents and foreign investors could elect to invest in the other market, despite a certain degree of barrier. During the peak of the AH Premium Index in 2007, the premium was so uniformly enormous that rendered the search and agency cost of purchasing H-shares negligible for the A-share investors. Additionally, the transmission of price sensitive information had greatly improved through technological advances as well as an increasing presence of foreign asset managers located within mainland China, thus the assumption that H-share investors were uninformed signal takers would likely not hold.

2.2 Illiquidity Discount

Liquidity, which measures the ease of transaction for both buyers and sellers, plays a role in determining the stock return. Amihud (2002) finds the expected market illiquidity positively affects ex ante stock excess return. Pastor and Stambaugh (2003) find that the expected equity returns are related cross-sectionally to the “liquidity betas” of the stocks. Intuitively, investors in illiquid stocks need to be compensated for higher expected returns, as they face an additional time-varying cost of search for the counter-party. Consequently those investors drive prices downward for the illiquid stocks, *ceteris paribus*. If the mainland China market provides better liquidity for investors, one might suspect that liquidity plays the central role in the discount of Hong Kong shares. Using the sample of cross-listed Chinese A-H shares traded between 2005-2013, during which the market-wide A-H premium kept rallying from 12% to well above 80%, I find that the median difference of the daily liquidity proxy, as measured by the percentage of closing bid-ask spread divided by the

intraday mid price, were indeed uniformly higher in H-shares than in A-shares.

<Figure 2: Bid-Ask Statistics>

Yet it remains a mystery why in the equity screen the Chinese shares provide better liquidity than their counterparts in Hong Kong, despite various stringent rules in the trading arrangements and restrictions of capital account in mainland China. On the other hand, the cross-correlation between the difference in liquidity and historical stock returns is not significant. If one argues that the inflated price in China is due to liquidity improvement from fundamental underlying changes during emerging market transitions, for which the price impact is smaller given the same order size, we should expect the difference in excess returns of H-shares minus A-shares to be positively affected by the overall excess liquidity from China. However, the liquidity premia in China stayed relatively constant, whereas the difference in the equity returns between the two markets were extremely volatile.

<Figure 3: Liquidity Premium vs. Equity Index Return Differentials >

2.3 Short Selling Restrictions

Speculative bubbles arise from the investors' inability to sell shares short. Scheinkman and Xiong (2003) present a model in which overconfidence generates disagreements among agents regarding asset fundamentals. In an environment with short-sale constraints, a premium from the implicit option to sell to other optimistic buyers in the future is priced into the asset, since the pessimistic traders do not participate in the market. Similar to the setting in our study, investors were not allowed to short A-shares until the beginning of a pilot program in early 2013. Though the short-selling ban may serve to explain the A-H premium, after government lifted the ban, some A-H shares saw neither convergence nor reversal in their price levels.

<Figure 4: Price Relationship Pre- and Post-Removal of Short Selling Ban>

To justify the insufficient price reversal after the implementation of A-shares short-selling, one should note that the securities lending fee is set to a uniformly high level by mainland Chinese regulators. At the time of writing this thesis, the securities borrowing fee for shares listed in Shanghai Stock Exchange stands at 10.6% per annum, with initial margin at 150%, maintenance margin at 130% and release margin at 300%. To give a simple example of the extent of short-sales cost, suppose an investor short sells 1000 shares at a price of \$5 per share. To get started, he will need to post collateral worth half of the short sell proceeds, which is equal to \$2500. Once the price of the shorted security rises above \$5.77, and for the sake of illustration, to \$6 per share, the investor needs to put in an additional \$300 to keep in line with the 150% margin. If the stock price moves down, which is in favor of the investor, he may withdrawal the collateral only when the share price drops below \$2.5 per share, while keeping the margin no less than 300%. On top of the margin requirements, short-sellers pay an additional annualized fee of 10.6% for the outstanding borrowed shares on a daily basis.

Apparently, imposed with such strict requirement, a short-seller needs to be convinced that the stock price will plummet to an extraordinarily low level in order to make the short position worthwhile. Hence, China's short-sales constraint, which is a form of market incompleteness, indeed provides some evidence on the seemingly low expected return in the A-share market.

3 A Modified Noise Trader Risk Model

In light of the market structure and trading behavior in the mainland China market, I introduce a theoretical model that aims to more accurately capture the pricing dynamics in the cross-listed A-H shares. The previous review of extant literature shows that short-selling restriction, a form of market incompleteness, may help explain the premia in A-shares observed over time. But it remains to resolve the puzzle of better liquidity provision among A-shares, despite unfavorable market conditions in China. I resort to the previous research of noise traders, whose presence can sustain an elevated price level, and whose superior excess return can rationalize the increased level of trading despite more optimal conditions in another market.

3.1 Model

The model follows from the celebrated noise trader risk model in DeLong, Shleifer, Summers and Waldmann (JPE 1990). Additionally, I examine the behavior of equilibrium asset pricing as well as the composition and excess return of noise traders with the consideration of market incompleteness. Intuitively, when the alternative asset other than the risky asset yields a poor return, the investor will have a difficult task in the portfolio optimization. Such form of market incompleteness, when the alternative asset becomes undesirable, is the key to our analysis. More notably, such situation is directly applicable to China's A-share market, in which the investors could earn essentially a rate of zero on the deposits, and few financial instruments other than stocks were available to them. We consider a two-state overlapping generations model, during which the agents make investment decisions in the first period and consume in the second period.

- Both agents exhibit constant absolute risk aversion (CARA), whose utility can be specified by the functional form $U(x) = -e^{-2\lambda \cdot x}$, where λ is the agent's coefficient of absolute risk aversion.
- Two types of securities are available in the financial market. A risk-free asset with fixed price equal to 1, denoted as B , pays a fixed real dividend r_f , and is in perfect elastic and infinite supply, meaning that each unit of it can be converted into a unit of consumption goods in the second period. One can think of B as a short-term financing instrument such as a Treasury bill with low maturity. One risky asset denoted as S , with price P_t and normally distributed log-return $R_t = \ln(\frac{P_t}{P_{t-1}})$, pays a fixed real dividend $r_d \gg r_f$, and has a fixed supply normalized to 1. Correspondingly, one can think of S as a dividend-paying stock, and during each generational shift, the issuer makes no changes such as stock split or buyback to the equity base.
- Regarding the agents in the economy, a proportion $0 < \mu < 1$ of them are noise traders, who have an additional mis-specified prior $\rho_t \underset{i.i.d.}{\sim} N(\rho^*, \sigma_{\rho_t}^2)$ on the distribution of P_{t+1} of S . The remaining agents are rational traders with the correct pricing for P_{t+1} . We also assume that σ_{ρ_t} is a monotone decreasing Cauchy sequence such that $\lim_{t \rightarrow \infty} Pr(|\rho_t - \rho| \geq \epsilon) = 0$

for $\forall \epsilon > 0$ and $\rho \sim N(\rho^*, \sigma_\rho^2)$ with σ_ρ^2 small. In other words, the mis-pricing converges to a point value ρ^* in the long run equilibrium. Intuitively from a practical standpoint, the variance in the mis-specified prior belief shrinks as time progresses, as noise traders learn about the “wisdom of the crowd” through information diffusion. Therefore, the distribution of ρ_t becomes increasingly concentrated at the theoretical mean ρ^* .

