MARKET INTEGRATION AND CURRENCY RISK PRICING IN CHINESE MAINLAND EQUITY MARKET: EVIDENCE FROM SHANGHAI-HONG KONG STOCK CONNECT

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Abstract

This paper investigates the two topics of market integration and currency risk pricing in the Chinese mainland equity market. It also examines the impact of liberalization policies, including currency reform and Shanghai-Hong Kong Stock Connect on the two topics. This paper employs both an unconditional multi-beta pricing model under the International Arbitrage Pricing Theory framework, and a conditional pricing model using the multivariate GARCH-in-Mean setup.

Using both monthly data and weekly data covering the period through January 2001 to September 2017, I find both world market risk and Chinese local market risk are positively priced in the Chinese mainland equity market, providing evidence of partial integration. A weak upward trend is detected for the low correlation between the Chinese mainland equity market and the world market. Currency risk is found to be negatively priced with a time-varying price. While world market risk and currency risk constitute essential components of the long-run total risk premium in the Chinese mainland equity market, local risks remain the dominant source in determining the short-run variations in the total risk premium.

A structural shift in risk pricing is detected after the currency reform for both world market risk and currency risk, making the positive price of world market risk more positive and the negative price of currency risk even more negative. Although foreign participation has increased rapidly after Shanghai-Hong Kong Stock Connect, there are no significant changes observed in the pricing process.

These findings suggest that international investors can still enjoy diversification benefit from the Chinese mainland equity market because of the low level of correlation and partial integration, but they must pay enough attention to the local source of risks and currency risk, and follow closely further liberalization policies.

Declaration

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- I confirm that the work submitted for assessment is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Appreciation

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CHAPTER 1 INTRODUCTION

1.1 Background to the study

Literature has broadly studied the topics of market integration and currency risk pricing for emerging equity markets, but the Chinese mainland equity market is always omitted from previous studies due to many reasons, including its relatively short history, lack of data and various restrictions on foreign holding. This paper intends to apply the international asset pricing model to the Chinese mainland equity market and seeks to answer whether the Chinese mainland equity market is segmented or integrated with the world market and whether foreign currency risk is priced in the Chinese mainland equity market. The two questions are examined in the context of China's gradual move to a more flexible exchange rate and its ongoing opening of the stock market, including the implementation of Shanghai-Hong Kong Stock Connect. The answers are of importance for international investors to understand risk pricing in the Chinese mainland stock market in deciding their portfolio diversification strategies.

Although China has opened many of her industries since joining the WTO, there are still many restrictions in her foreign exchange market and the stock market. RMB was only made fully convertible for current account in 1996; yet, the capital account is not fully open up to now[1]. The Chinese yuan (CNY), known as Renminbi or RMB for short, is under a managed floating regime although it has been getting more flexible since the 2005 currency reform. Foreign investors face various restrictions on investing in the Chinese mainland equity market. Due to currency and foreign holding restrictions, Chinese investors have had limited access to foreign stocks. However, restrictions were substantially lifted through the launch of Shanghai-Hong Kong Stock Connect, through which about 90% of Shanghai A-shares are open to foreign investors. Despite the ongoing opening process, the overall foreign holding in the Chinese mainland equity market is still very low. According to People's Bank of China, overseas entities held 1.17 trillion yuan (USD 179.77 billion) in Chinese domestic Renminbi equities, which accounts for only 2.3% of the total market capitalization of the Chinese mainland equity market[2].

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[1] IMF Country Report No. 17/247.

[2] Data source: Bloomberg. The total market capitalization of the Chinese mainland equity market was 7.72 trillion U.S. dollars as at 31 Dec 2017, equalling to 50.47 trillion yuan. The spot exchange rate of USD/CNY at 31 Dec 2017 was 6.5342.

Due to the low level of foreign holdings, it is reasonable to attribute the pricing of the Chinese mainland equity market mainly to the influence of local investors, which is the perspective taken by the analysis in this paper. In this section, I briefly introduce the exchange rate regime of China and the Chinese mainland equity market.

1.1.1 China Foreign Exchange Rate Regime: Managed Floating

Currently described as “managed floating”, the Chinese exchange rate regime is on its way to liberalization. From 1994 to 2005, it was a purely fixed regime, when Renminbi price of the U.S. dollar was fixed at around 8.28. This fixed regime changed in July 2005, when China announced it would revalue Chinese yuan and implement a “managed floating” regime. This new regime is based on market forces and is adjustable concerning a basket of currencies, but the weights of the basket have never been announced.[3]

