Trading Imbalances, Dual-Listed Shares, and Transitory Prices

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Keywords: Transitory Prices, Dual-Listed Shares, Liquidity

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Note: All referenced appendices are in the associated Internet Appendix.
Please see: *http://dl.dropbox.com/u/6555606/AHpremXsecAppendix.pdf*

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Abstract

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1 Introduction

Throughout the 1990s and 2000s, financial economists amassed considerable evidence that stock prices experience transitory movements. These movements are sometimes referred to as "temporary mispricings" or "reversals". Transitory price movements occur at frequencies ranging from a few seconds (microstructure) to months, and possibly years. Appendix A lists some of the empirical studies that document transitory stock price movements.[1]

The goal of this paper is to use order imbalances of dual-listed shares to estimate the magnitude and duration of transitory price movements.[2] Our approach starts with the standard assumption that a stock's observed price consists of two unobservable components. The first component is called the stock's "efficient price" (or fundamental price) and is assumed to follow a random walk. The second component is the "transitory price" and is assumed to be stationary. Another standard assumption is that order imbalances (initiated buys minus sells) can affect prices. Some order imbalances contain fundamental information and thus affect a stock's efficient price. Other imbalances can temporarily "push" prices above or below fundamental values and thus affect a stock's transitory price.

Focusing on dual-listed shares offers a number of advantages. Both of a company's dual-listed shares derive their value (in part) from the same fundamental information. We, thus, have two observed price series with which to estimate a single fundamental price series. Also, we have two time-series of trading imbalances. Thus, we had additional data with which to estimate the relationships between trading, efficient price movements, and transitory price movements. Finally, the relative prices of dual-listed shares are often tracked by investors and/or index companies. Movements in the relative prices of dual-listed shares allows investors and financial economists to "see" movements in transitory prices—even though these prices are unobservable. This ability is possible because the fundamental prices of a given share pair exactly cancel each other out.

[1] All appendices can be found in the associated Internet Appendix, an integral part of this paper. In addition to the above-mentioned list of empirical studies, the Internet Appendix contains proofs, additional results, and robustness checks. The Internet Appendix can be downloaded from: *http://dl.dropbox.com/u/6555606/AHpremXsecAppendix.pdf*

[2] Dual-listed shares are two non-fungible stocks, issued by the same company, with essentially identical dividend claims/voting rights, but traded in two different locations. We use the term *dual-listed shares* to differentiate from cross-listed shares (which are typically fungible), dual-listed companies (which refer to specific corporate structures), and dual-class shares (which typically have different voting or dividend rights.) Appendix B gives more details of the shares and markets studied in this paper. Section 1.1 gives examples of research involving other share types.

Why study transitory price movements? First, investors worry about prices being temporarily below fundamental value when they need to sell shares to fund consumption. Second, fund managers worry that a stock's price is temporarily above (or below) its fundamental value when building (or reducing) a position. Third, holders of contingent contracts worry that a stock's price may be above or below its fundamental value at the time of expiry. Fourth, and related to the previous reasons, regulators and exchanges typically work to reduce transitory price movements. Finally, transitory price movements may affect the allocation of resources in the economy—i.e., the role of prices in a market economy is diminished if transitory price movements are large relative to fundamental price movements.

In a frictionless world, prices do not deviate from fundamental values. In other words, a stock's transitory component is zero at all times. In a frictionless world, there is little need to study the prices of dual-listed shares. The prices of substitutes such as dual-listed shares should be the same at all points of time and across all trading locations (markets). What happens if there are frictions (even in one of the markets)? Examples of possible frictions include transaction taxes, legal differences, short-sale constraints, limited risk-bearing capacity, etc. When frictions exist, the prices of two otherwise similar securities can deviate substantially. If a financial economist observes that the prices of dual-listed shares do not move together, he can quickly deduce that at least one of the stock's transitory components is different from zero.

We start our investigation by offering a theoretical framework with which to study the relations between order imbalances and the prices of dual-listed shares. We model a single company with two non-fungible securities that trade in two separate markets. The securities are otherwise identical and have claims on exactly the same dividends. Each market is populated by informed traders and noise traders that are specific to the market. In addition, there are arbitrageurs who can trade in both markets. The arbitrageurs are risk averse and face a short-sale constraint in one of the markets. It is the limited risk-bearing capacity and short-sale constraint that represent the two main frictions studied in this paper.

The theoretical framework, in conjunction with a numerical analysis, produces seven testable implications. For example, we expect prices in one market to be greater than or equal to prices in the other market due to the arbitrageurs' short-sale constraint. Also, noise trader shocks have an asymmetric effect on returns due to the fact that the arbitrageurs can easily hedge upward movements in one market but not in the other. After detailing the testable implications from the model, we turn to an empirical study.

Our empirical analysis focuses on companies that have shares listed in both Hong Kong and China (mainland). We study a sample of 43 such stock pairs, between January 2006 and April 2009, using weekly data.[3] All 43 stock pairs are, or have been, part of a well-publicized index that tracks relative price differences. Market convention refers to the ratio of a company's mainland a-share price to its Hong Kong h-share price (times 100) as the company's "*AH Premium*". The average company-level *AH Premium* is 182.1 indicating that shares in China (mainland) sell for 1.8× more than shares in Hong Kong. At times, prices in China (mainland) are twice, three times, or even four times those in Hong Kong ... despite the fact that the two types of shares have equal claims on the same dividend stream.

More surprisingly (and perhaps more interestingly), the relative prices of the dual-listed shares are far from constant; price differences vary considerably over time. For the average company, the *AH Premium* has a volatility of 39.5 per week. If the company's *AH Premium* starts a week with a value of 182.1, a one standard deviation upward movement leads the *AH Premium* to end the week with a value of 221.6 (indicating prices in one market 2.2× prices in the other market). A one standard deviation downward movement leads the *AH Premium* to end the week with a value of 142.6 indicating prices in one market are 1.4× prices in the other market. These high levels of volatility indicate transitory prices are not negligible.

Our sample of 43 stock pairs has additional benefits—mainly the sample forces us to concentrate on large, heavily-traded stocks in a developed market. Readers can be assuaged that results in this paper are not driven by small, thinly-traded, and/or neglected stocks. The average market capitalization of a firm's Hong Kong-listed shares in our sample is USD 8.2 billion. The majority of Hong Kong Shares, USD 5.1 billion, represent the free float and are easily traded. In fact, the average company's Hong Kong-listed shares turn over 2.8× per annum.[4]

The main empirical contribution of this paper is to show the effect of trading imbalances, especially in Hong Kong, on the prices of a given company's shares. Our empirical methodology

[3] The sample length limits the durations we can detect. Given 173 weeks of data, we have enough power to detect transitory movements that last a couple months or less. Investigations into lower frequency movements are left for future research.

[4] We purposely omit the word "liquidity" from the text of this paper. Our results point out that high turnover does not necessarily imply low price impacts (from trades) nor does it imply low levels of transitory movements.

centers around estimating a state-space (statistical) model. The statistical model explicitly decomposes a company's observable stock price into an efficient price and a transitory price.[5] As mentioned earlier, studying dual-listed shares enhances the estimation procedure since there are two observed price series for every one fundamental price series. The state-space framework allows us to test whether trading from Hong Kong or China (mainland) has a bigger influence on a stock's efficient price. In other words, we are able to ask: Which order imbalances (investors) help incorporate fundamental information into prices? We can also ask to what extent investors tend to "push" share prices in their local market.