3.2 The Optimization Problem

It follows from the normality of R_t and ρ_t that the wealth W of either type of agent is normally distributed. With regard to the expected utility

$$E[U(W_t)] = \int_R f(x) \cdot U(x) dx, \quad f(x; \mu, \sigma^2) = \frac{1}{(2\pi\sigma^2)^{1/2}} \cdot e^{-\frac{(x-\mu)^2}{2\sigma^2}},$$

one can directly calculate that $E[U(W_t)] = -e^{-2\lambda\mu+2(\sigma\lambda)^2}$. Then, affine and monotonic transformations show that both agents maximize an equivalent expected utility function given by

$$E_t[U(W_{t+1})] = \mu - \lambda\sigma^2, \quad W_{t+1} \sim N(\mu, \sigma^2).$$

For the rational trader, subscripted as r , he solves

$$\max_{\omega_r} E_t[U(W_{t+1}^r)] = E_t[W_{t+1}^r] - \lambda \text{Var}_t[W_{t+1}^r],$$

where $W_{t+1}^r = \omega_r(r_d + P_{t+1}) + (W_t^r - \omega_r P_t) \cdot (1 + r_f)$.

Taking the F.O.C. w.r.t. ω_r yields

$$\omega_r = \frac{r_d + E_t[P_{t+1}] - P_t(1 + r_f)}{2\lambda \text{Var}_t[P_{t+1}]}.$$

For the noise trader, subscripted as n , he solves

$$\max_{\omega_n} E_t[U(W_{t+1}^n)] = E_t[W_{t+1}^n] - \lambda \text{Var}_t[W_{t+1}^n],$$

where $W_{t+1}^n = \omega_n(r_d + P_{t+1} + \rho_t) + (W_t^n - \omega_n P_t) \cdot (1 + r_f)$.

Taking the F.O.C. w.r.t. ω_n yields

$$\omega_n = \frac{r_d + E_t[P_{t+1}] - P_t(1 + r_f) + \rho_t}{2\lambda \text{Var}_t[P_{t+1}]}.$$

3.3 Equilibrium Price For the Risky Asset

By the market clearing condition for S , $\mu\omega_n + (1 - \mu)\omega_r = 1$, it follows that

$$P_t = \frac{r_d + E_t[P_{t+1}] - 2\lambda \text{Var}_t[P_{t+1}] + \mu\rho_t}{1 + r_f}. \quad (1)$$

In a steady-state equilibrium, $E_t[P_{t+1}] = E_{t+1}[P_{t+2}]$ and $\text{Var}_t[P_{t+1}] = \text{Var}_{t+1}[P_{t+2}]$. Hence, it follows from recursion and the law of iterated expectations that, for sufficiently large t ,

$$E_t[P_{t+1}] = \frac{r_d - 2\lambda \text{Var}_t[P_{t+1}] + \mu\rho^*}{r_f}. \quad (2)$$

$$\text{Var}_t[P_{t+1}] = \left(\frac{\mu}{1 + r_f}\right)^2 \sigma_{\rho_t}^2. \quad (3)$$

Finally, by plugging in (2) and (3) into (1), the equilibrium pricing function for S at time t is given by

$$P_t = \frac{r_d}{r_f} + \frac{\mu(\rho_t - \rho^*)}{1 + r_f} + \frac{\mu\rho^*}{r_f} - \frac{2(\mu\sqrt{\lambda}\sigma_{\rho_t})^2}{r_f(1 + r_f)^2}. \quad (4)$$

By the assumption of convergence in probability of ρ_t , the long run pricing for the risky asset converges to

$$P_t \xrightarrow{p} \frac{r_d}{r_f} + \frac{\mu\rho^*}{r_f} - \frac{2(\mu\sqrt{\lambda}\sigma_{\rho})^2}{r_f(1 + r_f)^2}. \quad (5)$$

3.4 Interpretation of the Equilibrium Price For the Risky Asset S

Equation (5) provides the pricing function of the risky asset S in the long run equilibrium. Note it also gives the correct pricing for S in the absence of noise traders, that is, when $\mu = 0$,

$$P_t \xrightarrow{p} \frac{r_d}{r_f} \quad (6)$$

More importantly, equation (5) depicts a nonlinear relationship between the risk-free rate and the equilibrium price of S .

- If ρ^* is positive, meaning that the noise traders are mistakenly bullish on the risky asset, the second term in (5) $\frac{\mu\rho^*}{r_f}$ captures a positive component in P_t , which increases i) when the risk-free rate r_f decreases, ii) when the proportion of the noise traders increases, or iii) when the bullishness of noise traders as measured by ρ^* increases. This corresponds with our hypothesis that when the alternative asset becomes less desirable, as in the form of decreasing r_f , with the presence of optimistic noise traders, they “over-invest” and push the expected return on the risky asset S down. This translates to an upward price pressure.
- The third term in (5) captures the effect of the risk generated by the variance of the mis-specified belief σ_ρ of the noise traders. A large variance translates to the possibility that the noise traders have been completely mistaken with the direction of P_{t+1} . Such effect exacerbates i) when μ increases or ii) when λ increases. Hence in such situation, both type of traders demand a higher expected return, which translates to downward price pressure. Fixing μ and λ , as r_f decreases, i.e. when the market becomes more incomplete, a larger negative component is priced into P_t . In other words, consistent with Heaton and Lucas (1994), both type of agents require a higher expected return when faced with market incompleteness.

Since we have assumed in the long run equilibrium, that $\lim_{t \rightarrow \infty} Pr(|\rho_t - \rho| \geq \epsilon) = 0$ for $\forall \epsilon > 0$ and $\rho \sim N(\rho^*, \sigma_\rho^2)$ with σ_ρ^2 small, the second effect (-) is dominated by the first effect (+). Hence, our theoretical analysis indicates, with the presence of noise traders who share a mis-specified belief

that concentrates to a “narrow” normal distribution of positive value in the long run equilibrium, the expected return of a risky asset decreases. Indeed, it indicates that a relatively elevated price level of the risky asset can be well sustained in an incomplete market dominated by bullish noise traders.

