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AH and A-ADR Premiums

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Abstract: This paper explores the micro-, meso- and macro-level determinants of the AH and A-ADR premiums using share price data from cross-listed companies over 2002-2020. During the period, the 9 pairs of shares listed in all three markets averaged an A-ADR premium around 30% and AH premium of 34%, while the weighted average AH premium of 116 pairs was 35%. Both types of premiums surged after the introduction of Shanghai–Hong Kong Stock Connect (SH Connect) in November 2014. Our empirical analyses find that micro factors weigh much more in explaining both types of premiums, and dividend ratio and financial openness are the two most important determinants. Besides, individual share liquidity is important for A-ADR premium, and market sentiment has a significant impact on AH premium. To test the policy impacts of foreign exchange rate reform and financial openness, we construct a two-stage two-country model, and prove that in certain scenarios, both can help to reduce price differences. The results also hold when we simulate the impacts of these two policy changes on premiums in a more generalized scenario numerically. Our empirical analyses also confirm the results of the model. The findings have multiple policy implications for promoting the price discovery capacity of A-shares and the resource allocation of capital markets in China.

Keywords: A share, H share, ADR, cross-listing, foreign exchange rate, financial opening

JEL Classification: F31，G14，G15

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I. Introduction

China's equity market marked its 30th anniversary in 2020, and is already the second largest in the world in terms of capitalization. In its early years of development, the Chinese equity market suffered from limited financing capacity; even today, its governance structure, information disclosure and transactions rules are not yet in line with the best practices. These shortcomings have forced some Chinese companies to list abroad or to cross-list on two or more exchanges to attract overseas funds, to enhance corporate governance and international reputation, and to expand their international market. Cross-listing also enables international investors to diversify their investment options, and to hold shares of high-quality companies in emerging markets (EM) with less convertible capital accounts (SEC, 2012[2]). EM investors can also hedge their domestic assets with shares in developed markets (Auguste et al., 2006).

Academics are particularly interested in the share price differences of the cross-listed firms. As a general rule, the stocks cross-listed between advanced markets share similar prices, while between advanced and emerging markets, stocks in advanced markets carry higher prices (Jithendranathan et al., 2000; Bae et al., 2008; Stigler et al., 2010). China does not follow this rule. First, the share prices in the A-share market have been higher than the share prices in the Hong Kong (H share) and the American Depository Receipts (ADRs) in the United States. Second, after the introduction of Shanghai–Hong Kong Connect (November 2014) and Shenzhen–Hong Kong Connect (December 2016) (hereafter, SH Connect, to include both), the connectivity of the markets has increased, yet both the AH premium and A-ADR premium have surged (Zhang et al., 2020).

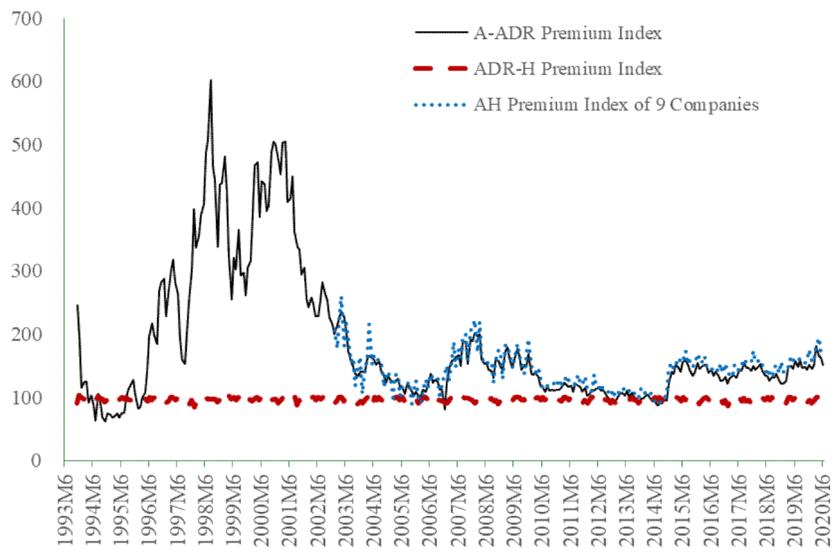

Figure 1: AH, A-ADR and ADR-H Premiums

2 SEC, "Investor Bulletin: American Depository Receipts," August 2012.

Note: ADR-H premium index is based on 15 Chinese stocks cross-listed in the main boards of the US and Hong Kong; A-ADR and AH premium index are based on 9 Chinese stocks listed in China, Hong Kong and the US; all are a capitalization-weighted average of monthly share price data.

In Figure 1, monthly A-ADR and AH premium indices are calculated using a similar formula to that of the HSAHP, an index of the weighted average of the cross-listed A and H share price differences based on the capitalization of A and H shares in circulation.[3] During the period from January 2003 to June 2020, the A-ADR premium index averaged around 142.0 and the AH premium index around 143.4 for the 9 companies listed in the three markets. Because H and ADR are fungible, the weighted premiums of H-shares are less than 1% of those of ADRs; as such, this paper focuses on A-ADR and AH premiums and their causes.

The evolution of different premiums can be divided into four periods. In period 1 (1993-2003), A-ADR premium rates had an extremely high average of 263.5. In this period, the Chinese market was in its primary stage of development, good companies were highly valued domestically, but received limited attention when listed overseas. In period 2 (**2004-2009**), the A-ADR premium index shrank to 144.4, while the AH premium index of the 9 companies was 149.0. During this period, the strong Chinese economy and rapid opening up lifted the enthusiasm of overseas investors of Chinese companies, and in turn, these companies' evaluation in the US markets. Chinese equity markets also went through drastic reform and expansion, both of which promoted the valuation of cross-listed companies. In period 3 (**2010-2014**), the A-ADR premium index further reduced to 108.7, while the AH premium index of the same 9 companies was 116.7. Notably, the listing of Alibaba, Jingdong and other high-quality Chinese companies in the US after 2013 energized the overall ADR prices. **In period 4 (2015-June 2020),** the A-ADR premium index expanded to 143.2, and the AH premium index of the 9 listed companies was 153.9. The reasons for such changes may include, among others, the introduction of SH Connect in November 2014, the recovery of A-shares from the market volatility experienced in 2015, the effects of the pandemic that broke out 2020, the Luckin Coffee incident, and geopolitical tensions between China and the US.

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[3]We construct an A-ADR premium index and an AH premium index by applying the formula of the Hang Seng China AH Premium Index (total market value of the constituent stocks using their A-share prices against that using their H-share prices). Considering that ADR conversion ratio varies across stocks and time, we convert A and H-shares in circulation into ADR shares, and A-share and H-share prices are also converted into US dollar per ADR share.

$$\mathrm{A-ADR\ Premium\ Index_{i,t}} = \frac{\sum_{i=1}^{9} \mathrm{Implied\ ADR\ Price\ of\ A-share}_{i,t} \cdot \mathrm{Stocks\ in\ Circulation}_{i,t} / \mathrm{ADR\ Conversion\ Ratio}_{i,t}}{\sum_{i=1}^{9} \mathrm{ADR\ Price}_{i,t} \cdot \mathrm{Stocks\ in\ Circulation}_{i,t} / \mathrm{ADR\ Conversion\ Ratio}_{i,t}}$$

$$\mathrm{AH\ Premium\ Index_{i,t}} = \frac{\sum_{i=1}^{9} \mathrm{A-share\ Price}_{i,t} \cdot \mathrm{Stocks\ in\ Circulation}_{i,t}}{\sum_{i=1}^{9} \mathrm{H-share\ Price}_{i,t} \cdot (HKD/RMB\ exchange\ rate)_t \cdot \mathrm{Stocks\ in\ Circulation}_{i,t}}$$

where i denotes individual stocks, t denotes date, Implied ADR Price of A-share $_{i,t}$ = [Price in Renminbi$_{i,t}$/ (Renminbi/USD spot exchange rate)$_t$] $\cdot$ADR Conversion ratio$_{i,t}$.

This paper compares A-ADR and AH premiums using a sample of 9 China-Hong Kong-US cross-listed equities and 116 China-Hong Kong cross-listed equities from January 2002 to June 2020. We analyze the micro-, meso- and macro-level factors in determining the premiums. To examine the policy impacts of foreign exchange rate reform and financial openness, we construct a two-period two-country model, and prove that in certain scenarios, both policies can help to reduce price differences. Further, we simulate the impacts of these two policy changes on premiums in a more generalized scenario using numerical analysis. Our empirical analyses confirm the results of the model with the quantitative impacts of macro-level factors such as financial openness and the US dollar index, meso-level factors (market sentiments) and micro-level factors (dividend ratio, speculative incentives, liquidity of individual shares, information asymmetry).

This paper contributes to the existing literature in four areas. First, it constructs a model to explore foreign exchange rate expectations, financial openness, information asymmetry and short selling on the share price differences. Most previous theoretical models conduct qualitative analysis of one factor in a framework of infinite periods (Greenwood et al., 2018; Eichler et al., 2009; Stulz and Wasserfallen, 1995; Chen et al., 2002). These models mainly based on the Gordon Growth Formula, and target issues related to dividend payment and speculation incentives as well as heterogeneity (Mei et al., 2009), making it difficult to examine multiple factors including policy impacts in a single framework. Second, it investigates the systematic jump of AH and A-ADR premiums using individual share prices, and test the effectiveness of financial openness and foreign exchange rates on reducing share price differences. Previously, only Zhang et al. (2020) noted the surge in the Hang Sheng AH premium index after the introduction of SH Connect and examined the issue from a macro perspective. Third, this paper examines the relative importance of different factors in explaining the share price differences, and our models are much more powerful than most previous empirical studies using individual share prices. Fourth, it extends the data of similar studies to mid-2020 with more careful selection of samples and added stability tests. Specifically, we exclude shares in the US OTC market as used in Arquette et al. (2008) to ensure effectiveness of the empirical tests. Moreover, we include a large sample of AH share premium to add stability to our tests and extra implications to the empirical results.

The paper is organized in five sections. Following this introductory section, Section II reviews the literature of cross-listed equity share price differences. Section III constructs a two-period two-country model to evaluate the impacts of foreign exchange rate expectations and financial opening on the price differences. Section IV conducts empirical analysis of A-ADR and A-H premiums and explores the reasons for their changes. Section V concludes with policy suggestions.

II. Literature Review

According to the law of one price, the prices of the same commodity or asset in different markets should be similar if the commodity or asset can be transacted between markets. If the markets are segregated, price differences will remain (Lamont and Thaler, 2003). With regard to the share prices of cross-listed firms, the price differences may stem from micro-level factors such as an individual share's liquidity, information asymmetry and supply; meso-level factors such as transaction rules and market liquidity; and macro-level factors such as capital control and foreign exchange

2.1 Impacts of Micro-level Factors on Premiums

Micro-level factors such as share liquidity, information asymmetry and share supply affect share price premiums through different channels. Chan et al. (2008) and Atanasova and Li (2018) find that liquidity affects ADR and their respective home country share prices, the latter study regards the transmission mechanism as including institutional transactions and the holding costs of the equity. Amihud (2002) considers that prices of illiquid shares consist of a liquidity premium compensation component, while Amihud et al. (2015) further note the evidence of significant positive illiquid return premium in the global equity markets.

Several empirical studies prove the information asymmetry hypothesis, that is, the less the information differs, the lower the share price premium (Hu and Wang, 2008; Chen and Zhou, 2009; Chen and Tan, 2013; Pascual et al., 2006; Chen and Choi， 2012; Frijns and Zwinkels, 2018). Sun and Tong (2000) use market capitalization of listed companies to measure information asymmetry, and find this indicator has strong explanatory power in explaining AB and AH premium. The rationale is that large companies have lower information asymmetry, owing to their high profile and larger amount of public information. Beckmann et al. (2015) find that information asymmetry caused the misvaluation of 482 ADRs from 33 countries over 1995-2012. Lu et al. (2018) argue that the main cause of the rising AH premium after the introduction of SH Connect is information asymmetry. In addition, a recent study by Wu et al. (2020) points out that the relative supply of share can explain 53% of AH premium, as such an increase in the Chinese equity supply will result in a reduction of AH premium.