As a quick preview of our findings, we show that signed order imbalances in China (mainland) have a statistically significant effect on a company's efficient price. Order imbalances from Hong Kong have essentially no effect on the efficient price. When looking at transitory prices, we show that order imbalances in both markets have statistically significant effects in their relevant markets. The state-space model allows us to quantify the economic effects. For example, a one standard deviation shock to order imbalances in Hong Kong is found to move weekly transitory prices 112 basis points in Hong Kong. Most importantly, we estimate that the variance of the transitory component alone accounts for 39.2% of a stock price's observed volatility in Hong Kong. The magnitudes associated with transitory movements are surprising because the companies in our study are large and heavily traded.

Finally, the associated Internet Appendix contains robustness checks and makes comparisons with a number of existing frameworks. For example, we show the volatility of our companies *AH Premiums* are 3.3× to 16.2× larger than equivalent measures of the Siamese twin stocks studied by Froot and Dabora (1999). We also show that a Roll-type decomposition estimates that transitory variance represents only 4% of total variance. This value is far less than the 39.2% that we estimate. Differences come from the fact that we assume markets have limited risk bearing capacity and a short sale constraint. The constraint, even though it is in China, affects the arbitrageurs' willingness to absorb order imbalances in Hong Kong.

[5] For readers who are unfamiliar with state-space estimation, we also estimate an ARMA model which produces qualitatively similar magnitudes and results.

1.1 Literature Review

Our study of Chinese dual-listed shares is related to a number of literature strands which we discuss below. Also, please see Appendix A for a list of empirical papers documenting transitory price movements.

First, there is a large strand of literature that looks at cross-listed shares. Karolyi (2010) surveys many of the corporate finance issues relating to cross-listing. There are also three relatively new papers on multi-market trading that include: Baruch, Karolyi, and Lemmon (2007); Gagnon and Karolyi (2010b); and Halling, Moulton, and Panayides (2011). The second one is most similar to our paper except the authors study intra-day prices and quotes. They find small deviations from price parity. Our paper, on the other hand, studies large and volatile price deviations at a weekly frequency. Gagnon and Karolyi (2010a) is a valuable reference.

The second strand studies dual-listed companies such as Royal Dutch and Shell—see Rosenthal and Young (1990). Froot and Dabora (1999) find differences between share prices appear to be correlated with the markets on which the shares are traded most. Chan, Hameed, and Lau (2003) give support to the earlier findings by showing the stocks in the Jardine Group covary more with Singapore's index after delisting from Hong Kong even though the core businesses did not change location. DeJong, Rosenthal, and VanDijk (2009) evaluate trading strategies designed to profit from price discrepancies of dual-listed companies. Our paper complements these papers by showing trading imbalances lead to the high levels of observed volatility.

A third strand studies dual-listed shares that trade only within China (mainland). A-shares were initially for local Chinese citizens while *b*-shares were for foreign investors. Prior to February 2001, Chan, Menkveld, and Yang (2007) show that most price discovery used to happen in the *a*-share market. Chan, Menkveld, and Yang (2008) construct a measure of information asymmetry to explain the *b*-share discount. Mei, Scheinkman, and Xiong (2009) find that speculative trading motives help explain the *a*-share premium over *b*-shares.

Fourth, state-space statistical models have been used to study round-the-clock price discovery for cross-listed stocks by Menkveld, Koopman, and Lucas (2007). The models have also been used to look at price pressure at a daily frequency by Hendershott and Menkveld (2010) and at a monthly frequency by Hendershott et al. (2010).

Finally, Froot and Ramadorai (2008) study cross-border equity flows, closed-end funds' NAVs, and price returns. They find cross-border flows are linked to fundamentals while closed-end fund flows are a source of price pressure. While Scruggs (2007) studies Siamese twin stocks and Chan, Kot, and Yang (2010) study a- and h-share prices, neither makes use of trading imbalances.

Our paper is structured as follows. Section 2 presents a parsimonious theoretical framework. Section 3 numerically analyzes the model and lists seven testable implications. Section 4 describes our empirical data and provides overview statistics. Section 5 estimates a state-space (statistical) model and provides support for the model's testable implications. Section 6 concludes.

2 Theoretical Framework

We model an economy with a single firm that has two claims to its dividends (i.e., two types of shares). The claims are equal in all respects except they trade in two separate markets and are not fungible. The two markets are denoted "a" and "h" and generally indicated using superscripts. Each market contains its own groups of informed traders and noise traders. There is another group of informed investors who can trade in both markets and act as arbitrageurs.

The Economy: We consider an economy with four dates $t = \{0, 1, 2, 3\}$ that are generally indicated using subscripts. There are two risky assets that receive exactly same cash flows. The risky assets both pay $\tilde{D}_3$ units of the consumption good at t=3. The cashflow can be written as $D_3 = \bar{D} + \epsilon_1 + \epsilon_2 + \epsilon_3$ where $\epsilon_t \sim N[0, \sigma_t^2]$. Each of the two stocks trade in one of two markets. We denote P_t^a and P_t^h as the prices of the stocks in these two markets at time t with $P_3^a = P_3^h = D_3$ on the final date. There is a single riskless asset. Without loss of generality, the price of the riskless asset is normalized to one each period.

Investors Specific to Market a: There are two groups of investors specific to market a. One group are informed investors (labeled "$\iota(a)$") and they adjust their demands in response to information release at each date (i.e., the ϵ_t's). The other group are noise traders (labeled

"$\eta(a)$"). They have inelastic demands and their trades do not respond to information releases (discussed below). Each group is assumed to have a mass of one and an initial endowment of W_0. Denote the holdings of the two groups in market a at time t as $X_t^{\iota(a)}$ and $X_t^{\eta(a)}$.

Investors Specific to Market h: There are two groups of investors specific to market h. One group are informed investors (labeled "$\iota(h)$") and they adjust their demands in response to information release at each date (i.e., the ϵ_t's). The other group are noise traders (labeled "$\eta(h)$"). They have inelastic demands and their trades do not respond to information releases (discussed below). Each group is assumed to have a mass of one and an initial endowment of W_0. Denote the holdings of the two groups in market a at time t as $X_t^{\iota(h)}$ and $X_t^{\eta(h)}$.

Arbitrageurs and a Short-Sale Constraint: A separate group of informed investors (labeled "α") are free to trade in both markets. This group can be thought of as arbitrageurs. We assume the group has a mass of one and an initial endowment of W_0. Since the arbitrageurs can hold both types of shares, their holdings are denoted $\{X_t^{\alpha(a)}, X_t^{\alpha(h)}\}$ at time t. Group α's holdings in market a are constrained to be nonnegative so that $X_t^{\alpha(a)} \geq 0$ for all time t. This assumption captures situations in which one of the markets has a short sale constraint. There are no such constraints in market h.

Timing of the Model and Shocks: Part of the assets' final dividends (ϵ_1) is revealed to all investors at t=1, a second part (ϵ_2) is revealed at t=2, and a third part (ϵ_3) is revealed at t=3. As mentioned above, the holdings of the noise traders are subject to exogenous shocks denoted $\Delta X_t^{\eta(a)}$ and $\Delta X_t^{\eta(h)}$ in markets a and h respectively. Noise trader holdings at date t are therefore $X_t^{\eta(a)} = X_{t-1}^{\eta(a)} + \Delta X_t^{\eta(a)}$ in market a and $X_t^{\eta(h)} = X_{t-1}^{\eta(h)} + \Delta X_t^{\eta(a)}$ in market h. The variance of the noise trader shocks may be different in the two markets with $\Delta X_t^{\eta(a)} \sim N[0, \sigma_a^2]$ in market a and $\Delta X_t^{\eta(h)} \sim N[0, \sigma_h^2]$ in market h. Shocks are independently and identically distributed across time and across markets.