3.5 Asymptotic Proportion of the Noise Traders

One may wonder the relationship between the proportion of noise traders and the other variables in the equilibrium. Examining equation (5), one can solve for u , the proportion of noise traders, by setting up a quadratic equation in terms of μ . More importantly, we are interested in the asymptotic behavior of μ when the market is incomplete. By the sending $\frac{r_f}{r_d} \rightarrow 0$, we mimic an asymptotic environment of incompleteness measured by the *relative* unattractiveness of the risk-free asset over the risky asset. The closed-form solution is given by

$$\mu \sim \max \left[\frac{\rho^* + \sqrt{(\rho^*)^2 + 8\lambda\sigma_\rho^2 r_d}}{4\lambda\sigma_\rho^2}, 1 \right]. \quad (7)$$

Equation (7) provides some promising insights. First of all, μ does not depend on the magnitude of the equilibrium price, nor on that of the risk-free rate r_f . The presence of irrational traders μ slowly increases at the order of square root of r_d . It also monotonically increases in ρ^* as expected, since a higher average bullish view shared by the noise traders indicates a higher likelihood for them to enter the market. Lastly, most important of all, though λ and σ_ρ^2 monotonically decrease in μ , the small equilibrium value of σ_ρ^2 guarantees that an arbitrarily large μ can be achieved even by a high risk aversion λ . This means that for almost all possible levels of the risk aversion shared by both type of traders, in the long run the noise traders dominate the trading volume in the market. Such property is in line with the empirical fact that in the much “more incomplete” mainland China market, though investors are generally considered to be “culturally” risk averse, from time to time we witness an enormous amount of evidence showing sustained irrational trading conducted by the mainland investors. This at least partly corroborates with the excess liquidity in cross-listed shares provided by the mainland Chinese A-shares.

3.6 Excess Return by the Noise Traders

The expected excess return, which measures the per unit return on the risky asset S over the risk-free asset B , can be written as

$$\frac{E_t[W_{t+1}] - W_t(1 + r_f)}{\omega} = r_d + E_t[P_{t+1}] - P_t(1 + r_f). \quad (8)$$

However, since the rational traders and noise traders hold different ω units of risky assets, we calculate the difference in excess returns by using

$$(\omega_n - \omega_r) \cdot [r_d + E_t[P_{t+1}] - P_t(1 + r_f)], \quad (9)$$

and take the unconditional expectation yields

$$E \left[\rho_t - \frac{\rho_t^2(1 + r_f)^2}{2\lambda\mu\sigma_{\rho_t}^2} \right] = \rho^* - \frac{[\sigma_{\rho_t}^2 + (\rho^*)^2](1 + r_f)^2}{2\lambda\mu\sigma_{\rho_t}^2}. \quad (10)$$

Hence, in the long run equilibrium, difference in expected excess return is

$$\lim_{t \rightarrow \infty} E \left[\rho_t - \frac{\rho_t^2(1 + r_f)^2}{2\lambda\mu\sigma_{\rho_t}^2} \right] = \rho^* - \frac{[\sigma_{\rho}^2 + (\rho^*)^2](1 + r_f)^2}{2\lambda\mu\sigma_{\rho}^2}. \quad (11)$$

Judging from the expression, the irrational traders can indeed achieve a higher excess return if the above term in equation (11) is positive. When μ is large enough, the advantage is obviously greater for noise traders as their belief, though incorrect, overwhelmingly influences the movement of the stock price. Moreover, a larger risk aversion coefficient λ , shared by both types of the traders, decreases the negative component in the second term, hence raising the expected excess return of the noise traders over that of the rational traders. Intuitively, as the traders become more risk averse, those with rational beliefs have less incentive to trade in the market, thus their reduced demand push down the price for the risky asset S . This translates to gains of the noise traders, who pocket the discounted shares and cumulatively profit from the transitory positive returns. Note also that when the market is incomplete, r_f is quite small. Hence, the negative term similarly decreases and the noise traders are again winners. All of the observations match pretty well with the empirical evidence in China, where the people are considered to be risk averse and the financial

market is comparatively incomplete, yet at the same time a heavy volume of irrational trading persists. Hence, the excess return differential analysis generates theoretical foundation on why the Chinese mainland investors form a “preferred habitat” in their home market, despite the possibility of diversifying their portfolio holdings to the Hong Kong market.

4 Empirical Analysis

In the following section, I design econometric specifications to identify the effect of market incompleteness on the pricing dynamics in the A-H twin shares. We are interested in studying whether the lack of alternative financial instruments and the presence of market frictions hamper the optimal selection in the portfolio optimization process for a representative mainland Chinese investor. Moreover, we would like to employ events of exogenous policy change to quantify how noise trading affects the level of mis-pricing in mainland China A-shares. We treat H-shares as a baseline for fair value pricing, based on the evidence that the corresponding ADRs in the United States closely track the local H-shares. Based on the findings in our theoretical model, I test the following hypotheses:

- H1 (“Equity Risk Premia”: Incompleteness on Asset Pricing): Controlling for a set of A-H equity pairs, a representative mainland Chinese investor exhibits a lower expected rate of excess return per unit of risk in the portfolio. Such differences in the levels of excess return converge when the relative market-level frictions become less outstanding in mainland China.
- H2 (“Survival”: Incompleteness with Noise Traders): Noise trading is prevalent during periods of severe market incompleteness, and noise-induced idiosyncratic shocks elevate the price level in A-shares persistently.

4.1 H1: Equity Risk Premia

Equity risk premium measures the expected excess return that a risky asset, such as an equity, provides over a risk-free asset, such as a short-term Treasury bill. Since a normal risk-averse investor

generally prefers the certainty equivalence of a risky payoff, a higher equity risk premium means that a larger compensation is needed for the investor to be indifferent between the risk-free asset and the risky asset. Correspondingly, the price of the risky asset should be lower to generate a higher return for the investor. Though the definition is easy to intuit, it is empirically difficult to calculate the true equity risk premium. To correctly do so, one would need to accurately estimate the expected return on the equity. Given the idiosyncratic and systemic risk components in the observed price level, historically it has always been a daunting task to obtain consistently reliable measures. Additionally, one may not always be able to find a financial instrument that is risk-free. Situation in the United States is easier to deal with, since the federal government debt has long served as a safe haven during times of financial turmoils. In emerging economies like China and Hong Kong, government debt is considered risky, given the inherent geopolitical and the currency convertibility risk. Hence, in order to calculate the required rate of excess return for equity investors in China, we need to construct a better measure.

In light of the situation in China and the difficulty with predicting expected return of equities, I use the *realized* information ratio to better gauge the excess rate of return for a representative mainland Chinese investor. The definition of information ratio is given by

$$IR = \frac{E(r_{portfolio}) - E(r_{benchmark})}{\sqrt{Var(r_{portfolio} - r_{benchmark})}},$$

which is the expected excess return of the portfolio over the market benchmark, divided by per unit of risk, expressed as the standard deviation of the excess return. Such measure circumvents the need for a risk-free rate, and the *realized* IR is able to provide an excellent estimate of the *upper bound* of the excess return over the market, which can be close to the expected rate of return, if the method of portfolio optimization is *sufficiently optimal*.