2.2 Impacts of Meso-level Factors on Premiums

Meso-level factors include transaction rules and investor structure. The rules in Hong Kong and the US normally represent the best international practices, but some rules in China do not. In general, the US and Hong Kong exchanges have strict requirements and procedures for listing and de-listing, mechanisms for information disclosure, and corporate governance. In comparison, Chinese equity markets suffer from limited market tools and less efficient transaction rules, especially information disclosure requirements. Moreover, the A-share market is dominated by individual investors with strong speculative incentives as shown in its high turnover ratio and short investment terms. For example, overseas investors and institutional investors account for 3% and 20% respectively in the A-share market, far below the percentages of such investors in the H-share market (46% and 60% respectively) and US market (16% and 62.4% respectively).

The institutional set-ups have helped the US and Hong Kong equity markets in price discovery, share transactions and risk management. The rules in Hong Kong and the US on initial public offerings, repos, and delisting are more flexible in seasoned and rights issues. This makes their market liquidity theoretically better than that of the Chinese market. For example, Chinese markets have adopted T+1, meaning that investors can sell the shares they purchased on or after the next trading day. In Hong Kong and the US, there is no such constraint under the T+0 rule, which enables short selling. T+0 can improve market liquidity, but has higher requirements for the risk management of investors. Moreover, Hong Kong allows more structured products and derivatives, but in the mainland, net shorting is prohibited. Further, the mainland has different rules on trading hours, daily price limits (daily fluctuation limit is capped at 10%), and margin trading, and some rules have partly prevented arbitrage between the two markets.

Several studies note that allowing for short sale can reduce share price premium. Huang et al. (2015) find that the relaxation of short sale constraints helped to reduce AH premium for 57 cross-listed companies during the period from 2009 to 2013. Blau et al. (2012) point out that ADR of one country is more prone to shorting if that country prohibits short selling as ADR may be under more frequent temporary mis-valuation.

Many studies confirm the impacts of US market sentiments on ADR price and ADR premium (Grossmann et al., 2007; Chan et al., 2008; Chen and Zhou, 2009; Wu and Chen，2015；Wu et al., 2017）. In addition, both Kadiyala and Kadiyala (2004) and Arquette et al. (2008) find that company sentiment and market sentiment (both measured by P/E ratio) have significant impacts on A-ADR premium.

2.3 Impacts of Macro-level Factors on Premiums

On the macro-level, China, Hong Kong and the US markets differ in terms of capital flow and foreign exchange rate arrangements. Capital accounts are convertible in Hong Kong and the US, but not in China where there are constraints regarding the primary equity market and individual investment abroad. Moreover, the

US dollar is the major reserve currency, and the HK dollar is pegged to it under a currency board arrangement, while RMB follows a managed floating arrangement with reference to a currency basket. China has made efforts to enhance the flexibility of the RMB foreign exchange rate, and on 11 August 2015, the foreign exchange rate market makers started to make quotations to the China Foreign Exchange Transaction Center using the previous day's closure rate. This enables the foreign exchange rate to better reflect the market demand and supply. Another landmark event happened in August 2019 when the US dollar to RMB rate surpassed 7; subsequently, RMB flexibility has notably improved. Because 7 is no longer the ceiling for RMB to US dollar rate, flexibility of the RMB foreign exchange rate and in turn, China's monetary policy, have been substantially enhanced.

Many studies have confirmed the impacts of foreign exchange rates on share price premium. RMB foreign exchange rate devaluation expectation (or US dollar appreciation expectation) is frequently used as a determinant for the expansion of AH and A-ADR premiums (Grammig et al., 2005; Arquette et al., 2008; Eichler et al., 2009; Eichler, 2011; Grossmann et al., 2017). Specifically, Arquette et al. (2008) find the foreign exchange expectation can explain 40% of AH and A-ADR premium changes. Li and Wu (2016) identify foreign exchange rate arrangement changes as able to affect share price premium, although to a less degree.

Financial openness affects share price premium via different pricing mechanisms due to market segregation (Hietala, 1989; Baruch et al., 2007; Gagnon and Karolyi, 2010; Goldstein et al., 2014; Greenwood et al., 2018; Ding et al., 2020). Hu and Wang (2008) find that AH premium is mainly caused by the market segregation and China's capital control. Using Argentina and Venezuela data from the early 2000s, Auguste et al. (2006) find that capital outflow control can enlarge home country share prices over ADR premium by affecting domestic demand. However, some other studies do not concur with these findings on the impacts of capital control, and find instead that share price premium is mainly a result of transaction costs and market liquidity (Rabinovitch et al., 2003).

In recent years, the impacts of SH Connect on AH premium have received much attention. Chan and Kwok (2015) and Nishimura et al. (2018) find that SH Connect has enhanced the price discovery capacity of A and H shares. Zhang et al. (2020) analyzes the systematic increase of AH premium index after 2015, and find that the US dollar index and the investors' expectations of the Chinese economy can explain such increases. Earlier studies focus more on the impacts of SH Connect on capital flow and market connectivity. Burdekin and Siklos (2018) and Lu et al. (2018) provide evidence that impacts of capital flow through SH Connect on AH premium are insignificant. Although following the introduction of SH Connect, the relationship between the indices of the two market (Huo et al., 2018; Ma et al., 2019) and the correlations of individual share prices (Chan and Kwok, 2015) have been enhanced, the connectivity of the two markets has not(Ma et al., 2019).

III. Model

Our model refers to existing theoretical studies on asset prices and price disparity. Most of these focus on the impact of a single factor, or conduct qualitative analysis in an economic framework of infinite period. First, the impact of financial openness on asset prices and price disparity is based on the market segmentation theory. Relevant studies include Errunza and Losq (1985, 1989), Alexander et al. (1987), Domowitz et al. (1997), Baruch et al. (2007), Greenwood et al. (2018) and Pavlidis and Vasilopoulos (2020). Second, the impact of exchange rate expectations on price disparity is straightforward in theory, and we refer to the empirical study of Eichler (2011). Third, studies on the impacts of information asymmetry or information friction on asset prices and price disparity are mainly based on the framework of Grossman and Stiglitz (1980). We assume that domestic investors have the information advantage as in Stulz and Wasserfallen (1995). Fourth, existing theoretical studies of the impact of short sale constraints on asset prices are mainly based on the framework of Miller (1977) and Harrison and Kreps (1978). Among these studies many (e.g., Chen et al., 2002) have introduced investors' heterogeneous expectations, and we follow suit in our model. In addition, some studies discuss the influence of multiple factors on asset prices and price disparity in one framework; for example, Diamond and Verrecchia (1987) and Hong and Stein (2003) consider the roles of information friction and short sale constraints. We refer to these studies to extend our model.

This paper explores the impacts of financial openness, foreign exchange rate expectation, information friction and short sale constraints on the price disparity of cross-listed shares in one model. To avoid the computational complexity of quantitative analysis in an economic framework with infinite periods, we consider an open economy with two periods. Specifically, we assume domestic firms can issue equities (**hereinafter called risky assets**) in both home and foreign capital markets. That is, a Chinese firm can issue shares in China (A share), Hong Kong (H share) and US (ADR). Owing to different institutional set-ups and consequent market segregation, the share prices of one firm in different markets are not necessarily equal, meaning that the law of one price may not hold. For simplification purposes, we standardize the quantity of risky assets in home and foreign markets as 1. We also assume an infinite number of investors in both markets, where a domestic investor is denoted by $i \in [0,1]$, and a foreign investor $j \in [0,1]$, and the sum of each type of investors equals 1.

3.1 Structure of the Model

3.1.1. Domestic Investors

Assume that the utility function of a domestic investor i is constant absolute risk aversion (CARA) preference, then:

$$U_i = \mathbb{E}_i\left[-\,exp\left(-\,\gamma \widetilde{W}_i\right)\right],$$

where $\mathbb{E}_i$ is the expectation operator of investor i, $\widetilde{W}_i$ represents wealth in the 2nd period, and γ represents the degree of risk aversion. In the model, a domestic investor can invest in risk-free and risky assets in the home market. The demands for these two assets are B_i and D_i, respectively. X_i is demand for the risky asset issued by domestic firms in the foreign market. The nominal prices of the risky assets in the home and foreign markets are q and q^*, respectively. Exchange rate in periods 1 and 2 are denoted as e_0 and e_1, representing the amount of foreign currency that can be exchanged by 1 unit of home currency. Higher e_0 or e_1 means appreciation of home currency in the period. After normalizing the exchange rate in the first period to one, we obtain the budget constraint in period 1:

$$W = qD_i + q^*X_i + B_i.$$

The value of the risky asset in both markets is $\tilde{v}$ in home currency (i.e. RMB) in period 2, so the return for investors in the domestic market is $\tilde{v}D_i$. Each unit of the risky asset issued by a domestic firm in the foreign market is worth $e_1\tilde{v}$ in period 2. Because domestic investors only care about their investment return in home currency, the return from the risky asset in foreign markets equals to $\tilde{v}$ in home currency. In this case, investors are not subject to exchange rate risk when investing across markets. After normalizing the return of the risk-free asset to one, the wealth in period 2 can be expressed as:

$$\widetilde{W}_i = \tilde{v}(D_i + X_i) + B_i = W + (\tilde{v} - q)D_i + (\tilde{v} - q^*)X_i.$$

Assume the value of the risky asset $\tilde{v}$ is determined by:

$$\tilde{v} = v + \varepsilon_v,$$

where ε_v is normally distributed, i.e., $\varepsilon_v \sim \mathcal{N}(0,\sigma_v)$. After substituting B_i into the utility function, we simplify the optimization problem of investor i as choosing D_i and X_i to maximize U_i. Therefore, we can obtain the demands for risky assets in home and foreign markets:

$$D_i = \frac{\mathbb{E}_i[\tilde{v}] - q}{\gamma \mathbb{V}_i[\tilde{v}]} \tag{1}$$

$$X_i = \frac{\mathbb{E}_i[\tilde{v}] - q^*}{\gamma \mathbb{V}_i[\tilde{v}]} \tag{2}$$

where $\mathbb{V}_i[\tilde{v}]$ stands for subjective variance of $\tilde{v}$ resulting from the information or beliefs biases of investor i.

3.1.2. Foreign Investors

The utility function of foreign investor j follows CARA preference:

$$U_j^* = \mathbb{E}_j\left[-exp\left(-\gamma^*\widetilde{W}_j^*\right)\right],$$

where $\widetilde{W}_j^*$ is investor j's wealth in the second period, and γ^* is the degree of risk aversion. We assume $\gamma^* = \gamma$ as the impacts of risk aversion on price disparity are beyond the scope of this paper. Foreign investor j begins with an endowment of W^* in period 1, which can be invested in both the risk-free and risky assets issued by domestic firms in the foreign market. Demands for these two assets are B_j^* and D_j^*, respectively. The price of the risky asset is q^*. Investor j can also buy risky assets issued by domestic firms in the domestic market, whose demand is represented by X_j^*. Therefore, the budget constraint for j is:

$$W^* = q^*D_j^* + qX_j^* + B_j^*.$$

Now, we standardize the return of the risk-free asset as 1, and express the wealth of investor j in the 2nd period as:

$$\widetilde{W}_j^* = \tilde{v}^*\left(D_j^* + X_j^*\right) + B_j^* = W^* + (\tilde{v}^* - q^*)D_j^* + (\tilde{v}^* - q)X_j^*,$$

where $\tilde{v}^*$ is the return of 1 unit of domestic risk assets of the foreign investor. Because the foreign investor shares a similar optimization preference with the domestic investor, demands for his/her risky assets are:

$$D_j^* = \frac{\mathbb{E}_j[\tilde{v}^*] - q^*}{\gamma\mathbb{V}_j[\tilde{v}^*]} \tag{3}$$

$$X_j^* = \frac{\mathbb{E}_j[\tilde{v}^*] - q}{\gamma\mathbb{V}_j[\tilde{v}^*]} \tag{4}$$

Assume the exchange rate in period 2 is：

$$e_1 = e + \varepsilon_e.$$

where $e \in [e_L, e_H]$ is unconditional expected value ($\mathbb{E}[e_1] = e$) and ε_e follows a normal distribution, $\varepsilon_e \sim \mathcal{N}(0, \sigma_e)$. Although one unit of the domestic asset in both markets has the same value $\tilde{v}$, the foreign investor needs to adjust it by exchange rate $\tilde{e}$:

$$\tilde{v}^* = e_1\tilde{v}.$$

An increase in e_1 (appreciation of domestic currency) will increase the returns of the risky asset in the foreign market for foreign investors. Thus, the domestic currency appreciation expectation will raise demand for the risky asset in the foreign market.