Agents' Maximization Problems: Informed traders in market a maximize their expected utility of wealth at t=3 which is denoted as $\mathbb{E}\big[U(W_3^{\iota(a)})\big]$. Informed traders in market h maximize their expected utility of wealth at t=3 which is denoted as $\mathbb{E}\big[U(W_3^{\iota(h)})\big]$. Finally, the arbitrageurs maximize their expected utility of wealth at t=3 which is denoted as $\mathbb{E}\big[U(W_3^{\alpha})\big]$. We assume all agents have exponential utility functions of the form $-e^{-\lambda W_3}$ where the λ coefficient of risk aversion could be different for each group of investors.

Assumption 1: In this paper, we set $\lambda = \lambda^{\iota(a)} = 0.5\lambda^{\iota(h)} = 0.5\lambda^{\alpha}$. This assumptions captures the idea that investors in market a are more risk-tolerant than both those in market h and the arbitrageurs.[6]

Equilibrium Prices and Holdings: Using backward induction, we solve for prices, holdings, changes in prices (returns), and changes in holdings (order imbalances) at dates t=$\{0, 1, 2, 3\}$. Agents at date t take expectations of prices and quantities at date t+1. We also solve for differences in the prices of the risky assets (across the markets). Appendix C gives proofs.

$$AH\ Prem_t \quad = \quad P_t^a - P_t^h \tag{1}$$

The difference between P_t^a and P_t^h is called the company's "*AH Premium*". Positive (negative) values indicate that the share price in market a is above (below) the price in market h. Appendix D gives expressions for prices and the *AH Premium* at each date.[7]

2.1 Summary of Results

Below, we briefly summarize prices by looking at the *AH Premium*$_t$ at date t=1. The price relationship is somewhat complicated. If the short sale constraint is binding, the arbitrageurs are limited in their ability to trade. The prices of stocks in markets a and h are not necessarily the same and the difference depends on the term $(X_1^{\eta(a)} - X_1^{\eta(h)})$. If the short-sale constraint is:

$$\begin{array}{cc} \text{Not Binding at } t\text{=1} & \text{Binding at } t\text{=1} \\ \hline \lambda \frac{1}{2}\sigma_3^2 \left(X_1^{\eta(a)} - X_1^{\eta(h)}\right) & \lambda\left(\sigma_2^2 + \frac{1}{2}\sigma_3^2\right)\left(X_1^{\eta(a)} - X_1^{\eta(h)}\right) \\ +\lambda\sigma_3^2 \frac{\sigma_a^2}{\sqrt{2\pi(\sigma_a^2+\sigma_h^2)}} + h.o.t. & +\lambda\sigma_3^2 \frac{\sigma_a^2}{\sqrt{2\pi(\sigma_a^2+\sigma_h^2)}} + h.o.t. \end{array} \tag{2}$$

Prices across markets are not necessarily equal even if the short-sale constraint is not binding at t=1. The arbitrageurs worry about the possibility the short sale constraint may bind next period (t=2). Note that, at any time t, the company's *AH Premium* is proportional to the

[6] To simplify solutions, we need to make some assumption about $\lambda^{\iota(a)}$, $\lambda^{\iota(h)}$, and λ^{α}. The notion that investors in market a are more risk-tolerant than those in market h carries through to our numerical analysis in Section 3. The risk tolerance of the noise traders plays no role in this framework as this group has inelastic demands.

[7] In a CARA-normal framework, and due to issues related to taking the ratio of two normal variables, the theoretically-calculated *AH Premium* is based on price differences. In Section 4, and in practice, the premium is based on the price ratio. Note that different measures and ratio measures are the same if parameters are chosen such that $P_t^h = 1$.

difference in cumulative noise trader shocks $\Sigma_t(\Delta X_t^{\eta(a)} - \Delta X_t^{\eta(h)})$.

A key point of the model is that the arbitrageurs drive prices so that expected returns are equal across markets (i.e., $\mathbb{E}[r_t^a] = \mathbb{E}[r_t^h]$). Such a condition does not imply prices are equal across markets.

3 Numerical Analysis and Model Implications

We numerically analyze the model using parameter values similar to those found in weekly data from China (mainland) and Hong Kong. To generate results, we draw one set of random numbers, calculate prices and holdings at each date $t = \{0, 1, 2, 3\}$. Since we have simulated data from three dates, we are also able to calculate returns and order imbalances over the t=0→1 and t=1→2 intervals. We then repeat the exercise 170 times to simulate having 170 weeks of adjoining periods (or approximately three years). Using the simulated return data, we are able to calculate the first-order autocorrelation coefficient.

The model contains two types of shocks. The first are the noise traders demand shocks and we assume that noise trading is more variable in market a than in market h. Specifically, $\Delta X_t^{\eta(a)} \sim \mathcal{N}[0, 0.0050^2]$ in market a and $\Delta X_t^{\eta(h)} \sim \mathcal{N}[0, 0.0020^2]$ in market h. This assumption matches measurable empirical quantities—see Section 5.

The second type of shock comes from information about the final dividend. We assume ϵ_1 and ϵ_2 are independently distributed $\mathcal{N}[0, 0.0550]$ while ϵ_3 is distributed $\mathcal{N}[0, 0.1100]$. Our model is stylized and we envisage $\sigma_3^2(\epsilon) > \sigma_2^2(\epsilon)$ so that date t=2 can be thought of as a shorter-term horizon while date t=3 represents a longer-time horizon. Finally, we set $\overline{D} = 0$ and λ=2.

> **Assumption 2:** At t=0, we endow investors with different quantities of stocks. The endowments are chosen, such that if there are no noise trader shocks, the holdings represent steady-state equilibrium values. The chart below summarizes the endowments.

Group	**Stock** a	**Stock** h
Noise traders (η)	50%	50%
Informed traders (ι)	50%	25%
Arbitrageurs (α)	0%	25%
Total	100%	100%

3.1 Model Implications

This section lists eight implications from our model. Seven of the implications are testable. Only Implication #3 (below) is not testable as it focuses on unobservable quantities for which we have no good proxy.

Implication #1: Mean Reversion. The *AH Premium* is mean reverting. Consider a regression in the form: $AH\ Prem_t = \alpha + \phi_1 AH\ Prem_{t-1} + \xi_t$. Using our simulated data, we numerically find $\phi_1 \simeq 0.77$.

Implication #2: Skewness. The short sale constraint only affects one market which causes price to deviate in one direction (only). We find $P_t^a \geq P_t^h$. From our numerical analysis, we find $\mathbb{S}\text{kew}[AH\ Prem_1] \simeq 1.48$. The skewness of returns in market a is positive. The skewness of returns in market h is negative. The difference in skewness results from arbitrageurs dampening downward movements in market a and upward movements in market h.

Implication #3: Binding of the Short Sale Constraint. As part of the numerical analysis, we calculate how often the short sale constraint binds ("b") or does not bind ("n"). Given the parameters mentioned at the start of this section, the short sale constraint never binds about 37.5% of the time. It binds only at t=2 about 12.5% of the time. Column 3 of the chart below summarizes the frequency of binding.

t=1	t=2	Bind Freq	VOL_1^a	VOL_1^h	$\Delta X_1^{\eta(a)}$	$\Delta X_1^{\eta(h)}$
n	n	37.50%	0.0046	0.0022	-0.0042	0.0007
n	b	12.50%	0.0025	0.0016	-0.0018	0.0004
b	n	12.50%	0.0027	0.0016	0.0022	-0.0005
b	b	37.50%	0.0044	0.0016	0.0041	-0.0007
		Wgt Avg	0.0040	0.0018	0.0000	0.0000
		Stdev	0.0029	0.0013	0.0050	0.0020

Implication #4: Total Volume and Noise Trader Shocks. From the chart above, we see average volume in market a is more than double that in market h (0.0040 vs. 0.0018). The standard deviation of volume in market a is also more than double that in market h (0.0029 vs. 0.0013). Noise trader shocks are zero on average reflecting the assumption about the mean of the related random variables. The standard deviations of the ΔX's reflect the assumptions we made about σ_a and σ_h.