Lai, Xing and Chen (2011)¹ suggests a nonparametric empirical Bayesian approach (NPEB) of portfolio optimization that generates substantial improvement over the mean-variance modern portfolio selection theory introduced by Markowitz (1952). The NPEB method reformulates the optimization problem in a Bayesian learning framework based on a a training period, in our case,

¹Please see Lai et al (2011) Section 6.3 for a similar empirical study.

composed of a rolling window that spans 12 weeks of log equity excess return, and after which the algorithm employs stochastic optimization to generate optimal portfolio weights in each of the following test periods. Theoretically the procedure requires virtually not any specialized view on the equity performance, yet by using only equity and index return data series, a sizable cumulative excess return can be achieved over time. Considering the nice features of the algorithm, I design a study based on the NPEB optimization to measure the representative risk premia in the two markets.

<Insert Lai et al (2011) Chart>

4.1.1 Description of the Data and Econometric Specification

In order to measure the risk-adjusted optimal excess return difference between representative investors in mainland China and Hong Kong, I screen and record the weekly log return for a sample of cross-listed A-H shares that underwent IPO in both markets prior to 2006, and add to each portfolio alternative investment instruments available in the respective market. In regards to the criteria of equity screening, I use a combination of 10 A-H pairs that span various levels of performance, industry, market capitalization and ownership type. I also ensure the data richness of the candidate companies, such that only companies with less than 10 missing price data during our study period from mid 2005 to mid 2010 are considered. I also obtain the corresponding return series for the market indices in both markets, where Shanghai Shenzhen 300 Index is used for China and Hang Seng Index for Hong Kong, to calculate the log weekly excess return.

To effectively model the alternative financial instruments available to investors in the two markets, I search for the most actively traded non-vanilla equity products during our study period. The Chinese portfolio consists of 4 instruments: the only index ETF (China 50), the only small-mid cap growth focused closed-end fund (Hanxing), the only large-cap blend focused closed-end fund (Jinxin) and the spot gold bullion contract traded in Shanghai commodities exchange. The Hong Kong portfolio also consists of 4 instruments: Hang Seng H-Share Index ETF, Tracker Fund

ETF, S&P 500 ETF, and the spot gold bullion contract traded worldwide. Even though Hong Kong provided way more alternative products than China did at the time, we choose comparable products to mimic similar choice sets in the two markets. Note by construction, the Chinese investor's portfolio is inevitably less diversified, due to the lack of any market wide-index ETFs, foreign investment products, and globally fair-priced commodity contracts.

I also factor the effects of market incompleteness, as in the form of trading and ownership restrictions, into our optimization. Specifically for the China portfolio, I impose a zero lower bound on short-selling and a 20% upper bound for individual instruments. For the Hong Kong portfolio, investors are allowed to short sell at most 30% and buy long at most 40% of individual instruments. Such rule is in line with the short-selling ban implemented in China during our study period, whereas the restriction on lower ownership in the China's portfolio reflects the limited supply induced by the shareholding structure in China. Unlike Hong Kong H-shares, China A-shares are segmented into publicly tradable shares and non-tradable state shares. During our time span, a high proportion of non-tradable shares existed virtually in all and primarily state-controlled enterprises, the motive of which has been often deemed as a political effort by the central government to retain grasp of the key sectors in China.

4.1.2 Findings on the Risk-adjusted Excess Return Difference

The results from the optimization show much higher *realized* rate of excess returns per unit risk, i.e. the information ratio, for the Hong Kong's portfolio, standing at a weekly average of 0.132 and median of 0.103 . Any specification of a two-sample comparison test provides irrefutable evidence that the average IR in China is much lower. However, post mid of 2007, we can spot a significant convergence in the excess return of the two portfolios. Prior to June 2007, the measure of information ratio in China is almost always much lower, with extremely large differentials during Feb-July 2006 and Oct 2006-April 2007. Such trend is somewhat indistinguishable during 2008, even with some reverse relationship in the second quarter of 2008. On the other hand, the average empirical risk aversion coefficient exhibited by a representative Chinese investor is lower, with a *p-value* of less than 1%.

<Figure 5: A-H Portfolio Information Ratio Difference>

Regarding our hypothesis H1, the NPEB method provides an empiricist's viewpoint of how market incompleteness affects the *risk-adjusted realized* excess return in China, after controlling for the fundamentals of financial instruments. During our period of study, mainland Chinese investors had to endure much inferior information ratios, yet such disadvantage seems to wane as time progresses. Such dynamics in the behavior of asset returns are consistent with the history of financial regulation and innovation in China at the time.

To begin with, China started to implement the share split reform in 2006, accompanied by extended negotiations between the shareholders and company management, which would later gradually free up significant portions of non-tradable shares held by government entities to the general public. As the float shares increase in the market, the ownership restriction imposed on ordinary investors is less severe. As a result, the equity prices would adjust to their fair value, allowing for higher returns in A-shares. Secondly, starting in 2007, many financial innovations were introduced that reduced the relative incompleteness of the Chinese mainland market. A variety of new sector- and index-specific ETFs managed by private asset managers flourished in the equity market. In June 2007, the first put warrant with cash settlement was introduced and listed in the Shanghai Stock Exchange. Put warrants essentially serve as insurance against potential downside risks in equities, hence they provide favorable investment channels for short-sellers that are bearish on the stock market. Shortly later in July 2007, China first implemented the centralized fixed-income electronic trading platform, where investors could finally bid for government and corporate bonds in an efficient and cost-saving manner. In consideration of the development in the “completion” of financial market in China, the empirical evidence agrees with H1 that as the cross-market completeness converges, the per unit risk return in Chinese A-shares rises to the levels in Hong Kong H-shares.

4.2 H2: Survival of Noise Traders

Given the evidence that market incompleteness in China indeed diminishes the realizable excess

return for Chinese A-share investors, we check whether noise trading, primarily those conducted by bullish traders, is prevalent in mainland China as predicted in Section 3.4. Further, according to our theoretical model, we would like to quantitatively determine whether such trading behavior can indeed be held responsible for upwardly distorting the price level in A-shares.

Note the identification of the presence and the effect of noise trading is an arduous task for a couple of reasons. Due to many unobservable factors in the financial market, typically one needs to test various strong assumptions to account for the potential endogeneity in the observational data. In other words, activities that are seemingly like noise trading may in fact be rational trading in disguise. Alternatively, one could utilize expertise and knowledge regarding the market condition to acquire substantial support for economic reasoning. For an example, we can make use of an exogenous policy change in the financial market, and compare the pre and post trading behavior between those affected by the policy and those not, provided that the two groups are very similar in nature, and no other significant events occur at the same time. Essentially, the identification is transformed from an observational study to the quasi-experimental framework.