3.1.3. Market Clearing

Assume that financial markets are not fully open, and only a domestic investor $i \in [0,\theta]$ and a foreign investor $j \in [0,\theta^*]$ can invest in both markets. We only consider the case with symmetric market openness, $\theta^* = \theta$. Then the market clearing conditions for risky assets in the domestic and foreign markets are：

$$\int_0^1 D_i\, di + \int_0^\theta X_j^*\, dj = 1 \tag{5}$$

$$\int_0^1 D_j^*\, dj + \int_0^\theta X_i\, di = 1 \tag{6}$$

Here, θ can be the degree of openness in capital markets, where $\theta = 0$ means completely closed, and $\theta = 1$, completely open. As informational frictions are not factored in, there is no need to take noise trade into account for market clearing conditions. Given data constraints in China, we assume that policies such as SH Connect, QFII and RQFII can affect θ. We can also use quantitative constraints as a measure of financial openness. For example, assume all investors can participate in both markets, but investments by domestic and foreign investors are subject to some limits such that $X_i \leq \bar{X}$ and $X_j^* \leq \bar{X}^*$. Then, larger $\bar{X}$ or $\bar{X}^*$ stand for fewer capital flow restrictions and a higher degree of openness.

In this paper, we denote the aggregate trading volume in the domestic market by foreign investors as X^* and the aggregate trading volume in the foreign market by domestic investors as X^*. Then we can have $X^* = \int_0^\theta X_j^*\, dj$ and $X = \int_0^\theta X_i\, di$. When constraints on trading restrictions are binding, then $\bar{X}^* = \int_0^\theta X_j^*\, dj$ and $X^* = \int_0^\theta X_i\, di$. That is, an increase in θ has the same meaning as an increase in $\bar{X}$ and $\bar{X}^*$ in the quantity constraint model. Although these two methods have the same properties in describing the extent of market openness, for numerical analysis it is simpler to use value of θ as the degree of openness in capital markets.

3.2 Characteristics of Equilibrium Price and Price Disparity

Assume all investors carry rational expectations and face the same information, that is,$\mathbb{E}_i(\cdot) = \mathbb{E}_j(\cdot) = \mathbb{E}(\cdot)$ and $\mathbb{V}_i(\cdot) = \mathbb{V}_j(\cdot) = \mathbb{V}(\ \cdot)$. After substituting the demand equations (1) and (4) into the domestic market clearing condition (5) and substituting demand equations (2) and (3) into the foreign market clearing condition (6), we can obtain price equations for risky assets in both markets:

$$q = \varphi E[\tilde{v}] + (1-\varphi)\mathbb{E}[\tilde{v}^*] - \gamma\varphi V[\tilde{v}], \tag{7}$$

$$q^* = \varphi^*\mathbb{E}[\tilde{v}^*] + (1-\varphi^*)\mathbb{E}[\tilde{v}] - \gamma\varphi^*\mathbb{V}[\tilde{v}^*], \tag{8}$$

where

$$\varphi = \frac{\mathbb{V}[\tilde{v}^*]}{\mathbb{V}[\tilde{v}^*]+\theta V[\tilde{v}]} = \frac{v^2\sigma_e+\sigma_v(e^2+\sigma_e)}{v^2\sigma_e+\sigma_v(e^2+\sigma_e)+\theta\sigma_v},$$

$$\varphi^* = \frac{\mathbb{V}[\tilde{v}]}{\mathbb{V}[\tilde{v}]+\theta V[\tilde{v}^*]} = \frac{1-\varphi}{1-\varphi+\varphi\theta^2}.$$

Hence $\frac{\partial\varphi}{\partial e} = \frac{2\theta\sigma_v^2 e}{\left(v^2\sigma_e+\sigma_v(e^2+\sigma_e)+\theta\sigma_v\right)^2} > 0$ and $\frac{\partial\varphi^*}{\partial e} =- \frac{\theta^2}{(1-\varphi+\varphi\theta^2)^2}\frac{\partial\varphi}{\partial e} < 0$. That is, the appreciation expectation of the domestic currency will affect the weight of pricing, and in turn, the prices in the two markets. We define price disparity function as $\Gamma = q - q^*$, from which we can obtain the following price disparity function:

$$\Gamma = \frac{\varphi(1-\varphi)(1-\theta^2)}{1-\varphi+\varphi\theta^2}(\mathbb{E}[\tilde{v}] - E[\tilde{v}^*]) + \gamma\frac{1-\varphi}{1-\varphi+\varphi\theta^2}\mathbb{V}[\tilde{v}^*] - \gamma\varphi V[\tilde{v}].$$

From $\varphi = \frac{\mathbb{V}[\tilde{v}^*]}{\mathbb{V}[\tilde{v}^*]+\theta V[\tilde{v}]}$ we can obtain $\mathbb{V}[\tilde{v}^*] = \frac{\varphi}{1-\varphi}\theta V[\tilde{v}]$, and then substitute it in the price disparity functions:

$$\Gamma = \frac{\varphi(1-\varphi)(1-\theta^2)}{1-\varphi(1-\theta^2)}v(1-e) + \gamma\left(\frac{\theta}{1-\varphi(1-\theta^2)} - 1\right)\varphi\sigma_v \tag{9}$$

Note that price disparity can also be denoted as $\tilde{\Gamma} = \frac{q-q^*}{q^*} = \frac{q}{q^*} - 1$. Since having the same properties in the form of differences and ratios will complicate calculations, and given that Γ and $\tilde{\Gamma}$ share similar monotonic properties, we use $\Gamma = q - q^*$ as the price disparity function in our model.

3.2.1. Impacts of Exchange Rate Expectation on Price Disparity

To study the relationship between expectations on exchange rate and price disparity, we first examine two extreme cases, in which $\theta = 0$ and $\theta = 1$, and then $0 < \theta < 1$.

Assumption 1：$\gamma < \bar{\gamma}$，where $\bar{\gamma} = \frac{v}{2\sigma_v e_H}$.

Under Assumption 1, $\gamma < \frac{v}{2\sigma_v e}$ always holds. Because σ_v is smaller than v, $\bar{\gamma}$ is still relatively larger even when e_H is large. This makes $\gamma < \bar{\gamma}$ a reasonable assumption.

Proposition 1： *When $\theta = 0$, the greater the expected depreciation of domestic currency (smaller e), the larger the price disparity; the higher the expected appreciation in domestic currency (larger e), the smaller the price disparity. That is, when $\theta = 0$, then $\frac{\partial\Gamma}{\partial e} < 0$. When $\theta = 1$, then $\Gamma = 0$, and the law of one price holds.*

Proof: when $\theta = 0$, then $\varphi^* = \varphi = 1$, and the price disparity $\Gamma = v(1-e) + \gamma[v^2\sigma_e + \sigma_v(e^2 + \sigma_e) - \sigma_v]$. As a result, we have $\frac{\partial\Gamma}{\partial e} = 2\gamma\sigma_v e - v$. Also, Assumption 1, that $\gamma < \bar{\gamma}$, can yield $\frac{\partial\Gamma}{\partial e} < 0$. When $\theta = 1$, $\varphi^* = 1 - \varphi$. After substituting $\varphi^* = 1 - \varphi$ into the price disparity function, it can be shown that $\Gamma = 0$， which means that $\frac{\partial\Gamma}{\partial e} = 0$. ***Q.E.D.***■

In a closed economy, $\varphi^* = \varphi = 1$ means that the exchange rate does not affect the asset prices in the domestic market (q), but does affect the price disparity by influencing the price in the foreign market (q^*). With complete financial openness, the price disparity means arbitrage opportunities, while the free flow of capital will make the market arbitrage opportunities disappear. Then the law of one price prevails, and the change of exchange rate will not affect the price disparity.

In the case that $0 < \theta < 1$, numerical analysis is needed to assess the effects of expected exchange rate on price disparity.

3.2.2. Effects of Capital Market Financial Openness on Price Disparity

In a financial market that is fully open ($\theta = 1$and $\varphi^* = 1 - \varphi$), price disparity $\Gamma = 0$ always holds. Hence, without considering distortions from information, expectations, and market microstructures, the law of one price always holds in an open market. In a closed financial market (e.g., $e = 1$), price disparity is $\Gamma = \gamma\sigma_e(v^2 + \sigma_v)$. Intuitively, with the opening up of a financial market, the price disparity will decline.

To simplify the analysis of the relationship between market openness and price disparity, we remove the effects of exchange rate expectations by setting $\mathbb{E}[e_1] = e_0$.

Proposition 2: *If* $\mathbb{E}[e_1] = e_0$*, the larger the extent of capital market openness (larger* θ *), the smaller the asset price disparity, i.e.,* $\frac{\partial\Gamma}{\partial\theta} < 0$. (The proof is in Appendix A1.)

Hence, in the case of $e \neq 1$, numerical analysis is also needed to assess the effects of financial openness on price disparity. The above discussions demonstrate that in general, expected appreciation of domestic currency and enhanced openness of financial markets can reduce price discrepancy. More specific situations require numerical analysis and simulation (Appendix A2).

3.3 Model Extensions

3.3.1. Effects of Information Frictions

To examine the impacts of information frictions on price differences, we assume that there exists noise trade in domestic and foreign markets with trading volumes of N and N^*, respectively. Both are normally distributed, $N \sim N(0,\sigma_N)$ and $N^* \sim \mathcal{N}(0,\sigma_N^*)$. Assume that both domestic and foreign investors receive private signals about $\tilde{v}$ (denoted by s and s^*, respectively)，which are determined as follows:

$$s = \tilde{v} + \varepsilon,$$
$$s^* = \tilde{v} + \varepsilon^*.$$

where $\varepsilon \sim N(0,1/\tau_\varepsilon)$ and $\varepsilon^* \sim \mathcal{N}(0,1/\tau_\varepsilon^*)$, and τ_ε and τ_ε^* are the accuracy of private signals for domestic investors and foreign investors, respectively. Assume $\varepsilon = \sqrt{\kappa}\varepsilon^*$, we then have $\tau_\varepsilon^* = \kappa\tau_\varepsilon$ $(0 < \kappa \leq 1)$. Hence, a higher κmeans less information asymmetry between two countries. Given that foreign investors receive poorer signals, they may learn from public information, such as asset prices q and q^*. To reduce the computation complexity from learning mechanisms of foreign investors, we assume that the size of noise trade is large enough, and that $1/\sigma_N$ and $1/\sigma_N^*$ are close to 0. Then, we can have $\mathbb{E}[\tilde{v}|s] \simeq \mathbb{E}[\tilde{v}|s,q,q^*]$ and $\mathbb{E}[\tilde{v}^*|s^*] \simeq \mathbb{E}[\tilde{v}^*|s^*,q,q^*]$, which means that noise trade invalidates public signals. According to the Bayes' Theorem, the introduction of information frictions will cause expectations of domestic investors to have the following properties:

$$\mathbb{E}_i[\tilde{v}] = \mathbb{E}[\tilde{v}|s] = v + \lambda(s - v),$$

$$\mathbb{V}_i[\tilde{v}] = \mathbb{V}[\tilde{v}|s] = \frac{1}{\tau_v + \tau_\varepsilon},$$

where $\lambda = \frac{\tau_\varepsilon}{\tau_v + \tau_\varepsilon}$ and $\tau_v = 1/\sigma_v$. As this section focuses on the effects of information frictions, we hold the exchange rate in the second period constant, i.e., $e_1 = e_0$. Then, the expectations of foreign investors are characterized by:

$$\mathbb{E}_j[\tilde{v}^*] = \mathbb{E}[\tilde{v}^*|s^*] = v + \lambda^*(s^* - v),$$