Implication #5: Cross-Market Return Correlations. Stock returns are positively, contemporaneously correlated across the two markets. The chart below shows a 0.64 correlation between r_1^a and r_1^h. Returns in both markets are mean reverting with first-order auto-correlation coefficients of -0.25.

	r_1^a	r_1^h	r_2^a	r_2^h
r_1^a	1	–	–	–
r_1^h	0.64	1	–	–
r_2^a	-0.25	-0.15	1	–
r_2^h	-0.15	-0.25	0.52	1

Implication #6: Return-OIB Correlation. The correlation of returns with order imbalances is stronger in market a than in market h. This implication come from the fact that arbitrageurs can easily hedge upward movements in market h.

Implication #7: Fundamental Volatility and *AH Premiums*. The average level of a company's *AH Premium* is proportional to the underlying (fundamental) volatility. We see $AH\ Prem_i \propto \sigma_{2,i}^2 + \sigma_{3,i}^2$ Also, Stdev[$AH\ Prem_i$] $\propto \sigma_{2,i}^2 + \sigma_{3,i}^2$.

Implication #8: Noise Trader Volatility and *AH Premiums*. From Equation (2) we see the average level of a company's *AH Premium* is proportional to the amount of noise trader volatility in market a. In short, $AH\ Prem_i \propto \sigma_a$.

We end this section by noting that our theoretical framework and the numerical analysis lead to some other predictions. For example, Appendix E outlines predictions related to correlations of turnover and noise trader shocks. We turn now to empirically studying the implications listed above.

4 Empirical Data and Overview Statistics

We study companies that have shares listed both in China (mainland) and in Hong Kong. Companies are chosen if their shares are, at one time or another, part of a well-publicized index that tracks price discrepancies of these dual-listed shares. More discussion about the *AH Premium Index* is given at the end of Section 4.1. Our sample totals 43 companies, begins on 03-Jan-2006, and ends on 30-Apr-2009. We select all stock pairs that have, at one time or another, been included in a well-publicized index that tracks relative price differences (see Appendix F). Throughout this paper, we report trading and price variables at a weekly frequency and we have 173 weeks of total data. Weeks run from close-of-market Wednesday through the close-of-market the following Wednesday.

[Insert Table I About Here]

Table I, Panel A shows the names and tickers of the 43 companies in our sample. We report market capitalizations as of 30-Apr-2009 and calculated in millions of USD. The average market capitalization is USD 32.7 billion while the median is USD 9.5 billion. For the Hong Kong-listed shares (only), the average market capitalization is USD 8.2 billion. The table also shows each company's industry based on Global Industry Classification Standard (GICS) codes. Finally, we report the number of weeks of available data for each company. As part of our robustness checks, we also restrict our sample to the 27 companies with 87 or more weeks of data.

4.1 Stock Market Data and Stock-Level AH Premiums

We obtain daily stock prices and returns from Datastream. Returns are compounded to a weekly frequency. All monetary values in this paper are converted to United States dollars (USD) because Chinese (mainland)-listed stocks are quoted in renminbi (RMB) and Hong Kong-listed stocks are quoted in Hong Kong dollars (HKD). Datastream provides RMB-USD and HKD-USD exchange rates.

$$AH\ Prem_{i,t} = \frac{P^a_{i,t}}{P^h_{i,t}} \times 100 \tag{3}$$

The price ratio of a company's a-shares and its h-shares is called the company's "*AH Premium*". Above, $P^a_{i,t}$ is the weekly closing price (on Wednesday) in China (mainland) after converting to USD. $P^h_{i,t}$ is the weekly price in Hong Kong also after converting to USD. A value of 100 indicates shares are selling for the same price on the two exchanges. A value greater than 100 indicates the price in China (mainland) is higher than the price in Hong Kong.

Table I, Panel B gives overview statistics related to companies' *AH Premiums*. For each company, we show its average $AH\ Prem_{i,t}$ as well as the associated standard deviation. The average company has a share price in China (mainland) that is 1.8× higher than its Hong Kong share price. More importantly, Panel B shows these premiums are very volatile over time. The average company has a standard deviation of $AH\ Prem_{i,t}$ that is 39.5 *per week*. Understanding the high levels of variation is a goal of this paper.

[Insert Figure 1 About Here]

Figure 1 graphs three points in the cross-section of *AH Premiums* over time. Each week, we plot the 25%, 50%, and 75% highest *AH Premium*. While premiums are relatively low in the first part of our sample, they grow noticeably in the latter part. The median firm ends the sample with a value just under 200 indicating that is Chinese (mainland) shares are selling for almost double the price of its Hong Kong shares.

The inter-quartile range also grows over time. In the first part of the sample, the range is approximately 50, while it is well over 100 in the latter part. Finally, we note that Figure 1 shows the high level of volatility associated with *AH Premiums*.

[Insert Figure 2 About Here]

Figure 2 plots three companies' *AH Premiums* over time. Looking at three individual companies, we see the same, high-levels of relative-price volatility. For one of the companies, Jiangxi Copper, the price of Chinese (mainland) shares is almost 4× the price of Hong Kong-listed shares in early 2008.

Table I, Panel B shows that a stock's $AH\ Prem_{i,t}$ is typically highly auto-correlated. The average *AR(1)* coefficient is 0.84 (note we are measuring the variable's level so a coefficient less than one indicates mean reversion). A first-order autocorrelation coefficient of 0.85 implies shocks have half-lives of 4.27 weeks. The finding matches Implication #1 from Section 3.1.

For each company, Column 5 shows the fraction of weeks with $P^a_{i,t}$ below or equal to $P^h_{i,t}$. As predicted by Implication #2, the prices in China (mainland) are above prices in Hong Kong about 92% of the time. Column 6 shows that $r^a_{i,t}$ and $r^h_{i,t}$ are typically correlated for the average company. The average correlation is 0.47 while the correlation is 0.50 for the median company. The finding matches Implication #5.

4.2 Order Imbalance Data

Order imbalance data come from the Thomson Reuters Tick History (TRTH) database. The database contains trades and quotes for stocks listed around the world. Data fields include a ticker code, local date, local time, and a variable indicating whether the record pertains to a trade or a quote. For a single trade, the database provides a transaction price in local currency and number of shares traded. For a single quote, there is a bid price and bid size or an ask price and ask size.

To compute the order imbalance in a given stock over a given day, we employ a trade-signing algorithm like the one proposed by Lee and Ready (1991). Trades that take place above the current midpoint of the bid and ask prices are classified as buyer-initiated. Trades below the midpoint are classified as seller-initiated.