4.2.1 Presence of Noise Trading

Noise trading in China has been documented in various literature. Xiong and Yu (2011) examine the deep out-of-the-money put warrants in China, which had essentially value equal to zero, yet were traded at inexplicable inflated prices and enormous turnover. Due to the finite maturity and predetermined strike price of a warrant contract, one can easily determine the bound of a put warrant's worth based on the market price of the underlying stock, if the term is near maturity and the stock price is sufficiently away from the strike price. In one case, investors traded a put warrant (Wuliangye), that was certain to expire worthless, for *2 billion* USD on a single day. Similar exorbitant trading behavior in the mainland China market is also documented in other literature. Mei et al (2009) record an average monthly turnover for Chinese A-shares at *47.4%* from 1993-2001, which translates to *569%* per annum. In other words, on average each floating A-share outstanding was traded *5.7* times every year.

<Insert Chart for Xiong and Yu (2011): Wuliangye Put Warrant>

4.2.2 Quasi-Experimental Design

To identify the presence of noise trading and its corresponding effects in the share price level in China, I employ an event-driven study that is unique for mainland China. The aforementioned share split reform naturally serves as an event to study potential noise trading, provided if the compensation plan is denominated only in bonus shares. This is because a pure equity split does not in any way change the earnings per share (EPS) held by the equity investors, but if we could detect irregular trading after the announcement of the compensation plan, we then have signs that investors carry a mis-specified belief, holding other factors constant. So why would a compensation plan be needed in the first place, if such event does not affect the EPS for current shareholders? In hindsight of early 2006 when most of such reforms were carried out, the media, investors and controlling shareholders all together appeared to deem the share split as bad news for the current holders of float shares. The convention was that the release of non-tradable shares would have a dilutive effect through the increase of supply, which was totally misguided since any type of shares enjoyed the same cash flow and voting rights, and not a single new share was created to change the capital base.

Given an exogenous share split event, I use a difference-in-difference method for the identification of noise trading. Specifically, I study the volume, price and value-traded, which were recorded on a transaction-by-transaction basis from a special brokerage data-set², during a two-week span before and after the share split announcement of Huadian Power on June 23th, 2006. To identify whether noise trading happened after the announcement, I select Huaneng Power as the control. Huaneng and Huadian are considered as substitutes, both of which are the part of the “Big Five” state-owned power and utilities enterprises, whose earnings and share prices are exposed to similar idiosyncratic shocks. A simple time series plot of the price movement of the two companies prior to the reform shows a strong parallel trend. Also note that the transaction volume in Huadian stayed constant prior to the announcement, hence we have insufficient evidence of Ashenfelter’s dip to invalidate the design of the study.

²I thank Professor Longbing Xu (SHUFE) for generously providing this data-set, as well as insights on the share-split reform in China.

<Figure 6: Huadian Trading Volume by Transaction>

<Figure 7: Huadian/Huaneng Daily Closing Price Pre-Announcement>

4.2.3 Evidence and Impact of Noise Trading

Given the exogeneity of Huadian share split reform, I first test whether the trading volume, as measured by the transaction-by-transaction number of shares traded, in Huadian significantly changed after the announcement, by setting Huaneng as the control.³ Specifically, I estimate the regression equation specified as

$$Volume_{ist} = Post_t + HD_s + \delta_v \cdot Post_t * HD_s + \epsilon_{ist}$$

where $Post_t$ is an indicator variable, equal to 1 if the time of transaction is after the announcement, and HD_s is an indicator variable, equal to 1 if the company is Huadian. We are interested in the δ_v , the treatment (announcement of split reform) effect on the trading volume of Huadian. Note by the specification, the point estimate of δ is equivalent to

$$(\overline{Vol}_{Post=1, HD=1} - \overline{Vol}_{Post=1, HD=0}) - (\overline{Vol}_{Post=0, HD=1} - \overline{Vol}_{Post=0, HD=0}).$$

<Regression Column 1 of Volume>

The regression results shows $\hat{\delta} = 71078.73$ with $p\text{-value} = 0.047$. This indicates that significant average volume increase happened after the announcement. On average, a typical transaction in Huadian increased by about 71 thousand shares, and the effect is significant at the 5% significance level. Given the evidence of noise trading, we estimate the effect of the announcement on the transaction price and the value of shares traded.

$$Price_{ist} = Post_t + HD_s + \delta_p \cdot Post_t * HD_s + \epsilon_{ist}$$

$$Value_{ist} = Post_t + HD_s + \delta_{tv} \cdot Post_t * HD_s + \epsilon_{ist}$$

³Note the ex-date of Huadian share split reform was on August, 1st. Hence, the trading volume in our sample was not affected by increase in float shares.

<Regression Column 2 of Price>

<Regression Column 3 of Value-traded>

The average effect for value traded is an increase of 283937.6 with a p -value of 0.108 , and the average effect for price is an increase of $.2942429$ with a p -value of 0 . Such result is consistent with our hypothesis that noise trading in Huadian induced a significant average share price increase of 29.4 cents (8.81% of last price pre-event). The average effect on the value-traded is positive with borderline significance at 10% , which sheds light on the evidence that the larger price increases were accompanied by relative smaller volume, and hence the significance of the average effect on the increase in value-traded is toned down. However, such observation provides valuable support for the evidence and the impact of noise traders, who transacted in relatively moderate volume at inflated prices, yet at the same time they significantly drove up the average price level of Huadian after the announcement of reform. In other words, under the incomplete market setting in China at the time, with the presence of bullish noise traders, who mistakenly reacted to the announcement containing no price-sensitive information, a significant increase in the price level could be sustained. As more of such exogenous events occurs, the price impact by noise traders in the long run could be substantial. Cumulatively, such idiosyncratic risks amount to a permanent and anomalous divergence of asset pricing from the fundamental level, and the rate of return on equities earned by investors has to be pushed down.