This type of managed floating is a fusion of fixed and floating system (Salitan, 2010). While market forces can decide whether Chinese yuan appreciates or depreciates, the monetary authority still has a discrepancy to limit the extent to which RMB appreciates or depreciates. Under the current regime, the daily trading prices of RMB against the U.S. dollar are allowed to move within a narrow trading band that centers on a so-called “central parity” price. The trading band was initially set at ±0.3 percent around the central parity rate, which is released daily by Chinese monetary authority. The setting of central parity rate is relatively opaque. Despite the fact that the market closing price often deviates from the central parity, the daily central parity barely moves. It is worth noting that the trading band has been widened several times and is now ± 2% around the central parity, as shown in Table 1. To increase exchange rate flexibility, a new "central parity exchange rate formation mechanism" was announced in August 2015. Major banks were requested by the monetary authority to provide quotes based on the last-day closing exchange rate as well as their sense of market supply and demand. Further steps were taken to enhance the flexibility of RMB exchange rate, as shown in Table 1.[4]

[3] IMF Country Report No. 17/247.
[4] IMF Country Report No. 17/247.

Table 1 Big events in RMB exchange rate regime

Date	Event
21 Jul 2005	Currency regime reform from fixed to "managed floating."
21 May 2007	The daily limit of fluctuation range was increased from 0.3% to 0.5%
16 Apr 2012	The daily limit of fluctuation range was increased to 1%
17 Mar 2014	The daily limit of fluctuation range was increased to 2%
11 Aug 2015	New "central parity exchange rate formation mechanism" is announced, where the market-making banks need to provide quotes based on previous day's closing price, as well as market supply and demand.
11 Dec 2015	China Foreign Exchange Trading System started to publish the "RMB Effective Exchange Rate Index."
Feb 2016	New guidance on the central parity exchange rate formation. Banks need to provide quotes based on the "previous closing rate plus overnight changes in a currency basket".
26 May 2017	New guidance on the central parity exchange rate formation. Banks need to include a "countercyclical adjustment factor" in their quotes.

Source: People's Bank of China, IMF

Figure 1 shows RMB exchange rate changes. USD/CNY is the nominal RMB price of U.S. dollar. BIS REER is the real effective exchange rate of RMB, reported by BIS (Bank of International Settlement). Generally, the two exchange rates show the same trend of RMB appreciation. Nominally, RMB has appreciated by 19.63% against U.S. dollar from 31 December 2000 to 30 September 2017[5]. As explained earlier, USD/CNY was fixed at about 8.28 yuan per dollar before the currency reform in July 2005, as is evident in Figure 1.

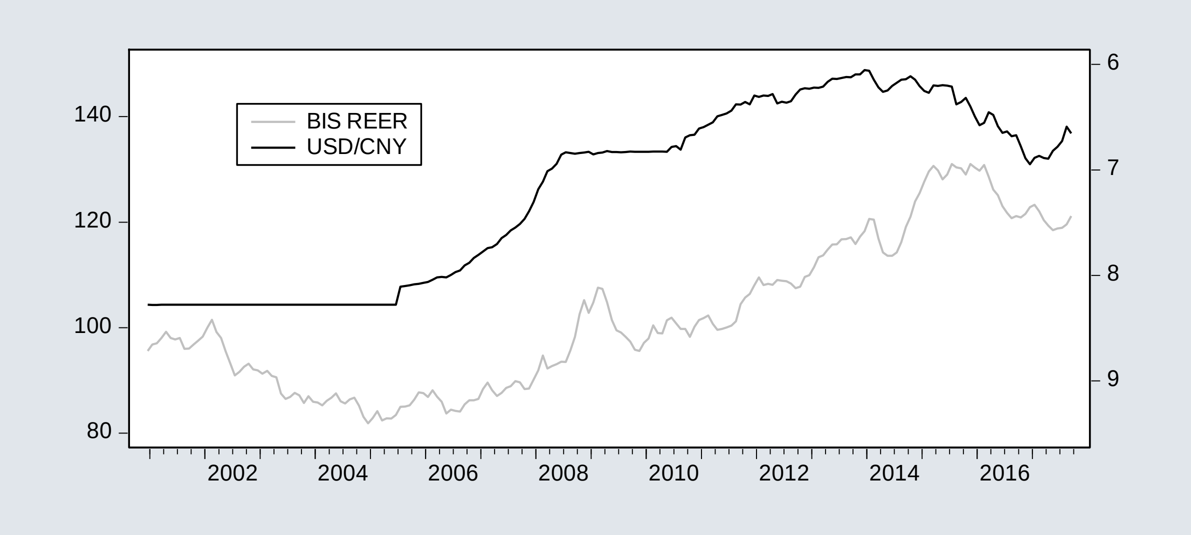
1.1.2 China Semi-Open Equity Market and the Shanghai-Hong Kong Stock Connect