For the 43 stocks in our sample, and during our 2006 to 2009 sample period, the TRTH database contains over 563 million trades of a shares and over 61 million trades of h shares. For each stock i, each day k, and each market (a or h) we calculate buyer-initiated volume and seller-initiated volume. In China (mainland) these quantities are denoted $Buy^a_{i,k}$ and $Sell^a_{i,k}$. We then follow these three steps:

Step 1: For each stock i, each day k, and each market we calculate order imbalance. The expressions below apply to a-shares. A similar expression applies to h-shares. Below, $Shrs^a_{i,k}$ denotes the number of stock i's tradeable shares (free float) in market a as of week t. Each stock's OIB is winsorized at the 0.5% and 99.5% levels.[8]

$$OIB^a_{i,k} \quad = \quad \frac{Buy^a_{i,k} - Sell^a_{i,k}}{Shrs^a_{i,k}}$$

Step 2: We standardize daily, stock-level order imbalances by subtracting the average daily order imbalance over days k-11 to k-70 and dividing by the standard deviation of order imbalance over the same interval. A similar expression applies to the h shares. The asterisk (*) indicates a standardized daily variable.

$$OIB^{a*}_{i,k} \quad = \quad \frac{OIB^a_{i,k} - mean\left[OIB^a_{i,k-11:k-70}\right]}{stdev\left[OIB^a_{i,k-11:k-70}\right]}$$

Step 3: We calculate weekly, standardized, stock-level order imbalance by summing over the days in week t:

$$OIB^a_{i,t} = \sum_{k \in week\ t} OIB^{a*}_{i,k} \qquad\qquad OIB^h_{i,t} = \sum_{k \in week\ t} OIB^{h*}_{i,k}$$

Table I, Panel C provides overview of trading and order imbalance data. Columns 2 and 3 show the free floats in each market (as fractions of shares outstanding). The average company has 24% of its China-listed shares available for trading in China. Of shares listed in Hong Kong, 89% of shares are available for trading on average.

Panel C also shows each company's average turnover in each market. Each week, we calculate a stock's turnover as number of shares bought divided by shares available to trade (free float).

[8] The number of tradeable a-shares and number of tradeable h-shares for each company and each week are obtained from Hang Seng Index Companies Ltd.

Low free floats and high volumes of trading in China (mainland) lead to a very large average turnover of 0.13. By comparison, the average turnover in Hong Kong is 0.05 per week which is over 2.5× per annum. The finding matches Implication #4 from Section 3.1.

Finally, Panel C shows the correlation of each company's order imbalances. For the average company, the correlation of $OIB^a_{i,t}$ and $OIB^h_{i,t}$ is 0.01 while the median value is 0.04. The low correlation fits with our model's assumption that noise trader shocks are uncorrelated across markets.

5 State-Space Model and Empirical Results

We estimate a state-space (statistical) model using the assumption that stock i's observable price can be decomposed into two, unobservable components. The first component is called the stock's "efficient price" and is denoted $m_{i,t}$. The second component is called the "transitory price" and is denoted $s_{i,t}$. The efficient price is assumed to follow a random walk with drift while the transitory price is assumed to be stationary.[9] During the estimating procedures, $p_{i,t}$ denotes the natural log of stock i's price as of week t.

In the case of dual-listed shares, there are two observable stock prices which are denoted $p^a_{i,t}$ and $p^h_{i,t}$. We assume the observable prices have the same efficient price but different transitory prices. Such an assumption makes economic sense in that a given company is assumed to have a single, fundamental value at any point in time. Observable prices can deviate from this fundamental value. The system of equations below represents our state-space (statistical) model:

$$
\begin{aligned}
p^a_{i,t} &= m_{i,t} + s^a_{i,t} + c \\
p^h_{i,t} &= m_{i,t} + s^h_{i,t} \\
m_{i,t} &= m_{i,t-1} + \delta_{i,t} + w_{i,t} \\
w_{i,t} &= \kappa^a \tilde{O}IB^a_{i,t} + \kappa^h \tilde{O}IB^h_{i,t} + u_{i,t} \\
s^a_{i,t} &= \phi^a s^a_{i,t-1} + \gamma^a OIB^a_{i,t} + \epsilon^a_{i,t} \\
s^h_{i,t} &= \phi^h s^h_{i,t-1} + \gamma^h OIB^h_{i,t} + \epsilon^h_{i,t}
\end{aligned}
\tag{4}
$$

[9] Internet Appendix I outlines an alternative estimation methodology based on an ARMA (statistical) model. Internet Appendix K provides parameter estimates for the ARMA (statistical) model.

In Equation (4), c is a constant that captures average price differences between the two stocks. Next, $\delta_{i,t}$ is the required rate of return and market component of the efficient stock price increase. It is defined as: $\delta_{i,t} = r_{f,t} + \beta_i(1.08^{\frac{1}{52}} - 1) + \beta_i f_t$. Here, $r_{f,t}$ is the riskless rate over week t, β comes from a regression of of stock i's returns on the market's returns in market h, and f_t is the demeaned return of the MSCI Broad China Index defined as $f_t = r_{m,t} - \bar{r}_m$. With regards to order imbalances, we have the following: $OIB^a_{i,t}$ is the standardized order imbalances for stock i during week t in market a, while $OIB^h_{i,t}$ is an analogous order-imbalance measure for market h. Also, $\tilde{O}IB^a_{i,t}$ is the residual from an regression of $OIB^a_{i,t}$ on four of its own lags. This captures the surprise component of order imbalances as this is the part that affects the efficient price. Finally, $\tilde{O}IB^h_{i,t}$ is an analogous measure for market h.

5.1 Parameter Estimates

We estimate the systems of equations shown in Equation (4) on a stock-by-stock basis. Estimation is by maximum likelihood using statistical software called `Ox` along with an add-on pack called `ssfpack`. See Koopman, Shephard, and Doornik (1999) for additional information about related estimation procedures. Appendix G has information about implementing the estimation and Hendershott et al. (2010) discusses the advantages of using a state-space model in a setting related to studying dual-listed shares.

For two of the 43 stocks in our sample, we do not have enough observations to estimate the state-space model. Therefore, Tables 2, 3, and 4 report cross-sectional average parameter estimates and standard errors across 41 stocks.[10]

[Insert Table 2 About Here]

In Table 2, the first set of numbers are related to the efficient price equations. The κ^a coefficient of 0.0022 and standard error of 0.0005 show that order imbalances in market a (China) are a statistically significant influence on a company's efficient price. In other words, fundamental information appears to be incorporated into prices via trading in the a-share market. The results is consistent with Chan, Menkveld, and Yang (2007).

[10] Internet Appendix J reports results similar to those shown below but first restricts our sample to the 27 companies with at least 87 weeks of data.

The second set of numbers are related to the transitory price equations. From the above estimates, we see that both transitory components are highly autocorrelated with coefficients of 0.8524 and 0.8430 respectively. A first-order autocorrelation coefficient of 0.85 implies shocks have half-lives of 4.27 weeks. The γ coefficients of 0.0052 and 0.0038 indicate that order imbalances affect the transitory prices in both the a and h markets. This finding is similar to Implication #6 from Section 3. Both γ coefficients are statistically significant at all conventional levels. We now turn to quantifying the economic magnitudes associated with the parameter estimates.

5.2 Economic Magnitudes

We multiply estimated coefficients by the standard deviation of our trading variables to better understand economic magnitudes. Results are reported in basis points ("bp") per week.

[Insert Table 3 About Here]

In Table 3, we can see that a one standard deviations change in Chinese OIB^a is associated with a 62 bp change in a stock's efficient price and a 150 bp change in a stock's transitory price. Likewise, a standard deviation change in the Hong Kong OIB^h is associated with essentially no change in a stock's efficient price and a 112 bp change in a stock's transitory price. The finding that $\gamma^a \cdot \sigma(OIB^a)$ is larger than $\gamma^h \cdot \sigma(OIB^h)$ confirms Implication #6.