5 Discussion

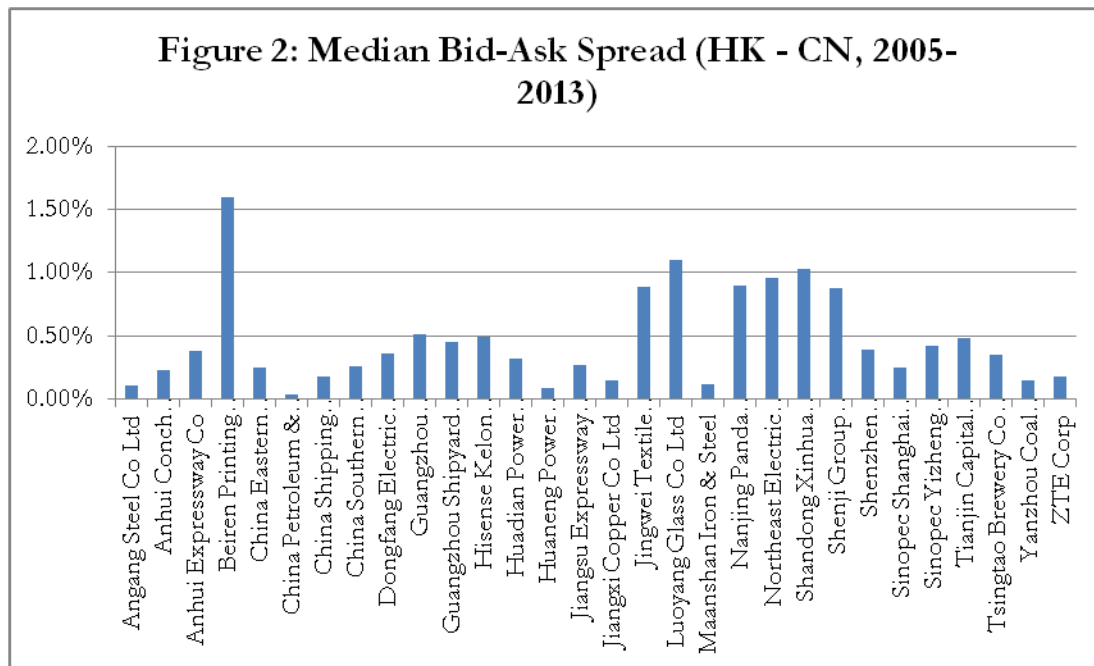
This paper develops a theoretical model in consideration of the impact of market incompleteness on the return of asset prices, with the presence of noise traders. The model shows that market incompleteness is negatively related to the returns earned by investors, as optimistic yet uninformed noise traders flood the market. In perfect market incompleteness, the proportion of noise traders can be sustained at a high level even for investors with high risk-aversion. Moreover,

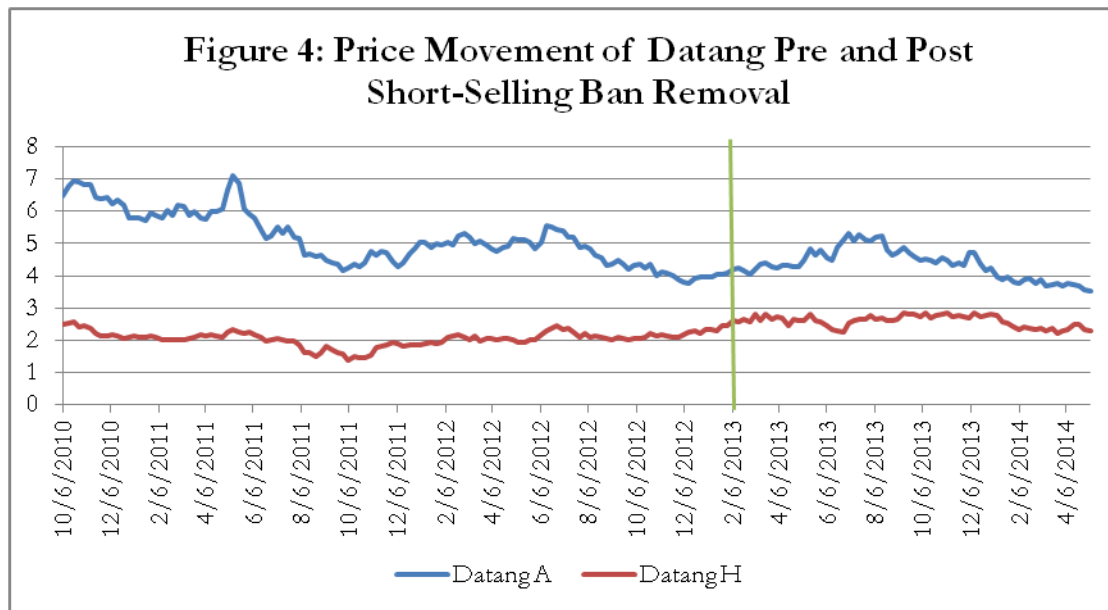
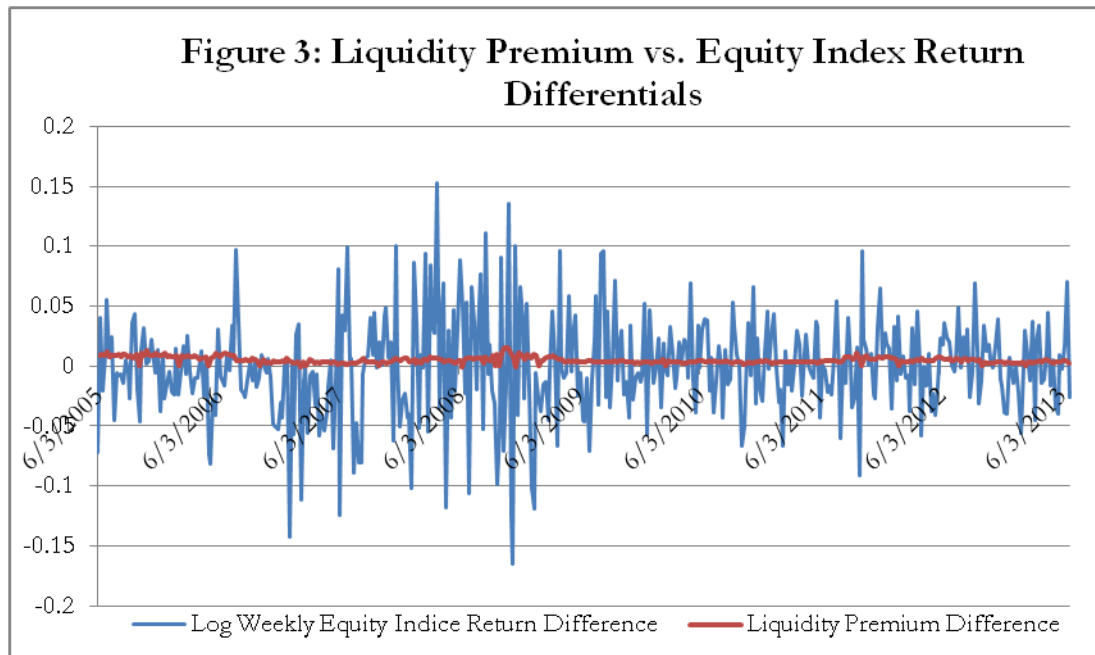
market incompleteness guarantees that risk averse noise traders earn higher excess returns than rational traders in the long run equilibrium. Using China's cross-listed A-H shares with the same fundamentals, we construct an empirical study comparing the realizable excess return by Chinese investors and Hong Kong investors, through a matched sample of securities in the each portfolio basket. Quantitatively, we determine that Chinese investors exhibited inferior information ratios when factoring the transaction frictions and limited availability of alternative financial instruments in the mainland. As market completeness condition improved in China, such disadvantage waned. We also detect noise trading using exogenous non-price-sensitive events under a quasi-experimental framework, and evaluate price level formation post the events. We see significant evidence that noise trading in China translates to positive transitory shocks to the average price level, yet for which the support is persistent.

It remains for us to further analyze and identify many difficult issues mentioned in this paper. The formation of bullish noise traders is exogenously determined in our setting, and it would be extremely valuable to study whether noise trading behavior can be endogenous. In other words, why did the incomplete market structure in China induce a fervent group of noise traders holding obviously mistaken convictions? Would such behavioral biases still be formed given the counterfactual setting, that is in a perfectly complete market?