$$\mathbb{V}_j[\tilde{v}^*] = \mathbb{V}[\tilde{v}^*|s^*] = \frac{1}{\tau_v + \tau_\varepsilon^*} = \frac{1}{\tau_v + \kappa\tau_\varepsilon},$$

where $\lambda^* = \frac{\tau_\varepsilon^*}{\tau_v + \tau_\varepsilon^*} = \frac{\kappa\tau_\varepsilon}{\tau_v + \kappa\tau_\varepsilon}$. In the presence of noise traders, the market clearing conditions become:

$$\int_0^1 D_i\, di + \int_0^\theta X_j^*\, dj + N = 1,$$

$$\int_0^1 D_j^*\, dj + \int_0^\theta X_i\, di + N^* = 1.$$

As such, the price functions can be written as:

$$q = \varphi E[\tilde{v}|s] + (1 - \varphi)\mathbb{E}[\tilde{v}^*|s^*] - \gamma(1 - N)\varphi V[\tilde{v}|s]$$
$$q^* = \varphi^*\mathbb{E}[\tilde{v}^*|s^*] + (1 - \varphi^*)\mathbb{E}[\tilde{v}^*|s^*] - \gamma(1 - N^*)\varphi^*\mathbb{V}[\tilde{v}^*|s^*],$$

where $\varphi = \frac{\mathbb{V}[\tilde{v}^*|s^*]}{\mathbb{V}[\tilde{v}^*|s^*] + \theta V[\tilde{v}|s]}$, $\varphi^* = \frac{\mathbb{V}[\tilde{v}|s]}{\mathbb{V}[\tilde{v}|s] + \theta V[\tilde{v}^*|s^*]}$. We can finally obtain the following price disparity function:

$$\Gamma = \frac{\varphi(1-\varphi)(1-\theta^2)}{1-\varphi+\varphi\theta^2}(\lambda(s - v) - \lambda^*(s^* - v)) + \gamma\frac{1-\varphi}{1-\varphi+\varphi\theta^2}\frac{1-N}{\tau_v+\kappa\tau_\varepsilon} - \gamma\varphi\frac{1-N^*}{\tau_v+\tau_\varepsilon},$$

where $\varphi = \frac{\tau_v+\tau_\varepsilon}{\tau_v+\tau_\varepsilon+\theta(\tau_v+\kappa\tau_\varepsilon)}$. Since noise trade is random, it only matters in the short run; in the long run, the expected price discrepancy can be written as:

$$\mathbb{E}[\Gamma] = \gamma\frac{1-\varphi}{1-\varphi+\varphi\theta^2}\frac{1}{\tau_v+\kappa\tau_\varepsilon} - \gamma\varphi\frac{1}{\tau_v+\tau_\varepsilon} = \gamma\frac{(1-\theta)(1-\kappa)}{\tau_v+\kappa\tau_\varepsilon+\theta(\tau_v+\tau_\varepsilon)}\frac{\tau_\varepsilon}{\tau_v+\tau_\varepsilon+\theta(\tau_v+\kappa\tau_\varepsilon)}.$$

Proposition 3: *The degree of information asymmetry is positively correlated with the expected price discrepancy*, i.e., $\frac{\partial E[\Gamma]}{\partial\kappa} < 0$.

Proof: Based on the formula of $\mathbb{E}[\Gamma]$, we can have $\frac{\partial E[\Gamma]}{\partial\kappa} = -\frac{\mathbb{E}[\Gamma]}{1-\kappa}\left\{1 + \frac{(1+\theta)^2\tau_v+(1+2\theta\kappa+\theta^2)\tau_\varepsilon}{\gamma(1-\theta)}\mathbb{E}[\Gamma]\right\}$. Since $\mathbb{E}[\Gamma] > 0$, $\frac{\partial E[\Gamma]}{\partial\kappa} < 0$. Hence, as the degree of asymmetric information becomes less severe, the expected price discrepancy decreases. ***Q.E.D.*** ■

When financial markets are completely open, $\theta = 1$, so $\mathbb{E}[\Gamma] = 0$. Hence, even with information asymmetry, the law of one price still holds.

3.3.2. Heterogeneous Expectations and Short Sale Constraints

In order to investigate the relationship between short sale constraints and asset price discrepancy, we assume that investors have heterogeneous expectations on asset prices. Using the DSSW model in DeLong et al. (1990), we assume that expectations of domestic and foreign investors have the following properties:

$$\mathbb{E}_i[\tilde{v}] = v + \eta_i,$$
$$\mathbb{E}_j[\tilde{v}^*] = v^* + \eta_j^*,$$

where η_i and η_j^* represent distortions caused by irrational expectations with normal distributions, $\eta_i \sim \mathcal{N}(0, \sigma_\eta)$ and $\eta_j^* \sim \mathcal{N}(0, \sigma_\eta^*)$.

If $\eta_i > 0$, then domestic investors are more optimistic towards future returns of assets; if $\eta_j^* > 0$, then foreign investors are more optimistic, and vice versa. According to the DSSW model, this kind of expectation will not distort variance, i.e., $\mathbb{V}_i[\tilde{v}] = \mathbb{V}[\tilde{v}]$ and $\mathbb{V}_j[\tilde{v}^*] = \mathbb{V}[\tilde{v}^*]$. It has been proved that this form of expectation is equivalent to having a distorted factor in expectations, which makes expectation irrational (Hansen and Sargent, 2008; Jurado, 2016).

Without a short sale constraints, demands from domestic investors in an open economy are the same as those in the previous section. Under the assumption of a fully open market, price functions can be derived as:

$$q = \varphi \int_0^1 \mathbb{E}_i[\tilde{v}]\, di + (1 - \varphi) \int_0^1 \mathbb{E}_j[\tilde{v}^*]\, dj - \gamma\varphi V[\tilde{v}],$$

$$q^* = \varphi^* \int_0^1 \mathbb{E}_j[\tilde{v}^*]\, dj + (1 - \varphi^*) \int_0^1 \mathbb{E}_i[\tilde{v}]\, di - \gamma^*\varphi^*\mathbb{V}[\tilde{v}^*].$$

Since η_i and η_j^* are both normally distributed, then $\int_0^1 \mathbb{E}_i[\tilde{v}] = \mathbb{E}[\tilde{v}]$ and $\int_0^1 \mathbb{E}_j[\tilde{v}^*]\, dj = E[\tilde{v}^*]$. Intuitively, even though every individual investor has irrational expectations, average expectations can still be rational when all investors can participate. In this case, the price functions are the same as in the previous part with rational expectations. However, when there are short sale constraints in the domestic market, demands of domestic and foreign investors are different:

$$D_i = max\left\{0, \quad \frac{\mathbb{E}_i[\tilde{v}] - q}{\gamma V[\tilde{v}]}\right\}, \qquad X_i = \frac{\mathbb{E}_i[\tilde{v}] - q^*}{\gamma V[\tilde{v}]},$$

$$D_j^* = \frac{\mathbb{E}_j[\tilde{v}^*] - q^*}{\gamma^*\mathbb{V}[\tilde{v}^*]}, \qquad X_j^* = max\left\{0, \quad \frac{\mathbb{E}_j[\tilde{v}^*] - q}{\gamma^*\mathbb{V}[\tilde{v}^*]}\right\}.$$

Since the foreign market does not limit short selling, its asset price q^* does not vary; only asset price in the domestic market affects changes in price discrepancy. Therefore, there exist $\bar{\eta} = q - v$ and $\bar{\eta}^* = q - ev$ such that when $\eta_i \leq \bar{\eta}$, foreign investments by domestic investors are 0; when $\eta_j^* \leq \bar{\eta}^*$, domestic investments by foreign investors are 0. Then, we can derive the following market clearing conditions:

$$\int_0^1 \frac{\mathbb{E}_i[\tilde{v}|\eta_i > \bar{\eta}] - q}{\gamma V[\tilde{v}]} di + \int_0^1 \frac{\mathbb{E}_j\left[\tilde{v}^*|\eta_j^* > \bar{\eta}^*\right] - q}{\gamma^* \mathbb{V}[\tilde{v}^*]} dj = 1.$$

Therefore:

$$\int_0^1 \frac{\mathbb{E}_i[\tilde{v}] - q}{\gamma V[\tilde{v}]} di + \int_0^1 \frac{\mathbb{E}_j[\tilde{v}^*] - q}{\gamma^* \mathbb{V}[\tilde{v}^*]} dj = 1 - D_\eta - X_\eta,$$

where $D_\eta = \int_0^1 \frac{q - \mathbb{E}_i[\tilde{v}|\eta_i \le \bar{\eta}]}{\gamma V[\tilde{v}]} di, X_\eta = \int_0^1 \frac{q - \mathbb{E}_j\left[\tilde{v}^*|\eta_j^* \le \bar{\eta}^*\right]}{\gamma^* \mathbb{V}[\tilde{v}^*]} dj$. Then the price function is the following:

$$q = \bar{q} + \gamma\varphi\left(D_\eta + X_\eta\right)\mathbb{V}[\tilde{v}],$$

where $\bar{q} = \varphi \int_0^1 \mathbb{E}_i[\tilde{v}]\, di + (1 - \varphi) \int_0^1 \mathbb{E}_j[\tilde{v}^*]\, dj - \gamma\varphi V[\tilde{v}]$ is the asset price without restrictions on short sales.

Proposition 4: *Under heterogeneous expectations, the price in the domestic market with short sale constraints is higher than that without restrictions. That is* $q > \bar{q}$.

Proof: From $\bar{\eta} = q - v$ and $\mathbb{E}_i[\tilde{v}|\eta_i \le \bar{\eta}] \le v + \bar{\eta}$, we can have $\mathbb{E}_i[\tilde{v}|\eta_i \le \bar{\eta}] \le v + \eta_i \le v + \bar{\eta} = q$, which is equivalent to $\mathbb{E}_i[\tilde{v}|\eta_i \le \bar{\eta}] \le q$. Therefore, we can have $\int_0^1 \{q - \mathbb{E}_i[\tilde{v}|\eta_i \le \bar{\eta}]\}\, di > 0$, from which we can obtain $D_\eta > 0$. Similarly, it can be proven that $X_\eta > 0$. From $D_\eta > 0$ and $X_\eta > 0$, we obtain $q > \bar{q}$. ***Q.E.D***. ■

The above analysis demonstrates that short sale constraints will increase asset prices in the domestic market by $\gamma\varphi\left(D_\eta + X_\eta\right)\mathbb{V}[\tilde{v}]$. Since short sale constraints in the domestic market do not affect the asset prices in the foreign market q^*, the conclusion from Proposition 4 implies that relaxing short sale constraints will reduce price disparity. The above analysis shows that the law of one price always holds in a fully open market, regardless of information asymmetry. However, if we consider heterogeneous expectations by investors and short sale constraints in the domestic market, price discrepancy still exists. In conclusion, relaxing short sale constraints will narrow down price disparity in a fully open market.

IV.Empirical Analyses

4.1 Methodology and Data

Following Arquette et al. (2008), we define the ADR premiums of A-share and H-share firms as:

$$\mathrm{A - ADR\ Premium_{i,t}} = \frac{\mathrm{Implied\ ADR\ Price\ of\ A\ share_{i,t} - ADR\ \ Price_{i,t}}}{\mathrm{Implied\ ADR\ Price\ of\ A\ share_{i,t}}},$$

where *i* denotes individual stocks, *t* denotes date, Implied ADR Price of $\mathrm{A\text{-}share_{i,t}}$= [Price in Renminbi/(Renminbi/USD spot exchange rate)] ·ADR Conversion ratio, and we consider offshore and onshore Renminbi/USD exchange rate. The A-share versus H-share premium is defined as:

$$\text{AH Premium}_{i,t} = \frac{\text{A share Price}_{i,t} - \text{H share Price}_{i,t} \cdot (\text{HKD/Renminbi exchange exchange rate})_t}{\text{A share Price}_{i,t}}.$$

We follow Arquette et al. (2008), Beckmann et al. (2015) and Grossmann and Ngo (2020) to set up the ADR premiums determinant model.

$$\begin{aligned} \text{A-ADR Premium}_{i,t} &= \alpha_0 + \alpha_1 \text{ExpectedExchangeRateChange}_t \\ &+ \alpha_2 \text{MarketSentiment}_t + \alpha_3 \text{DividendYield}_{i,t} + \alpha_4 \text{Illiquidity}_{i,t} \\ &+ \alpha_5 \text{SpeculativeMotive}_{i,t} + \alpha_6 \text{InformationAsymmetry}_{i,t} + \varepsilon_{i.t} \end{aligned} \tag{10}$$

where *i* denotes individual stocks, *t* denotes date. The determinant models for AH premium are set similarly, while definitions of some explanatory variables are appropriately adjusted. The definitions of explanatory variables and the related influence mechanism on the price premiums are presented as follows.