We test Implication #7 from Section 3.1 which suggests that *AH Premiums* are cross-sectionally related to fundamental volatility. Such a tests highlights the power of our state-space model. Fundamental volatility is unobservable. Stock price volatility may not be a good proxy for fundamental volatility in markets with limited risk-bearing capacity (since noise trader shocks also affect stock volatility). We use a Kalman filter and smoother to estimate all quantities shown in Equation (4). Note that from the fourth line in Equation (4), we see $\sigma(w)$ is a function of $\kappa^a \cdot \sigma(OIB^a)$, $\kappa^h \cdot \sigma(OIB^h)$, and $\sigma(u)$. Although not reported, we find a 0.39 cross-sectional correlation of a stock's average $AHPrem_{i,t}$ and its $\sigma_i(w)$. We also regress a stock's average $AHPrem_{i,t}$ on a constant and its $\sigma_i(w)$. The regression coefficient is 0.26 with a 2.63 t-statistic. This finding confirms Implication #7.

We test Implication #8 from Section 3.1 which suggests that *AH Premiums* are cross-sectionally related to noise trader volatility in market a. Since $OIB^a_{i,t}$ has been standardized in—see Section 4.2—we use $\gamma^a \cdot OIB^a_{i,t}$ as a measure of noise trader volatility (or simply γ^a). Although not reported, we also regress a stock's average $AHPrem_{i,t}$ on a constant and 1,000 times its γ^a coefficient. The regression coefficient is 8.54 with a 3.70 t-statistic. This finding confirms Implication #8.

5.3 Variance Decomposition

To further understand economic magnitudes, we decompose the variances of stock returns. The first step is to re-write the fundamental expression for prices from Equation (4). The expression below, starts with the expressions for $p^h_{i,t}$ and for $p^h_{i,t-1}$ and then takes differences. As we are using log-prices, the difference is the stock's return.

$$\Delta p^h_{i,t} = \Delta m_{i,t} + \Delta s^h_{i,t} \tag{5}$$

$$\sigma^2(r^h_{i,t}) = \sigma^2(\Delta m_{i,t}) + \sigma^2(\Delta s^h_{i,t}) + 2Cov(\Delta m_{i,t}, \Delta s^h_{i,t}) \tag{6}$$

We use a Kalman filter and smoother to calculate all quantities shown in Equation (5). We then decompose the variance of stock i's returns to those parts shown in Equation (6). Internet Appendix H shows the standard deviation of stock returns for each company in our sample.

[Insert Table 4 About Here]

In Table 4, and for Hong Kong, efficient price variance accounts for 47.5% of the average stock's total variance. Transitory variance accounts for 39.2% of total variance. While σ_u and σ_ϵ are orthogonal by design, there is no such requirement for $m_{i,t}$ and $s_{i,t}$. The chart above shows, $m_{i,t}$ and $s_{i,t}$ are slightly positively correlated such that the covariance term accounts for 13.3% of total return variance.

5.4 Robustness Checks

The associated Internet Appendix contains a number of robustness checks. We report state-space parameter estimates only for those companies with 87 or more weeks of data. We report parameter estimates based on a ARMA (statistical) model. We compare the volatility of our *AH Premiums* to the relative price movements of Siamese twin stocks studied by Froot and Dabora (1999). We also compare our variance decomposition to a Roll (1984)-type decomposition.

6 Conclusions

This paper studies order imbalances and prices of dual-listed shares (stock pairs). Why do the relative prices of two very similar securities exhibit large and volatile differences? One contribution of this paper is to link order imbalances and market frictions to changes in relative prices.

We start the paper by offering a theoretical framework that models a single company with two non-fungible securities. The securities are otherwise identical, but trade in two separate markets and are not fungible. We introduce two main frictions: 1) Arbitrageurs can trade in both markets, but face a short-sale constraint in one of the markets. 2) Investors are risk-averse implying they must be compensated for taking on inventory risk à la Grossman and Miller (1988). The theoretical framework, in conjunction with a numerical analysis, produces a number of testable implications.

Our empirical analysis leads to most of the paper's conclusions and empirical contributions. We study a sample of 43 companies that have shares listed in both Hong Kong (called h shares) and in mainland China (called a shares). We show the average company's *AH Premium* is 182.1 indicating that shares in China (mainland) sell for 1.8× more than shares in Hong Kong.

More surprisingly (and perhaps more interestingly), the relative prices of the dual-listed shares are far from constant; price differences vary considerably over time. For the average company, the *AH Premium* has a volatility of 39.5 per week. If the company's *AH Premium* starts a week with a value of 182.1, a one standard deviation upward movement leads the

AH Premium to have a value of 221.6 (indicating prices in one market are 2.2× above prices in the other market). A one standard deviation downward movement leads the *AH Premium* to have a value of 142.6 (indicating prices in one market are 1.4× above prices in the other market).

Tests of the model's implications come, in part, from estimating a state-space (statistical) model. We show signed order imbalances in China (mainland) have a statistically significant effect on the efficient price. Order imbalances in both markets have statistically significant effects on the transitory components in their relevant markets. Focusing on shares in the developed market, a one standard deviation shock to order imbalances is found to move weekly transitory prices by 112 basis points in Hong Kong. Overall, we estimate that the variance of the transitory component alone can explain 39.2% of a Hong Kong stock price's observed volatility.

The high levels of transitory volatility arguably represent the paper's most surprising result. Companies in our sample have Hong Kong market capitalizations of USD 8.2 billion, on average. These are not small companies. What's more, Hong Kong is considered to have a developed stock market. The city is home to numerous financial institutions including banks, hedge funds, insurance companies, etc. It is a bit surprising to think of transitory shocks on the order of 112 basis points per week.

There are a number of directions for future research. One idea is to incorporate brokerage account data into our state-space estimation. With such data, we might be able to construct order imbalance measures for relatively naive individuals and for relatively sophisticated institutions. Using these order imbalances may help us to better identify transitory and permanent changes in stocks prices.

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Table I – Panel A
Overview of Companies in Our Sample

The table shows the 43 companies in our data sample. A-shares trade in China (mainland). H-shares trade in Hong Kong. Market capitalization is in millions of US dollars. Industries are based on Global Industry Classification Standard (GICS) codes. The final column shows the number of weeks a company is in our sample.