On the other hand, it would be beneficial to identify whether the price impact from noise trading in A-shares significantly attenuated as the market completeness situation had enhanced in China. Further, according to our model, momentum-based noise traders on average gain a higher excess return than fundamental-driven investors in the Chinese A-share market. So it would be nice to check whether event-driven stock rallies persisted more frequently in an incomplete market, yet noise trading became less profitable as the completeness of the Chinese market had improved. However, testing these assumptions require additional individual level transaction panel data that span longer periods and cover exchange-wide individual observations. Such study will be of immense value for future research in this area.

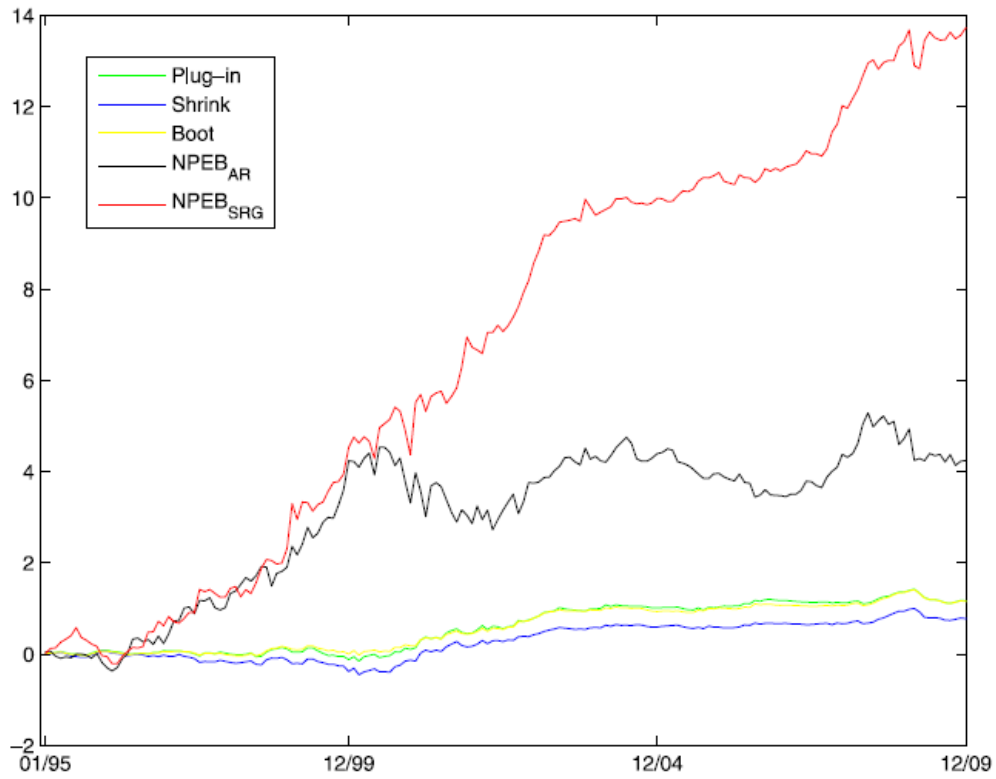
6 Figures

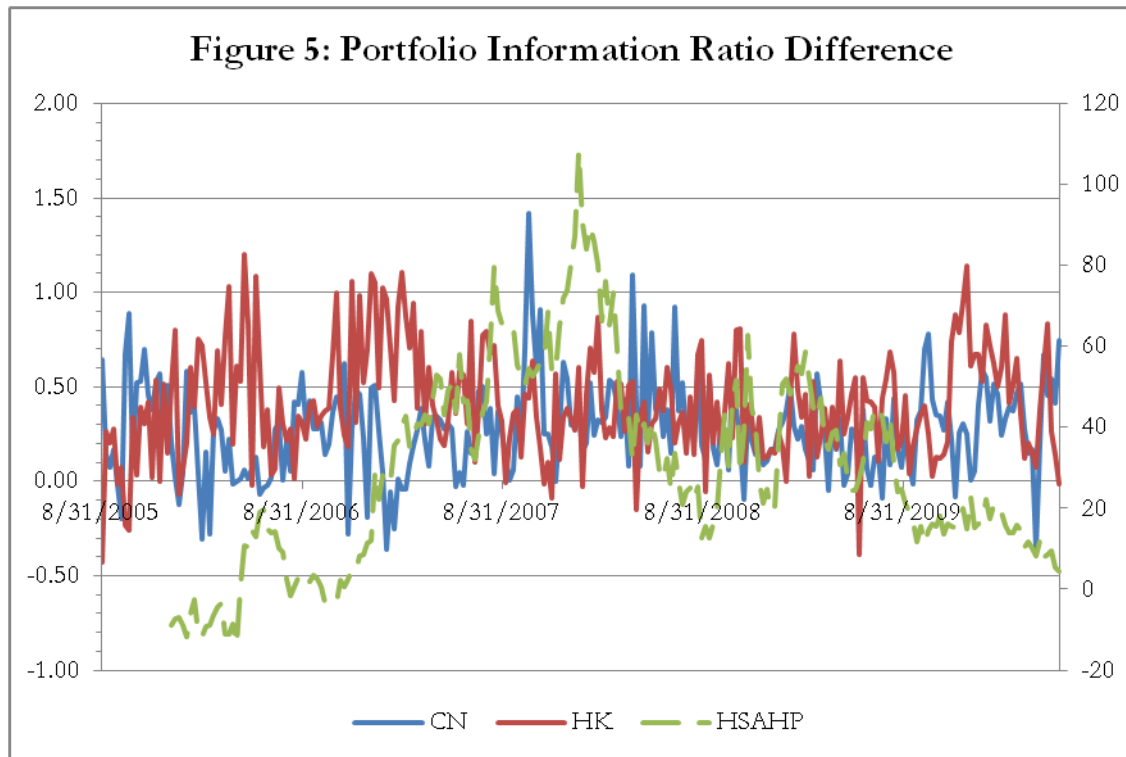




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FIG. 4. *Realized cumulative excess returns over the S&P500 Index.*