$\text{ExpectedExchangeRateChange}_t$ is a macro-level indicator of the predicted change in exchange rates implied by forward contract rates. Specifically, expected exchange rate changes of CNY (or CNH, offshore exchange rate) and HKD versus USD are defined as the corresponding forward rates minus spot exchange rates. The decline of $\text{ExpectedExchangeRateChange}_t$ indicates expected appreciation of the local currency versus the US dollar. Figure 2 shows the trends based on 1 year forward (adopted from Arquette et al., 2008), while forward rates with a duration of 1 month, 3 months or 6 months share a similar trend. The expected depreciation of offshore Renminbi exchange rate during 2015 and 2017 is significantly stronger than that of onshore exchange rate. As there are no forward exchange rates between the Hong Kong dollar and Renminbi, this variable is not included in the determinant analysis of AH premium, and the influence of the exchange rate on AH premium is mainly illustrated by the US dollar index.

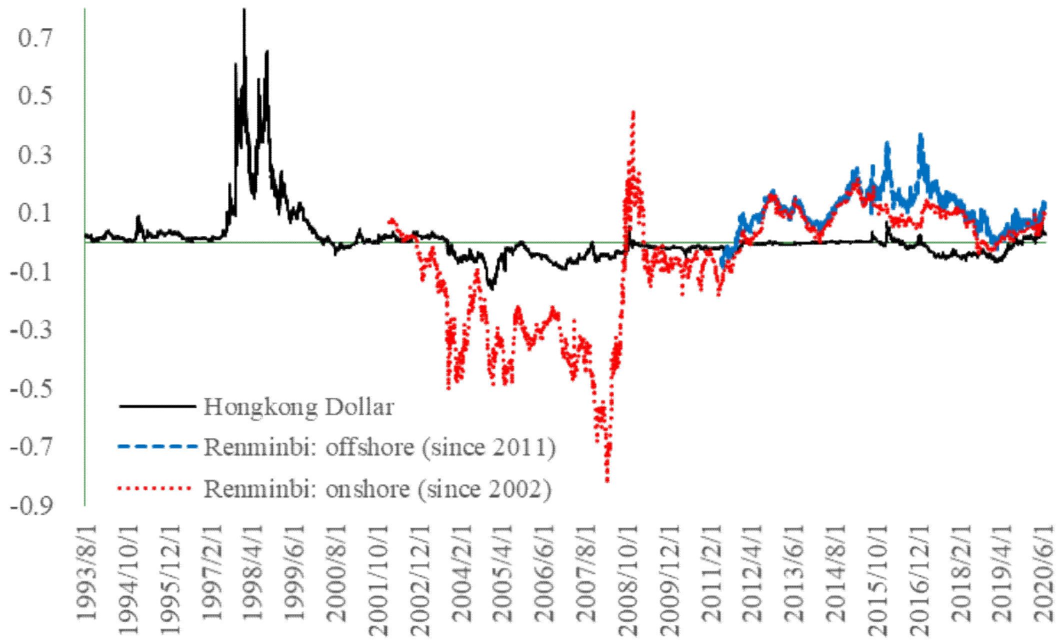

Figure 2: Expected Exchange Rate Changes of Renminbi and Hong Kong Dollar

MarketSentiment_t is a variable at the stock market level, the ratio of price-to-sales ratios of stock indices (domestic market versus the US stock market, or mainland versus Hong Kong stock market). The price-to-sales ratio is used instead of price-earning ratio, considering that some stocks have negative PE ratios (Arquette et al., 2008). For stock market indices, we choose the Shanghai A-Share Index, Hang Seng China Enterprises Index and S&P 500 Index, respectively.

$\text{DividendYield}_{i,t}$ is an indicator for individual stocks, the dividend yield of A-share in the past 12 months. For AH premium analysis, this variable is defined as a ratio of the dividend yield of A-share versus H-share in the past 12 months.

$\text{Illiquidity}_{i,t}$ is an indicator proposed by Amihud (2002) to measure stock level illiquidity. A higher value means more illiquidity, as one dollar of trading volume generates a larger price impact (absolute value of stock returns). Specifically, the illiquidity of stock i in month t is defined as:

$$\text{Illiquidity}_{i,k} = \frac{1}{N_{i,t}} \sum_{d=1}^{N_{i,t}} \frac{|r_{i,d,k}|}{Dvol_{i,d,k}}$$

where $|r_{i,d,k}|$ is the absolute value of return on stock i on day t during month k, $Dvol_{i,d,k}$ is the trading volume in million US dollars of stock, and $N_{i,t}$ is the number of trading days (with non-zero trading volume) during month k. For the analysis of AH premium, ratio of this illiquidity indicator between A and H shares is used. Since the illiquidity indicator has a monthly frequency, it is replicated for each day in the same month, thus converted into daily data.

We follow Mei et al. (2009) to define a proxy for speculative motives, $\text{SpeculativeMotive}_{i,t}$; that is,

$$\tau_{it}^{A} = \ln\left(1 + turnover_{it}^{A}\right), \tau_{it}^{H} = \ln\left(1 + turnover_{it}^{H}\right),$$

where $turnover_{it}^{A}$、$turnover_{it}^{H}$ are turnover rates of A-share and H-share respectively. Mei et al. (2009) shows that the speculative component in A-share prices is positively related to the turnover rate. Since turnover series of ADRs are not available, we employ τ_{it}^{A} as the proxy for speculative motive in A-ADR premium analysis. However, the turnover rates may be less indicative of speculative components for H-share and can be used as a liquidity indicator. For AH premium analysis, the speculative indicator is defined as τ_{it}^{A} minus τ_{it}^{H}.

$\text{InformationAsymmetry}_{i,t}$ is a proxy of standard deviation of stock prices within a month, as in Beckmann et al. (2015) and Grossmann and Ngo (2020). Because multiple stock markets are involved, we use the ratio of the standard deviations between ADR and A-share (or H-share) for ADR premium analysis and use the ratio between A-share and H-share in the AH premium analysis.

Several policy-related variables are also included in the empirical analysis, including financial openness and reform of stock market trading rules. Given that existing indices of China's capital account openness have few observations or barely change (such as the Chinn-Ito index and the capital account openness index released by the IMF), we introduce two financial openness measures *Openness1* and *Openness2* (annual data), where *Openness1*is the ratio of overseas assets and liabilities to GDP ratio, and *Openness2*is the ratio of overseas assets and liabilities (excluding foreign exchange reserves) to GDP. When analyzing the AH premium, we consider Shanghai (Shenzhen)-Hong Kong Stock Connect as an important mechanism for financial openness, and set dummy variables $D_{SH\ Connect}$ accordingly.

The relaxation of short sale constraints on A-share was a milestone of stock market reform in mainland China. The reform was implemented gradually, applied to different stocks on different dates, as listed in Appendix Table 1 for our sample stocks. We define a policy dummy $D_{Short-sell}$ according to the dates for individual stocks.

Our sample covers all cross-listed stocks in the US, mainland China and Hong Kong stock exchanges (cross-listed stocks in the OTC market are excluded). Specifically, there are 9 A-ADR stock pairs (listed in the three markets) and 116 AH stock pairs (Main-Board and Small and Medium Enterprise Board in China's stock market), as according to data accessed at the end of June 2020. The information and listing dates of the 15 companies are provided in Appendix Table 1, while the corresponding details for other AH cross-listed companies are omitted for the sake of concision, but are available upon request. The full sample period runs from February 1993 to June 2020, but is automatically restricted to January 2002 onward, due to the availability of forward exchange rates.

Data on individual stocks are retrieved from Wind Database; these include daily stock prices, trading volumes, price-to-sale ratios, and dividend yields. From the same database, we also obtain price-to-sales ratios of stock market indices, including the S&P 500, Hang Seng China Enterprises Index, and Shanghai A-share Index. Some other series are extracted from DataStream, including spot exchange rate of CNY (and HKD) versus the US dollar, and CNY (and HKD) forward contract rates (with a duration of 1 year) versus USD. The financial openness indicators are constructed by the authors based on data from China's National Bureau of Statistics and State Administration of Foreign Exchange. Our sample constitutes unbalanced panel data.

Table 1 summarizes the descriptive statistics of selected variables. A-ADR premium averages around 30%, and AH premiums 35% for the whole sample. For the explanatory variables, the expected offshore RMB exchange rate depreciation is stronger than that of the onshore exchange rate. The price-to-sales ratio of A-shares is higher than that of ADRs, and information asymmetry is more severe for ADRs than for H-shares. Given factors related to the composition of investors, A-shares carry weaker liquidity, and stronger speculative motives than H-shares. According to unit root tests of variables (Appendix Table 2), the time-series and panel data are all stable, hence can be used for our empirical analysis.

Table 1: Summary Statistics for Selected Variables (Jan 2002-June 2020)

	Obs.	Mean	Std. Dev.	Min	Max
Panel A: Mainland China-US ADR sample (9 A–ADR stock pairs)					
A-ADR premium (offshore RMB exchange rate, %)	21,933	29.362	19.572	–35.475	76.956
A-ADR premium (onshore RMB exchange rate, %)	35,768	34.900	21.702	–48.630	85.049
Expected exchange rate change (offshore)	2,375	0.110	0.070	–0.081	0.370
Expected exchange rate change (onshore)	4,604	–0.077	0.204	–0.827	0.452
Market sentiment (relative price-to-sales ratio)	4,741	1.100	0.616	0.430	3.580
Dividend yield	37,505	1.745	1.829	0.000	14.144
Illiquidity indicator	37,368	0.158	0.353	0.002	4.982
Speculative motive	34,895	0.555	0.542	0.000	4.091
Information asymmetry	37,368	1.300	0.639	0.133	8.855
Panel B: Mainland China -Hong Kong sample (116 A-H stock pairs)					
A-H premium (%)	273,214	35.009	25.828	–68.317	92.409
A-H premium (%, the 9 companies)	32,909	33.923	21.291	–30.948	85.447
Market sentiment (A-H)	4,565	0.702	0.216	0.248	1.383
Dividend yield (A-H)	246,756	0.657	0.389	0.000	13.829
Illiquidity Indicator (A-H)	297,571	1.238	6.541	0.000	476.513
Speculative motive (A-H)	273,410	0.243	0.590	–3.401	4.285
Information asymmetry (A-H)	299,504	1.028	1.303	0.000	123.212
Natural logarithm of market capitalization (in millions RMB)	302,574	6.128	1.607	1.782	11.223
Panel C: Other Variables					
The US dollar index (JP Morgan)	4,826	109.422	9.899	92.279	132.947

Note: 1. A-ADR premium (offshore RMB exchange rate) is based on offshore RMB versus USD exchange rate (CNH); The CNH data start on April 30, 2012, retrieved through the Wind database from ICAP. A-ADR premium (onshore RMB exchange rate) is calculated with onshore RMB versus USD exchange rate, which is published by the China Foreign Exchange Trade System and dates back to January 2, 1981.

2. "The 9 companies" means the 9 companies cross-listed in the US, mainland China, and Hong Kong markets.

4.2 Determinants Analysis of A-ADR Premium

Table 2 presents impacts of explanatory variables on A-ADR premium based on equation (10)[4], and the following observations are noteworthy. First,

[4] VIF (Variance Inflation Factor) statistics indicate no severe multicollinearity in our empirical analysis. For models in Table 2, VIF values of all variables are less than 3, mean VIF value of the model is less than 2. For models of AH premiums, the mean values of VIFs are less than 3, only the VIF value of dummy variable $D_{SH\,Connect}$ is around 5, indicating mild collinearity. For this reason, we adopt variable $Openness1$ instead of $D_{SH\,Connect}$ in the optimal model for AH premium.