Name	A Ticker	H Ticker	Total Mkt Cap (US$ mil)	H.K. Mkt Cap (US$ mil)	Industry (GICS Codes)	# of Wks of Data
Air China	601111	0753	9,537	2,046	Airlines	140
Anhui Conch	600585	0914	10,644	2,663	Construction Mat.	173
Anhui Expressway	600012	0995	1,106	244	Transport Infra.	165
Bank of China	601988	3988	119,676	27,759	Comm. Banks	147
Bankcomm	601328	3328	44,041	18,183	Comm. Banks	102
Beijing N Star	601588	0588	1,918	150	Real Estate	132
CCB	601939	0939	133,111	127,272	Comm. Banks	82
CHALCO	601600	2600	17,320	2,926	Metals & Mining	104
China Coal	601898	1898	17,451	3,460	Oil, Gas & Fuels	60
China COSCO	601919	1919	15,787	2,068	Marine	96
China East Air	600115	0670	2,531	265	Airlines	60
China Life	601628	2628	97,611	25,587	Insurance	120
China Oilfield	601808	2883	7,712	1,166	Energy Equip.	82
China Rail Cons	601186	1186	17,257	2,877	Constr & Engin.	34
China Railway	601390	0390	17,153	2,861	Constr & Engin.	60
China Shenhua	601088	1088	68,952	9,209	Oil, Gas & Fuels	78
China Ship Dev	600026	1138	5,333	1,440	Marine	173
China South Air	600029	1055	4,249	418	Airlines	86
Chongqing Iron	601005	1053	987	159	Metals & Mining	86
CITIC Bank	601998	0998	24,897	5,633	Comm. Banks	86
CM Bank	600036	3968	32,930	4,850	Comm. Banks	135
CSCL	601866	2866	5,748	881	Marine	69
CSR	601766	1766	7,312	930	Machinery	8
Datang Power	601991	0991	10,441	1,591	Indep Power	123
Dongfang Elec	600875	1072	4,586	418	Elec. Equip.	173
Guangshen Rail	601333	0525	4,643	621	Road & Rail	122
Guangzhou Pharm	600332	0874	786	84	Pharmaceut	173
Guangzhou Ship	600685	0317	1,300	199	Machinery	86
Huadian Power	600027	1071	3,652	379	Indep Power	173
Huaneng Power	600011	0902	12,162	2,093	Indep Power	173
ICBC	601398	1398	197,229	46,189	Comm. Banks	130
Jiangsu Express	600377	0177	4,147	856	Transportation	173
Jiangxi Copper	600362	0358	7,233	1,565	Metals & Mining	173
Maanshan Iron	600808	0323	4,109	666	Metals & Mining	173
PetroChina	601857	0857	293,150	18,104	Oil, Gas & Fuels	73
Ping An	601318	2318	42,977	15,467	Insurance	112
SH Electric	601727	2727	12,568	994	Elec. Equip.	17
ShenzhenExpress	600548	0548	1,391	283	Transportation	173
Sinopec Corp	600028	0386	111,978	12,558	Oil, Gas & Fuels	173
Tianjin Capital	600874	1065	1,040	64	Comm Svcs	173
Tsingtao Brew	600600	0168	3,809	1,521	Beverages	173
Yanzhou Coal	600188	1171	7,980	1,769	Oil, Gas & Fuels	173
Zijin Mining	601899	2899	16,667	3,122	Metals & Mining	52
Average			**32,677**	**8,176**		**118**
Median			**9,537**	**1,591**		**122**

Table I – Panel B

The table provides an overview of weekly prices and returns for the 43 companies in our sample. A-shares trade in China (mainland). H-shares trade in Hong Kong. A company's *AH Premium* is defined as 100 times the ratio of P^a to P^h. We report the *AR(1)* of each company's AH Premium. We also report the correlation of each company's weekly returns.

Name	**Avg** $AH\ Prem_{i,t}$	**Stdev** $AH\ Prem_{i,t}$	***AR(1)* Coef**	**Frac w/** $P^a \leq P^h$	**Corr** (r^a, r^h)
Air China	206.6	65.1	0.94	4%	0.55
Anhui Conch	104.9	16.8	0.87	43%	0.62
Anhui Expressway	126.0	26.3	0.93	24%	0.15
Bank of China	142.6	28.3	0.94	15%	0.43
Bankcomm	125.0	22.5	0.92	24%	0.58
Beijing N Star	291.0	70.5	0.89	0%	0.55
CCB	124.3	19.8	0.91	9%	0.62
CHALCO	219.0	45.1	0.86	0%	0.50
China Coal	146.7	29.1	0.78	2%	0.53
China COSCO	184.0	46.2	0.84	0%	0.52
China East Air	415.9	90.1	0.86	0%	0.54
China Life	129.1	26.9	0.94	18%	0.58
China Oilfield	230.8	39.1	0.79	0%	0.52
China Rail Cons	106.7	6.3	0.34	18%	0.53
China Railway	120.2	14.9	0.78	7%	0.42
China Shenhua	143.7	15.4	0.61	0%	0.55
China Ship Dev	129.4	30.8	0.91	20%	0.51
China South Air	296.5	58.2	0.88	0%	0.53
Chongqing Iron	242.3	46.7	0.84	0%	0.55
CITIC Bank	176.3	31.0	0.88	0%	0.40
CM Bank	112.4	15.5	0.88	21%	0.66
CSCL	267.5	58.6	0.86	0%	0.46
CSR	145.5	4.6	0.00	0%	0.45
Datang Power	246.4	78.4	0.84	0%	0.22
Dongfang Elec	149.4	36.6	0.92	3%	0.46
Guangshen Rail	158.7	18.9	0.81	0%	0.25
Guangzhou Pharm	219.3	55.9	0.96	0%	0.38
Guangzhou Ship	196.7	41.8	0.81	0%	0.55
Huadian Power	208.3	74.0	0.95	5%	0.21
Huaneng Power	142.1	39.2	0.94	22%	0.21
ICBC	120.9	16.2	0.89	8%	0.60
Jiangsu Express	119.3	12.3	0.73	2%	0.23
Jiangxi Copper	208.7	64.7	0.94	0%	0.57
Maanshan Iron	146.1	43.2	0.93	13%	0.43
PetroChina	198.2	29.0	0.85	0%	0.44
Ping An	113.7	22.6	0.93	40%	0.68
SH Electric	347.5	44.3	0.65	0%	0.63
ShenzhenExpress	153.6	42.8	0.95	12%	0.28
Sinopec Corp	167.5	38.8	0.93	1%	0.43
Tianjin Capital	305.5	134.8	0.98	0%	0.47
Tsingtao Brew	132.9	19.7	0.87	9%	0.47
Yanzhou Coal	152.5	44.5	0.93	4%	0.36
Zijin Mining	157.6	34.5	0.81	0%	0.49
Average	**182.1**	**39.5**	**0.84**	**8%**	**0.47**
Median	**153.6**	**36.6**	**0.88**	**2%**	**0.50**

Table I – Panel C

The table provides an overview of weekly trading variables for the 43 companies in our sample. A-shares trade in China (mainland). H-shares trade in Hong Kong. Columns 2 and 3 report free floats as percentages of shares listed. Columns 4 and 5 report average weekly turnover, by company, as percentages of shares available to trade (free floats). We also report each company's correlation of weekly order imbalances.

Name	**Free Float Mkt *a***	**Free Float Mkt *h***	**Avg Turn(*a*)**	**Avg Turn(*h*)**	**Corr (OIB^a, OIB^h)**
Air China	0.16	0.54	0.17	0.07	0.20
Anhui Conch	0.26	1.00	0.07	0.04	0.12
Anhui Expressway	0.33	1.00	0.10	0.02	0.09
Bank of China	0.03	0.39	0.11	0.07	0.07
Bankcomm	0.25	0.62	0.10	0.03	-0.09
Beijing N Star	0.43	1.00	0.24	0.05	0.11
CCB	0.92	0.20	0.07	0.04	-0.25
CHALCO	0.21	1.00	0.11	0.07	0.12
China Coal	0.18	0.98	0.13	0.05	-0.11
China COSCO	0.20	0.96	0.15	0.10	0.09
China East Air	0.15	1.00	0.13	0.06	-0.11
China Life	0.05	1.00	0.12	0.07	0.07
China Oilfield	0.19	1.00	0.09	0.04	-0.32
China Rail Cons	0.25	0.85	0.11	0.05	-0.08
China Railway	0.26	0.91	0.11	0.05	0.02
China Shenhua	0.11	1.00	0.07	0.05	-0.20
China Ship Dev	0.26	1.00	0.14	0.04	0.11
China South Air	0.35	0.95	0.15	0.07	-0.10
Chongqing Iron	0.30	1.00	0.12	0.05	0.30
CITIC Bank	0.07	0.41	0.07	0.05	0.33
CM Bank	0.46	1.00	0.06	0.07	0.02
CSCL	0.27	0.96	0.09	0.10	0.10
CSR	0.35	0.90	0.21	0.06	-0.06
Datang Power	0.30	1.00	0.15	0.06	-0.07
Dongfang Elec	0.29	1.00	0.11	0.04	-0.09
Guangshen Rail	0.39	1.00	0.14	0.03	0.07
Guangzhou Pharm	0.23	1.00	0.15	0.03	-0.04
Guangzhou Ship	0.50	1.00	0.15	0.06	0.09
Huadian Power	0.21	1.00	0.11	0.05	0.06
Huaneng Power	0.21	1.00	0.08	0.04	-0.03
ICBC	0.04	0.48	0.12	0.06	-0.22
Jiangsu Express	0.09	1.00	0.11	0.03	-0.10
Jiangxi Copper	0.20	1.00	0.21	0.11	0.04
Maanshan Iron	0.22	1.00	0.17	0.10	0.15
PetroChina	0.02	1.00	0.06	0.04	-0.23
Ping An	0.35	0.54	0.09	0.06	0.05
SH Electric	0.07	1.00	0.35	0.07	0.09
ShenzhenExpress	0.20	1.00	0.12	0.02	-0.03
Sinopec Corp	0.06	1.00	0.10	0.05	0.10
Tianjin Capital	0.25	1.00	0.24	0.05	0.04
Tsingtao Brew	0.40	0.50	0.07	0.03	-0.07
Yanzhou Coal	0.15	1.00	0.16	0.07	0.02
Zijin Mining	0.11	1.00	0.34	0.05	0.28
Average	**0.24**	**0.89**	**0.13**	**0.05**	**0.01**
Median	**0.22**	**1.00**	**0.12**	**0.05**	**0.04**