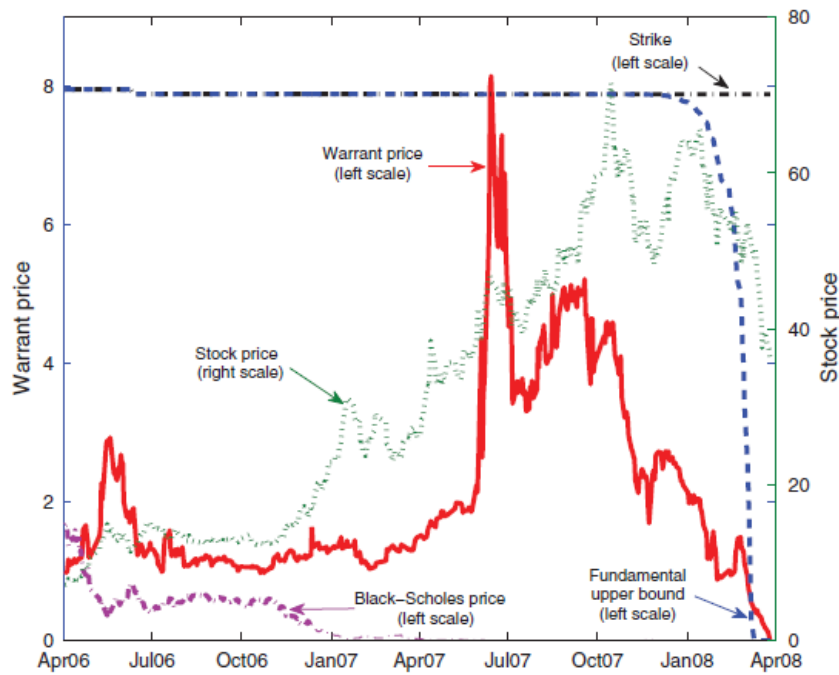
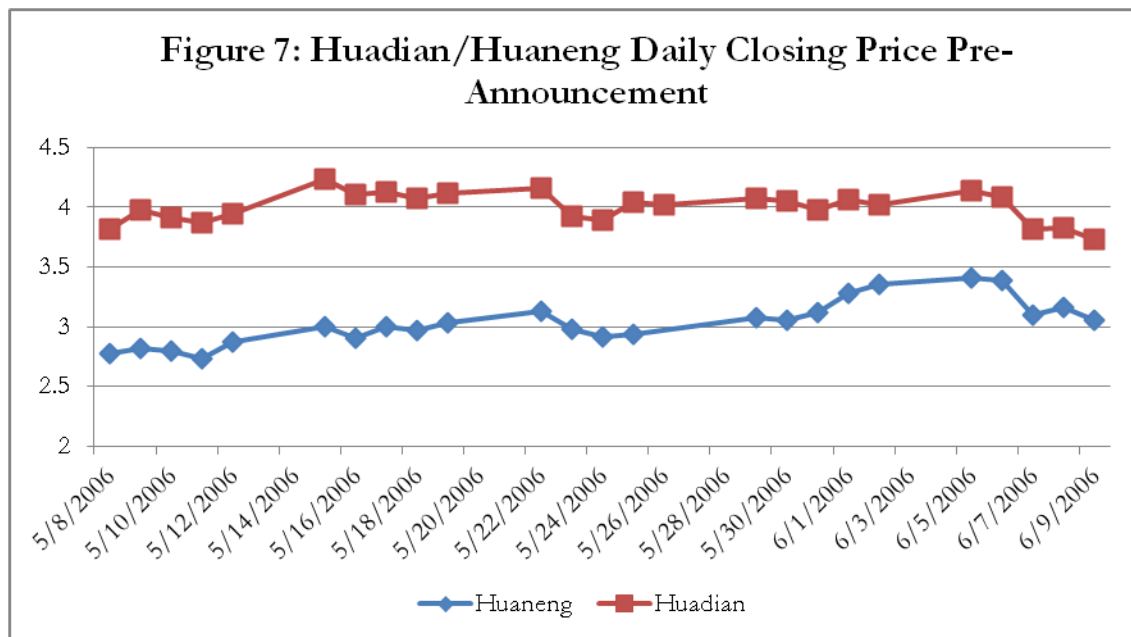
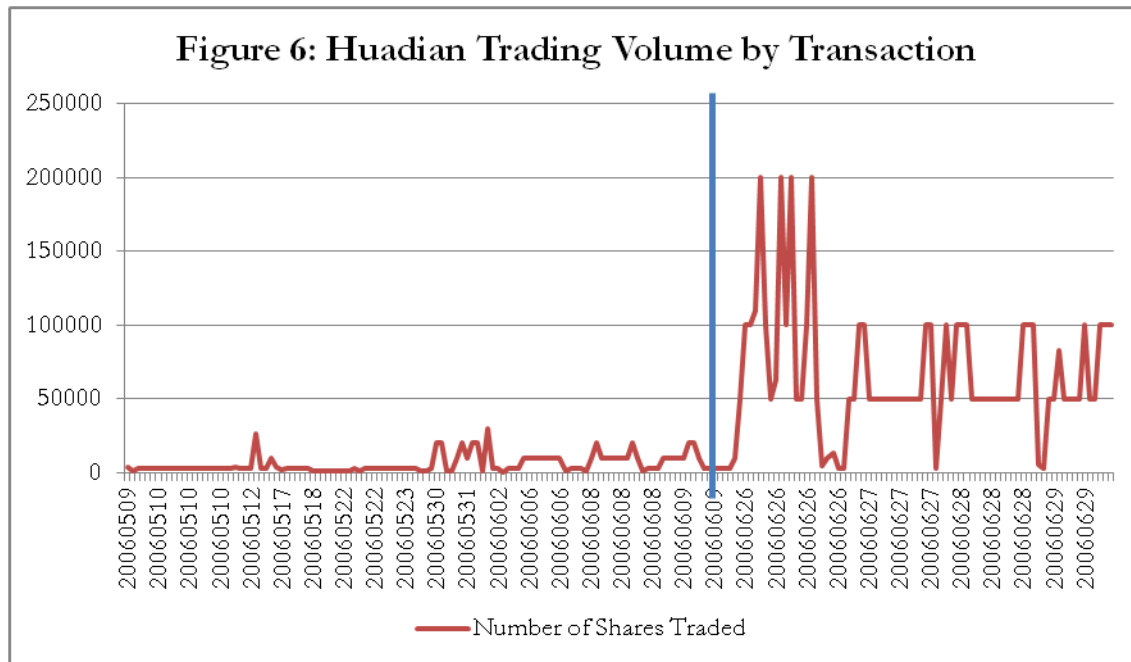


FIGURE 1. PRICES OF WULIANG PUT WARRANT

Notes: This figure shows the daily closing prices of WuLiang stock and its put warrant, along with WuLiang warrant strike price, upper bound of its fundamental value assuming WuLiang stock price drops 10 percent every day before expiration (maximum allowed per day in China's stock market), and its Black-Scholes price using WuLiang stock's previous one-year rolling daily return volatility.



7 Regression Output

	(1)	(2)	(3)
	Volume	Price	Value-Traded
Post	-13773.7 (-0.39)	-0.244*** (-6.63)	-83552.1 (-0.48)
HD	-44760.2* (-2.40)	-1.633*** (-40.94)	-245154.5* (-2.51)
HD*Post	71078.7* (2.00)	0.294*** (6.83)	283937.6 (1.61)
Constant	52235.2** (2.80)	5.075*** (151.14)	270741.3** (2.78)
Observations	182	182	182

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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