$\text{ExpectedExchangeRateChange}_t$ has a positive impact on the A-ADR premium, or alternatively, the premium shrinks as investors anticipate RMB appreciation (decline of $\text{ExpectedExchangeRateChange}_t$). That is, RMB appreciation increases the value of the underlying asset of the listed companies, and thereby reduces A-ADR premium. This is consistent with the results in our theoretical model and with the study by Arquette et al. (2008) which examines ADR and Hong Kong H-share discounts versus A-share during 1998-2006. The impact of $\text{ExpectedExchangeRateChange}_t$ remains both statistically and economically significant as we add more explanatory variables.

Second, the higher MarketSentiment_t the domestic market (mainland China) has, the higher the A-share price relative to ADR (higher A-ADR premium), which is consistent with Arquette et al. (2008).

Third, shares with higher dividend payment ($\text{DividendYield}_{i,t}$) are more attractive to US investors (due to favorable capital gain tax arrangement or lower holding costs), and produce higher ADR prices, thereby generating lower A-ADR premium. This is in line with the reasoning in Arquette et al. (2008) and Grossmann and Ngo (2020).

Fourth, illiquid shares include a liquidity compensation component in their prices (Amihud, 2002). Consequently, those illiquid A-shares are less attractive to ADR investors, and worsen the liquidity condition of corresponding ADRs. This can add to the A-ADR premium. Fifth, information asymmetry of underlying stocks ($\text{InformationAsymmetry}_{i,t}$) is positively related to the A-ADR premium. This is because information asymmetry hampers price discovery and is associated with persistent ADR mispricing, as documented in Beckmann et al. (2015). Sixth, the US dollar index ($\text{USdollarIndex}_\text{t}$) is positively related to A-ADR premium, which is consistent with evidence in Zhang et al. (2020) regarding the AH premium index. Introduction of the $\text{USdollarIndex}_\text{t}$ variable weakens the influence of $\text{ExpectedExchangeRateChange}_t$, and adds to the explanatory power of the model.

Table 2: Determinants of A-ADR Premium (onshore exchange rate)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
$\text{ExpectedExchangeRateChange}_t$	22.612***	17.049***	20.331***	17.352***	22.222***	24.324***
(onshore exchange rate)	(0.583)	(0.564)	(0.595)	(0.654)	(0.593)	(0.614)
MarketSentiment_t	12.077***	15.115***	15.528***	15.104***	12.880***	13.376***
	(0.183)	(0.182)	(0.183)	(0.182)	(0.200)	(0.203)
$\text{DividendYield}_{i,t}$	–3.841***	–3.936***	–3.933***	–3.938***	–4.015***	–4.006***
	(0.053)	(0.051)	(0.051)	(0.051)	(0.050)	(0.050)
$\text{Illiquidity}_{i,t}$	16.032***	14.042***	12.656***	13.927***	11.014***	10.194***
	(0.287)	(0.276)	(0.287)	(0.303)	(0.297)	(0.303)
$\text{SpeculativeMotive}_{i,t}$	7.162***	5.901***	6.218***	5.905***	4.699***	5.039***
	(0.195)	(0.187)	(0.187)	(0.187)	(0.191)	(0.193)
$\text{InformationAsymmetry}_{i,t}$	4.417***	3.703***	3.621***	3.693***	3.335***	3.303***
	(0.145)	(0.139)	(0.139)	(0.139)	(0.138)	(0.138)
$\text{USdollarIndex}_\text{t}$		60.663***	44.227***	60.016***	65.297***	52.307***
		(1.030)	(1.426)	(1.249)	(1.035)	(1.455)

Openness1			–26.559***			–20.388***
			(1.600)			(1.609)
Openness2				–1.286		
				(1.405)		
$D_{Short-sell}$					–7.368***	–6.775***
					(0.284)	(0.288)
Constant	17.092***	–268.526***	–165.200***	–264.212***	–281.699***	–201.321***
	(0.316)	(4.857)	(7.885)	(6.769)	(4.836)	(7.970)
Observations	34,132	34,132	34,132	34,132	34,132	34,132
Adj-R^2	0.413	0.467	0.471	0.467	0.477	0.480

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Consistent with the propositions in our theoretical models, the policy variables have the predicted signs and significant coefficients, and add to the explanatory power of the estimation model. Specifically, financial openness significantly narrows A-ADR premium, as seen from both indicators *Openness1* and *Openness2*. The introduction of these two financial openness indicators strengthen the positive impact of expected exchange rate changes, and weaken the impact of the US dollar index. This may reflect the coordinated advancement of Chinese financial opening and exchange rate reform progress.

The relaxation of short sale constraints on A-shares significantly narrows the A-ADR premium, which confirms our theoretical results. The transmission mechanisms could be two-fold. First, the easing of constraints adds A-share stock liquidity, strengthen the impact of dividend yield, and weakens the impacts of speculative motive and information asymmetry (as displayed in column (5), Table 2), thus facilitates price discovery in the domestic market. Second, it helps to moderate the deviation of ADR prices' from its fundamental value, which is an opposite effect to that of a prohibition on short selling as stated in Blau et al. (2012).

As onshore and offshore Renminbi exchange markets are segregated, we also analyze A-ADR premiums using offshore Renminbi/US dollar exchange rate. Table 3 shows that the explanatory variables share the same signs as those in Table 2, with the exception of the expected foreign exchange rate, where the sign changes after adding the US dollar index. Such a change is probably due to the collinearity between these two variables; therefore, we omit the US dollar index in the following estimations. The magnitude of the effect of the expected offshore exchange rate on A-ADR premium is smaller than that of the onshore exchange rate. The coefficient of expected offshore exchange rate change is 10.970 (column (1) in Table 3), and its standard deviation is 0.0696, hence a one-standard increase in expected offshore exchange rate leads to an increment in A-ADR premium of about 0.764 percentage points. The influence is smaller than that of onshore exchange rate, where a one-standard deviation in expected onshore exchange rate change leads to a change in

A-ADR premium of about 4.617 percentage points. This reflects the fact that onshore Renminbi exchange rate was not liberalized in its early years, and investors tend to be more sensitive to its fluctuation than to that of offshore exchange rate.

Table 3: Determinants of A-ADR Premium (offshore exchange rate)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
$\text{ExpectedExchangeRateChange}_t$	10.970***	–30.916***	15.040***	46.374***	16.910***	23.390***
(offshore exchange rate)	(1.737)	(1.501)	(1.473)	(1.608)	(1.772)	(1.489)
MarketSentiment_t	11.809***	39.695***	26.068***	24.088***	6.788***	19.385***
	(0.689)	(0.639)	(0.605)	(0.631)	(0.762)	(0.654)
$\text{DividendYield}_{i,t}$	–2.807***	–2.860***	–2.921***	–2.899***	–2.815***	–2.935***
	(0.059)	(0.049)	(0.050)	(0.052)	(0.059)	(0.049)
$\text{Illiquidity}_{i,t}$	50.330***	82.099***	72.309***	63.786***	38.570***	56.416***
	(1.405)	(1.207)	(1.216)	(1.255)	(1.602)	(1.359)
$\text{SpeculativeMotive}_{i,t}$	14.477***	12.272***	12.863***	14.221***	14.283***	12.560***
	(0.307)	(0.255)	(0.261)	(0.271)	(0.305)	(0.257)
$\text{InformationAsymmetry}_{i,t}$	4.428***	3.271***	5.052***	5.133***	4.316***	4.908***
	(0.197)	(0.163)	(0.167)	(0.175)	(0.196)	(0.165)
$\text{USdollarIndex}_\text{t}$		113.881***				
		(1.187)				
Openness1			–161.496***			–164.917***
			(1.831)			(1.809)
Openness2				–174.415***		
				(2.344)		
$D_{Short-sell}$					–8.113***	–11.285***
					(0.541)	(0.456)
Constant	11.419***	–538.910***	160.210***	170.166***	22.613***	178.933***
	(0.623)	(5.762)	(1.768)	(2.204)	(0.971)	(1.898)
Observations	19,812	19,812	19,812	19,812	19,812	19,812
Adj-R^2	0.315	0.532	0.508	0.465	0.323	0.523

4.3 Determinants Analysis of A-H Premium

Drawing on the rich data set of 116 A-H stock pairs, we analyze the effects of explanatory variables on AH premium, in order to provide additional insights and check similarities with A-ADR premium determinants. A concern with the whole sample regressions is that the relationship of interest may be disturbed by omitted company characteristics, to reduce this concern we control for firm capitalization in our estimations. Results of the whole sample and a subsample of the 9 companies (cross-listed in three markets) are presented in Table 4. The interpretation of the estimation coefficient signs and significance are parallel to those of A-ADR premium. Financial openness and removal of short sale constraints again appear to narrow the A-share and H-share price gaps. However, the magnitudes of these influences differ across variables. A one-standard deviation variation in market sentiment causes an adjustment to AH premium of 6.481 percentage points, which is smaller than the 7.270 percentage points of A-ADR premium, reflecting higher sensitivity of ADR investors with respect to market fluctuations. A one-standard deviation changes in information indicators leads to an adjustment to AH premium of 0.889 percentage points, much smaller than the impact on A-ADR premium (about 7.584 percentage points); this difference could be attributed to a lower level (and larger marginal effect) of information asymmetry between the A and H markets than between the A and ADR markets. Compared with the whole sample, the AH premiums of the 9 companies are more sensitive to market sentiment, financial openness and enabling of short selling. Moreover, these 9 companies are less sensitive to dividend yield as a one-standard deviation rise of dividend yield can reduce AH premiums by 8.251 percentage points, as compared to 12.427 percentage points for the whole sample of 116 companies.

Table 4: Determinants of A-H Premium

Variables	All 116 Companies				The 9 Companies			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
$\mathrm{USdollarIndex}_t$	12.560***	–7.075***	23.521***	9.123***	–14.276***	–39.147***	21.032***	–4.220***
	(0.357)	(0.519)	(0.746)	(0.553)	(1.012)	(1.363)	(1.924)	(1.437)
$\mathrm{MarketSentiment}_t$	25.521***	28.388***	27.371***	29.904***	28.885***	32.639***	35.369***	37.558***
	(0.193)	(0.199)	(0.222)	(0.198)	(0.458)	(0.474)	(0.545)	(0.459)
$\mathrm{DividendYield}_{i,t}$	–34.971***	–34.198***	–34.825***	–32.540***	–28.984***	–28.011***	–27.661***	–22.174***
	(0.095)	(0.096)	(0.096)	(0.097)	(0.248)	(0.248)	(0.254)	(0.258)
$\mathrm{Illiquidity}_{i,t}$	–0.008*	–0.012**	–0.011**	–0.036***	–0.708***	–0.793***	–0.825***	–1.067***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.035)	(0.035)	(0.035)	(0.034)
$\mathrm{SpeculativeMotive}_{i,t}$	0.262***	0.537***	0.233***	–0.462***	0.041	0.329	–0.578***	–1.956***
	(0.061)	(0.061)	(0.061)	(0.062)	(0.204)	(0.202)	(0.205)	(0.197)
$\mathrm{InformationAsymmetry}_{i,t}$	0.634***	0.590***	0.698***	0.650***	–1.480***	–1.504***	–1.014***	–1.649***
	(0.040)	(0.039)	(0.040)	(0.039)	(0.177)	(0.175)	(0.177)	(0.167)
ln(capitalization)	–5.597***	–5.598***	–5.574***	–5.014***	–2.681***	–2.595***	–2.646***	–2.400***
	(0.024)	(0.024)	(0.024)	(0.025)	(0.071)	(0.070)	(0.071)	(0.067)
Openness1		–34.395***		–29.616***		–41.930***		–26.406***
		(0.662)		(0.657)		(1.560)		(1.511)
$D_{\text{SH connect}}$			–2.612***				–8.737***	
			(0.156)				(0.406)	
$D_{\text{Short-sell}}$				–6.496***				–12.614***
				(0.083)				(0.222)
Constant	12.644***	136.490***	–39.270***	53.719***	120.806***	275.339***	–47.375***	95.470***
	(1.655)	(2.897)	(3.514)	(3.052)	(4.746)	(7.421)	(9.127)	(7.749)
Observations	243,484	243,484	243,484	243,484	31,857	31,857	31,857	31,857
Adj-R^2	0.601	0.605	0.601	0.615	0.452	0.464	0.460	0.514

In addition to *Openness1* and *Openness2*, we also consider SH Connect as an important milestone for financial openness, and investigate its influence on AH premium. Table 4 shows that the dummy variable $D_{\mathrm{SH\ connect}}$ has negative and significant impacts on AH premium (more economically significant for the 9 companies), implying that SH Connect has improved price parity in the two stock markets. This adds to the findings of existing studies, which explain the jump in the AH premium index in December 2014 as mainly driven by systematic shifts in the US dollar index, market sentiment and other factors (Nishimura et al., 2018; Chan and Kwok, 2015)[5].