Table 2
Parameter Estimates

This table shows parameter estimates for the state-space model shown in Equation (4) and directly below.

$$
\begin{aligned}
p^a_{i,t} &= m_{i,t} + s^a_{i,t} + c \\
p^h_{i,t} &= m_{i,t} + s^h_{i,t} \\
m_{i,t} &= m_{i,t-1} + \delta_{i,t} + w_{i,t} \\
w_{i,t} &= \kappa^a \tilde{O}IB^a_{i,t} + \kappa^h \tilde{O}IB^h_{i,t} + u_{i,t} \\
s^a_{i,t} &= \phi^a s^a_{i,t-1} + \gamma^a OIB^a_{i,t} + \epsilon^a_{i,t} \\
s^h_{i,t} &= \phi^h s^h_{i,t-1} + \gamma^h OIB^h_{i,t} + \epsilon^h_{i,t}
\end{aligned}
$$

	κ^a	κ^h	σ_u
Param	0.0022	-0.0002	0.0274
Stderr	(0.0005)	(0.0004)	(0.0021)

	ϕ^a	ϕ^h	γ^a	γ^h	$\sigma_{\epsilon(a)}$	$\sigma_{\epsilon(h)}$
Param	0.8524	0.8430	0.0052	0.0038	0.0582	0.0585
Stderr	(0.0067)	(0.0124)	(0.0006)	(0.0006)	(0.0024)	(0.0023)

Table 3
Economic Magnitudes

This table estimates economic magnitudes of parameters from our state-space model.

		Market a		Market h	
Effic Eq	(bp)	Trans Eq	(bp)	Trans Eq	(bp)
$\kappa^a \cdot \sigma(\tilde{O}IB^a_{i,t})$	62	$\gamma^a \cdot \sigma(OIB^a)$	150	$\gamma^h \cdot \sigma(OIB^h)$	112
$\kappa^h \cdot \sigma(\tilde{O}IB^h_{i,t})$	-3	$\sigma(\Delta s^a)$	573	$\sigma(\Delta s^h)$	574
$\sigma(w)$	200				

Table 4

Variance Decomposition

This decomposes return variance of the Hong-Kong listed stocks in our sample.

$$\Delta p_{i,t}^h = \Delta m_{i,t} + \Delta s_{i,t}^h$$

$$\sigma^2(r_{i,t}^h) = \sigma^2(\Delta m_{i,t}) + \sigma^2(\Delta s_{i,t}^h) + 2Cov(\Delta m_{i,t}, \Delta s_{i,t}^h)$$

	$\sigma^2(r_{i,t}^h)$	$\sigma^2(\Delta m_{i,t})$	$\sigma^2(\Delta s_{i,t}^h)$	$2Cov(\Delta m_{i,t}, \Delta s_{i,t}^h)$
Average	100%	47.5%	39.2%	13.3%
Stderr	(n.a.)	(7.5%)	(6.1%)	(2.0%)

Figure 1
Cross-Section of AH Premiums

The figure shows three points in the cross-section of company-level *AH Premiums* at a weekly frequency. A given company's *AH Premium* is defined as 100 times the ratio of its China (mainland) *a*-share price to its Hong Kong *h*-share price. A value of 100 indicates a company's *a*-shares are selling for the same price as its *h*-shares. We show the 25th, 50th, and 75th percentile over time. Data are weekly starting 03-Jan-2006 and ending 30-Apr-2009.

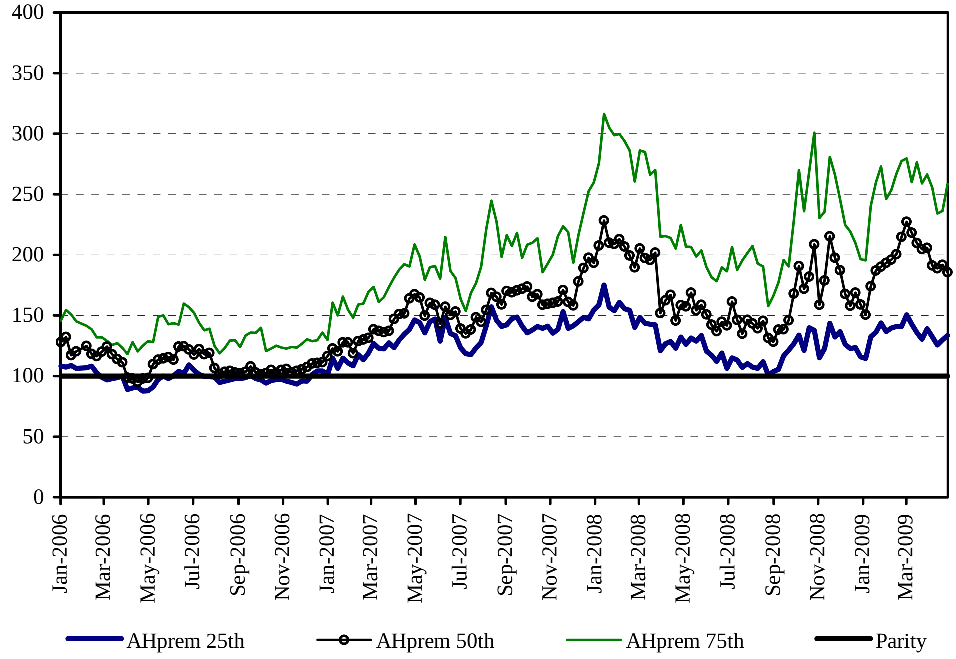

Figure 2
AH Premiums for Three Companies

The figure shows the time-series of *AH Premiums* for three companies at a weekly frequency. A given company's *AH Premium* is defined as 100 times the ratio of its China (mainland) *a*-share price to its Hong Kong *h*-share price. A value of 100 indicates a company's *a*-shares are selling for the same price as its *h*-shares. The first company is Jiangxi Copper. The second company is Shenzhen Expressway. The third company is China Shipping. Data are weekly starting 03-Jan-2006 and ending 30-Apr-2009.