4.4 Exchange Rate Reform Affects the Sensitivity of A-ADR and AH Premium on Exchange Rates

The RMB foreign exchange rate regime began in 1994 as a market-based, managed floating rate with reference to the U.S. dollar system. On July 21, 2005, it became a managed floating exchange rate based on market supply and demand with reference to a basket of currencies. On August 11, 2015, the People's Bank of China changed the RMB/USD central parity quoting mechanism to enhance the market determination of RMB exchange rate (hereafter, "8.11 Reform"). According to Das (2019), the RMB/USD exchange rate appreciated by about 26% during the period from July 2005 to July 2015, and real effective exchange rate appreciated by 58%. Since the reform in 2015, the RMB/USD exchange rate has followed a path of depreciation, and market expectations of substantial depreciation were strong during 2015 to 2018 (Figure 2). Under such circumstances, the RMB/USD exchange rate of "7" became a psychologically important level.

Comparing the influences of onshore and offshore RMB exchange rate on A-ADR price premiums prior to and after the related reforms can shed light on the effectiveness of these reforms. As demonstrated in Table 5, the impact of onshore RMB exchange rate on A-ADR premium has significantly increased while that of the US dollar has decreased since the "8.11 reform" (as compared with column (2) in Table 2), and the impacts of onshore and offshore rates have been further enhanced since the market quoted RMB exchange rate dropped below 7. This has illustrated the effectiveness of financial opening and exchange rate reform policies[6]. First, the

[5] The shifts could be confirmed through t-test and standard deviation comparison of the explanatory factors around December 2014 (the initiation of SH-connect). Results omitted here for concision, but available upon request.

[6] We confirm this conclusion with rolling window estimations. A window of 36 months is adopted for estimating the A-ADR premium determinant model with variables including expected exchange rate changes, US dollar index and Openness1. Only significant coefficients of the three variables are retained. The results show that expected changes of onshore exchange rate exerts larger impacts on A-ADR premium after August 2015 and the second half of 2019, roughly consistent with the timing of the "811 reform" and RMB exchange rate dropping below "7". Meanwhile, the influence of the dollar index weakened significantly. In addition, the role of financial opening in narrowing A-ADR premium was relatively stable before 2010, became most significant during

financial opening policies have strengthened the linkage between A-shares and ADR, and RMB/USD exchange rates as an important market-based rate exert greater impacts on the ADR prices. Second, since the "8.11 reform", floating flexibility of onshore RMB exchange rates has been gradually enhanced, together with the investors' adaptability to its changes. Third, since the exchange rate dropped below the psychologically important level of 7, investors are more sensitive to signals of exchange rate volatilities.

Table 5: Effectiveness of Exchange Rate Reform as seen from A-ADR Premium

Variables	**August 11, 2015** (the "811 reform") **- June 30, 2020**		**August 5, 2019** (RMB exchange drops below "7") **- June 30, 2020**	
	(1)	**(2)**	**(3)**	**(4)**
$\text{ExpectedExchangeRateChange}_t$ (onshore exchange rate)	35.602***		81.865***	
	(3.417)		(8.332)	
$\text{ExpectedExchangeRateChange}_t$ (offshore exchange rate)		3.754		76.410***
		(2.452)		(7.998)
MarketSentiment_t	4.065***	6.245***	75.834***	96.444***
	(1.509)	(1.671)	(6.941)	(6.176)
$\text{DividendYield}_{i,t}$	–1.863***	–1.888***	–1.538***	–1.522***
	(0.052)	(0.053)	(0.068)	(0.070)
$\text{Illiquidity}_{i,t}$	71.460***	73.496***	69.174***	70.808***
	(2.513)	(2.534)	(2.842)	(2.903)
$\text{SpeculativeMotive}_{i,t}$	7.332***	7.418***	–13.923***	–13.410***
	(0.360)	(0.365)	(0.987)	(1.001)
$\text{InformationAsymmetry}_{i,t}$	2.750***	3.333***	–1.165***	–0.510**
	(0.176)	(0.173)	(0.244)	(0.240)
USdollarIndex_t	52.862***		76.055***	
	(4.063)		(9.343)	
Constant	–229.292***	23.547***	–366.300***	–12.200***
	(19.671)	(0.917)	(43.349)	(3.032)
Observations	10,610	10,610	1,962	1,962
Adj-R^2	0.250	0.231	0.415	0.382

The effectiveness of RMB exchange rate reform is also confirmed by the sensitivity of AH premium to the US Dollar (Table 6). Since the "8.11 Reform" the AH premiums have become less sensitive to the US dollar index, implying that investors in Hong Kong are more adaptive to fluctuations in RMB/HKD exchange rate[7]. However, its influence on the whole sample is smaller than on the 9 companies, which might reflect investors' heterogeneous requirements on exchange rate premium for different stocks[8]. Although the sensitivity of AH premium on the US dollar index

2013-2014, but has been weakened since 2017.

[7] Rolling window estimations show that the influence of US dollar index on AH premium fluctuates widely over time. It was significantly enhanced after the global financial crisis, but weakened significantly around the launch of Shanghai-Hong Kong Stock Connect. Financial opening reduced AH premium significantly before 2017, while since 2017 its influence has been weakened.

[8] In general, equities in counter-cyclical sectors are less sensitive to foreign exchange rate changes.

increased after the RMB/USD exchange rate dropped below 7 in August 2019, for the 9 companies the magnitude is around two-thirds of the influence of the "8.11 Reform", implying that the effects of market connection mechanism and the exchange rate reform are generally solid.

Table 6: Sensitivity of AH Premium to the US Dollar: Before and After Exchange Rate Reform

Variables	All 116 Companies		The 9 Companies	
	(1)	(2)	(3)	(4)
USdollarIndex_t	14.865***	–59.088***	4.430**	–53.916***
	(0.677)	(1.498)	(1.756)	(3.019)
MarketSentiment_t	25.648***	8.941***	30.956***	16.171***
	(0.195)	(0.329)	(0.483)	(0.649)
$\text{DividendYield}_{i,t}$	–34.962***	–48.811***	–28.520***	–53.634***
	(0.095)	(0.163)	(0.250)	(0.408)
$\text{Illiquidity}_{i,t}$	–0.009*	–0.068***	–0.740***	–0.019
	(0.005)	(0.004)	(0.035)	(0.060)
$\text{SpeculativeMotive}_{i,t}$	0.236***	0.277***	–0.568***	–1.570***
	(0.062)	(0.075)	(0.209)	(0.284)
$\text{InformationAsymmetry}_{i,t}$	0.637***	2.454***	–1.640***	–0.173
	(0.040)	(0.073)	(0.177)	(0.209)
ln(capitalization)	–5.592***	–3.386***	–2.689***	–0.437***
	(0.024)	(0.029)	(0.071)	(0.070)
$\text{D}_{811\ \text{Reform}} \cdot \text{USdollarIndex}_t$	–0.111***		–0.984***	
	(0.028)		(0.076)	
$\text{D}_{\text{ExchangeRateBelow7}} \cdot \text{USdollarIndex}_t$		0.738***		0.639***
		(0.023)		(0.049)
Constant	–542.392***	167.179***	33.217***	318.354***
	(10.642)	(25.907)	(8.228)	(14.538)
Observations	243,484	102,491	31,857	10,306
Adj-R^2	0.601	0.674	0.455	0.676

Note: $\text{D}_{811\ \text{Reform}}$ is a dummy for dates since August 11, 2015 (the "811 reform"), $\text{D}_{\text{ExchangeRateBelow7}}$ is a dummy for dates since August 5, 2019, when the market quoted RMB exchange rate dropped below 7. For columns (2) and (4), the sample period is restricted to August 11, 2015-June 30, 2020.

4.5 Relative Importance of Factors in Explaining Cross Market Price Premiums

Following Harmon and Walker (1995), Shea (1997) and Artavanis et al. (2015), we calculate partial r-squares to illustrate which variables are incrementally important. Based on an optimal model, partial R^2 of a variable x is calculated by removing it and keeping all other variables, then comparing the error sum of squares (SSE) of the reduced model and optimal model[9]. A higher value of partial R^2 means the variable is incrementally more important.

Overall, micro-level factors are more important than macro-level and meso-level factors in determining A-share price premium. Table 7 shows that four factors are

[9] The proportion of variation explained by x that cannot be explained by the other factors (denoted as group A) is given by $R^2_{x|A} = \frac{SSR(x|A)}{SSE(A)} = \frac{SSE(A) - SSE(A,x)}{SSE(A)}$. Partial r-squares do not necessary add up to R^2 of the optimal model.

relatively more important than others in explaining A-ADR premium, namely, dividend yield, financial openness, speculative motive, and illiquidity indicator. This implies that the abnormal A-share premium versus ADR (as compared with ADR premium in other economies) is mainly caused by China's institutional and market-specific features. The orderly opening-up of financial markets, strong speculative motives of A-share investors, and illiquidity of individual stocks all contribute to the price premium. For A-ADR premium based on offshore exchange rate, investors care most about financial openness. For AH premium, dividend ratio and financial openness contribute most, while market sentiment and the relaxation of short sale constraints are more important than speculative motive and illiquidity indicator and other factors, whose partial R^2 are less than 0.02. Meso-level factors are incrementally more important for explaining AH premium than for A-ADR premium, possibly resulting from the more severe cross-market herding behavior in A-H markets than in A-ADR markets.

Moreover, after the "8.11 Reform", the partial R^2 of expected exchange rate change (both onshore and offshore exchange rates) declines from over 0.04 to less than 0.002, its ranking also drops significantly. This re-confirms our views that the effect of the exchange rate reform is solid, and that foreign investors are more adaptive to fluctuations in RMB exchange rates.

Table 7: Partial R^2 of Main Explanatory Variables

Variables		A-ADR Premium: Onshore exchange rate, Since August 2005	A-ADR Premium: Onshore exchange rate, Since "811" reform	A-ADR Premium: Offshore exchange rate, Since August 2005	A-ADR Premium: Offshore exchange rate, Since "811" reform	A-H Premium: All 116 Companies	A-H Premium: The 9 Companies
Macro-level	Expected exchange rate change	0.044	0.001	0.042	0.002	--	--
	US dollar index	0.020	0.001	--	--	0.000	0.005
Meso-level	Capital account openness	**0.067**	**0.074**	**0.329**	**0.096**	**0.259**	**0.281**
	Market sentiment	0.120	0.002	0.048	0.005	**0.030**	**0.116**
	Removal of short sale constraints	0.035	--	0.032	--	**0.031**	**0.127**
Micro-level	Dividend yield	**0.183**	**0.114**	**0.166**	**0.116**	**0.386**	**0.159**
	Illiquidity indicator	**0.029**	**0.060**	**0.075**	**0.062**	0.016	0.012
	Speculative motive	**0.041**	**0.038**	**0.165**	**0.105**	0.007	0.000
	Information asymmetry	0.025	0.014	0.035	0.011	0.002	0.009

Note: Due to data availability of *Openness1*, this table covers only the sample period between 2014 and 2019.

V. Conclusion and Policy Implications

This paper explores the micro-, meso-, and macro-level determinants of the significant AH and A-ADR premiums over the period 2002-2020. The empirical analyses find that the most important determinants of the two types of premium are micro-level factors (dividend yield, share liquidity, speculative incentive of investors, information asymmetry, etc.), followed by macro- (expected foreign exchange rate changes, and financial openness) and meso-level (market sentiment) factors. The following findings are noteworthy. First, dividend ratio is the most decisive in premium determination, meaning that international investors pay most attention to fundamentals. Second, market sentiment is incrementally more important for explaining AH premium than A-ADR premium, reflecting the fact that irrational cross-market herding behavior is stronger between the A and H markets than between the A and ADR markets. Third, over the observed period overseas investors are more sensitive to China's financial market openness, and more adaptive to RMB foreign exchange rate volatility.

The relative importance of determinants for the premiums also illustrates that the Chinese equity market still lacks investor rationality and a degree of financial openness. For example, the high A-ADR premium mainly comes from insufficient market openness, speculative incentives and lack of liquidity. Empirical analysis of A-H premium also confirms that financial openness and market sentiment are important in determining AH premiums.

The empirical results manifest the impacts of foreign exchange rate reform and financial openness policies. For example, impacts of expectations of onshore foreign exchange rate on A-ADR premium have been much enhanced since the "8.11 Reform", while the impacts of the US dollar index have been moderated. Both confirm the effectiveness of the RMB foreign exchange rate reform. Meanwhile, the reduced relative importance of expected (onshore) foreign exchange rates in determining premiums also reflects that overseas investors are more adaptive to foreign exchange rate volatilities in China. These results based on individual share prices confirm the conclusion of Zhang et al. (2020) that the systematic rise of the AH premium after late 2014 can be attributable to the US dollar index, while the introduction of SH Connect has enhanced the price discovery capacity of A-shares.

The empirical findings show that certain policy measures can help to enhance the price discovery capacity of the Chinese equity market and thereby reduce A-ADR and AH premium. These measures include, among others, enhancing RMB foreign exchange rate flexibility and stabilizing foreign exchange rate expectation; improving transaction rules in line with the international best practices; enhancing market connectivity and financial market openness; developing long-term institutional investors to reduce speculative transactions; and setting reasonable dividend ratios to increase investment value of A-shares as well as ADR and H-shares.

It would be valuable for future research to explore the impacts of geopolitics on premiums of cross-listed shares as more Chinese companies may be forced to shift from the US exchanges to the Hong Kong Exchange. In particular, if the pricing mechanism of cross-listed share can generate cross-market externalities, then the cross-listed shares may carry higher value than single-market listed shares. This will make cross-listing a preferred option for many companies.

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Appendix A1. The Proof of Proposition 2

Proposition 2: *If* $\mathbb{E}[e_1] = e_0$*, i.e.,* $e = 1$*, the larger the extent of capital market openness (larger* θ*), the smaller the asset price disparity, i.e.,* $\frac{\partial\Gamma}{\partial\theta} < 0$.

Proof: If $e = 1$, then:

$$\Gamma = \gamma\left(\frac{\theta}{1-\varphi(1-\theta^2)} - 1\right)\varphi\sigma_v,$$

where,

$$\varphi = \frac{v^2\sigma_e + \sigma_v(1+\sigma_e)}{v^2\sigma_e + \sigma_v(1+\sigma_e) + \theta\sigma_v}$$

$$\frac{\partial\varphi}{\partial\theta} = -\frac{\varphi(1-\varphi)}{\theta} < 0$$

We thus obtain:

$$\frac{\partial\Gamma}{\partial\theta} = \gamma\sigma_v\left[\left(\frac{\theta}{(1-\varphi+\varphi\theta^2)^2} - 1\right)\frac{\partial\varphi}{\partial\theta} + \frac{\varphi(1-\varphi-\varphi\theta^2)}{(1-\varphi+\varphi\theta^2)^2}\right]$$

$$= \gamma\sigma_v\frac{\varphi}{\theta(1-\varphi+\varphi\theta^2)^2}[(1-\varphi)(1-\varphi+\varphi\theta^2)^2 - \varphi\theta^3]$$

$$= \gamma\sigma_v\frac{\varphi}{(1-\varphi+\varphi\theta^2)^2}\left[\frac{\sigma_v(1-\varphi+\varphi\theta^2)^2}{v^2\sigma_e + \sigma_v(1+\sigma_e) + \theta\sigma_v} - \varphi\theta^2\right]$$

$$= \gamma\sigma_v\frac{\varphi\theta^2}{(1-\varphi+\varphi\theta^2)^2}\left[\frac{\sigma_v}{v^2\sigma_e + \sigma_v(1+\sigma_e) + \theta\sigma_v}\left(\frac{\sigma_v}{v^2\sigma_e + \sigma_v(1+\sigma_e) + \theta\sigma_v} + \varphi\theta\right)^2 - \varphi\right]$$

$$= \gamma\sigma_v\frac{\varphi^2\theta^2}{(1-\varphi+\varphi\theta^2)^2}\left[\frac{\sigma_v}{v^2\sigma_e + \sigma_v(1+\sigma_e)}\left(\frac{\theta v^2\sigma_e + \theta\sigma_v(1+\sigma_e) + \sigma_v}{v^2\sigma_e + \sigma_v(1+\sigma_e) + \theta\sigma_v}\right)^2 - 1\right]$$

$$= -\gamma\sigma_v\frac{\varphi^2\theta^2}{(1-\varphi+\varphi\theta^2)^2}\frac{\sigma_v(v^2+\sigma_v)\sigma_e}{v^2\sigma_e + \sigma_v(1+\sigma_e)}\left[\left(\frac{\theta v^2\sigma_e + \theta\sigma_v(1+\sigma_e) + \sigma_v}{v^2\sigma_e + \sigma_v(1+\sigma_e) + \theta\sigma_v} + 1\right)\frac{1-\theta}{v^2\sigma_e + \sigma_v(1+\sigma_e) + \theta\sigma_v} + 1\right]$$

$$= -\gamma\sigma_v\frac{\varphi^2\theta^2}{(1-\varphi+\varphi\theta^2)^2}\frac{\sigma_v(v^2+\sigma_v)\sigma_e}{v^2\sigma_e + \sigma_v(1+\sigma_e)}\left[\left(\frac{\theta v^2\sigma_e + \theta\sigma_v(1+\sigma_e) + \sigma_v}{v^2\sigma_e + \sigma_v(1+\sigma_e)}\varphi + 1\right)\frac{1-\theta}{v^2\sigma_e + \sigma_v(1+\sigma_e)}\varphi + 1\right]$$

Therefore, we can obtain $\frac{\partial\Gamma}{\partial\theta} < 0$。 ***Q.E.D.*** ■

Appendix A2. Numerical Analysis of the Model

This paper shows that RMB appreciation expectation and enhanced financial market openness in China can reduce A-ADR and AH premiums. Figure A1 illustrates the features of premium in a more general scenario using numerical analysis. It shows that the higher the expected appreciation of domestic currency (e) and the openness of financial market (θ), the lower the premium. Moreover, higher openness of financial market reduces the marginal impacts of foreign exchange rate expectation on premium.

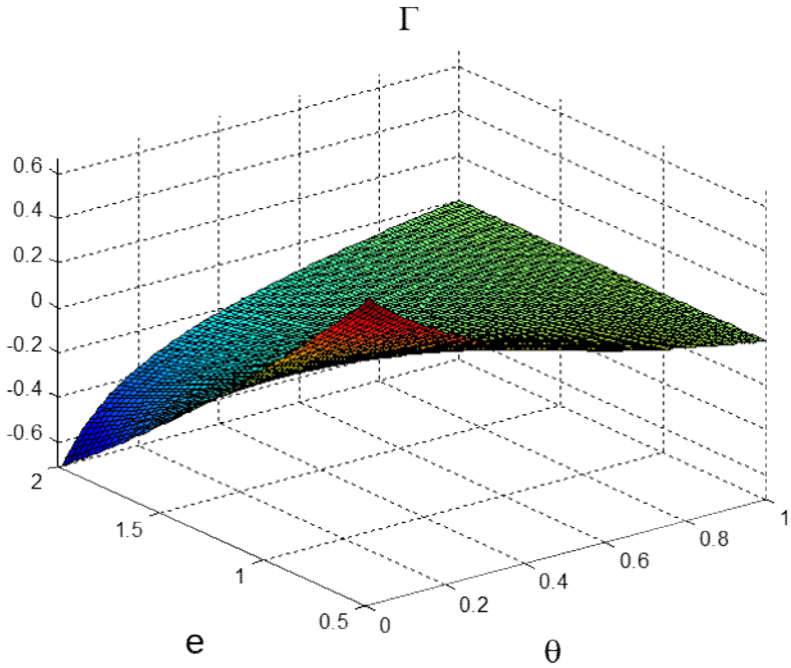

Figure A1.

Impacts of Exchange Rate Expectation and Financial Market Openness on Share Price Premium

Note: $\gamma = 1$、$v = 1.2$、$\sigma_e = 0.1$、$\sigma_v = 0.1$。

Appendix Table 1: The 9 Companies Included in the Sample

Order	Name	H-share		ADR		A-share		
		Ticker	Listing Date	Ticker	ADR Effective Date	Ticker	Listing Date	Short-sell Effective Date
1	Sinopec Shanghai Petrochemical	0338	1993/7/26	SHI	1993/7/26	600688	1993/11/8	2013/9/16
2	Guangshen Railway	0525	1996/5/14	GSH	1996/5/14	601333	2006/12/22	2013/1/31
3	China Eastern Airlines	0670	1997/2/5	CEA	1997/2/4	600115	1997/11/5	2011/12/5
4	China Southern Airlines	1055	1997/7/31	ZNH	1997/7/30	600029	2003/7/25	2011/12/5
5	Huaneng Power International	0902	1998/1/21	HNP	1994/10/5	600011	2001/12/6	2013/1/31
6	PetroChina	0857	2000/4/7	PTR	2000/4/6	601857	2007/11/5	2010/3/31
7	China Petroleum & Chemical	0386	2000/10/19	SNP	2000/10/18	600028	2001/8/8	2010/3/31
8	Aluminum Corporation of China	2600	2001/12/12	ACH	2001/12/11	601600	2007/4/30	2010/3/31
9	China Life Insurance	2628	2003/12/18	LFC	2003/12/17	601628	2007/1/9	2010/3/31

Appendix Table 2: Unit Root Tests (January 2002 – June 2020)

Time Series

Variables	Dickey-Fuller Statistics	p-value
ln(the US dollar index)	–16.318	0.000
Expected exchange rate change (offshore)	–9.959	0.000
Expected exchange rate change (onshore)	–14.227	0.000
Market sentiment (A-ADR)	–13.614	0.000
Market sentiment (A-H)	–2.759	0.064

Panel Data

Variables	FisherStatistics	p-value	Im-Pesaran-Shin Statistics	p-value
A-ADR premium (offshore RMB exchange rate, %)	–0.265	0.605	–4.245	0.000
A-ADR premium (onshore RMB exchange rate, %)	2.149	0.016	–5.679	0.000
Dividend yield (A-share)	10.832	0.000	–9.278	0.000
Illiquidity Indicator (A-share)	18.930	0.000	–16.140	0.000
Speculative motive (A-share)	83.574	0.000	–34.914	0.000
Information asymmetry (A-ADR)	26.546	0.000	–20.489	0.000
A-H premium (%)	34.007	0.000	–21.499	0.000
Dividend yield (A-H)	52.477	0.000	—	—
Illiquidity Indicator (A-H)	109.280	0.000	–73.554	0.000
Speculative motive (A-H)	264.617	0.000	–120.000	0.000
Information asymmetry (A-H)	80.880	0.000	–77.850	0.000
ln(market capitalization)	4.497	0.000	–5.965	0.000

***Note*:** In unit root tests of panel data, the listed Fisher statistic is Modified inv. chi-squared. The null hypothesis Ho: all panels contain unit roots. For Fisher-type unit-root test, Ha: at least one panel is stationary. For Im-Pesaran-Shin unit-root test, Ha: some panels are stationary.