The Chinese equity market consists of three different markets: A-share market, B-share market, and H-share market. A-shares and B-shares are listed on the two stock exchanges in mainland China, namely Shanghai Stock Exchange, and Shenzhen Stock Exchange. Only Chinese domestic investors are allowed to buy A-shares, which is priced in Chinese yuan. B-shares are only investable by foreign investors and investors from Hong Kong, Macau, Taiwan and Chinese citizens who live abroad. B-shares are priced in either HKD or USD. After 19 Feb 2001, Chinese mainland investors are also permitted to buy B-shares. The first B-share was issued in 1991. H-shares are Chinese registered companies' shares listed on the HKEX (The Stock Exchange of Hong Kong). By 31 Dec 2017, there were 3467 A-shares listed on the two mainland stock exchanges. Comparatively, there were only 100 B-shares and 252 H shares

[5] Data source: Bloomberg

listed[6]. The Chinese mainland equity market can be described as a combination of A- and B-share market. Since B-share market is relatively small, the Chinese mainland equity market is dominated by A-share market[7].

Figure 1 RMB exchange rate change



The right axis (inverted) shows nominal USD/CNY (RMB price of U.S. dollar) obtained from Bloomberg. A decrease of USD/CNY means appreciation of Chinese yuan. The left axis shows REER (Real effective exchange rate) of RMB, obtained from Bank of International Settlement. REER is a trade-weighted real currency index. An increase of REER means appreciation of RMB. The graph covers monthly observations from 2001:1 to 2017:9.

On November 2002, China started to open her mainland equity market to QFII, namely Qualified Foreign Institutional Investors. By 31 Dec 2017, foreign institutions had been granted with an accumulated quota of USD 97.16 billion, or 1.3%[8] of the total market capitalization of China mainland stock market. RQFII is another mechanism of opening, allowing qualified foreign institutions to invest with offshore Renminbi in the Chinese mainland equity market. On the other hand, Chinese investors also have access to foreign equities through QDII, short for Qualified Domestic Institutional Investors, which provides mainland institutional investors to invest in overseas markets. By the end of 2017, domestic institutions had been availed with an accumulated quota of USD 89.99 billion[9]. The change of accumulated approved quota for QFII and QDII are graphed in Figure 2 a).

On 17 November 2014, a new mechanism of a bidirectional opening was launched: Shanghai-Hong Kong Stock Connect (I use "the Connect" for short in the remainder of this paper). This

[6] Data source: The Stock Exchange of Hong Kong
[7] The Stock Exchange of Hong Kong report daily data on market capitalization of A-, B- and H-shares, see http://www.hkex.com.hk/Mutual-Market/Stock-Connect/Statistics/Hong-Kong-and-Mainland-Market-Highlights?sc_lang=en#select3=0&select2=1&select1=26
[8] USD/CNY exchange rate used is 6.5342.
[9] The data of QFII, QDII is obtained from State Administration of Foreign Exchange of China.

mechanism allows Chinese mainland investors to trade eligible shares listed on the Stock Exchange of Hong Kong, thus expands the channel for Chinese mainland investors to hold foreign financial assets. More importantly, the Connect greatly increases the extent of openness of Chinese A-share market, allowing Hong Kong and international investors to invest in eligible shares that form up to 90% of the total market capitalization of A-shares listed on Shanghai Stock Exchange[10]. Through the Connect, there are two directions of trading activities: one is the northbound trading in Shanghai A-shares by Hong Kong and overseas investors, another is southbound trading in Hong Kong stocks by Chinese mainland investors. The mechanism is overall very flexible, allowing not only institutional investors but also individual investors to participate. However, there's not without restriction. A daily quota exists for both directions on the net buy amount. The daily quota for northbound trading and southbound trading is RMB 13 billion and 10.5 billion[11], respectively. Initially, there was an aggregate quota for the Connect, which was then abolished in August 2016[12]. The Connect provides for the first time a straightforward channel between the two major stock exchanges, which are categorized into two polar cases: one is almost closed while the other is super open. The Connect is a big progress of Chinese stock market liberalization. Different from QFII mechanism, the Connect opens Chinese A-share market to foreign individual investors. Hence, it is reasonable to expect more foreign holdings of Chinese A-shares after the Connect. In fact, the accumulated net purchase of Shanghai A shares and Hong Kong stocks through the Connect has reached 210.03 billion yuan and 714.81 billion HK dollar[13], respectively, by the end of 2017.

Through the QFII mechanism and the Connect, foreign holding in the Chinese mainland equity market increased rapidly over the last three years, as shown in Figure 2. The net flow into the Chinese mainland equity market through the Connect has contributed to 17.88% of the total foreign holding by the end of 2017[14]. Despite the rapid increase, the total foreign holding remains low in the Chinese mainland equity market, as described earlier.

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[10] Data source: The Stock Exchange of Hong Kong, Bloomberg

[11] Equal to USD 1,990 million and 1,530 million respectively, using the spot exchange rate as at 31 Dec 2017.

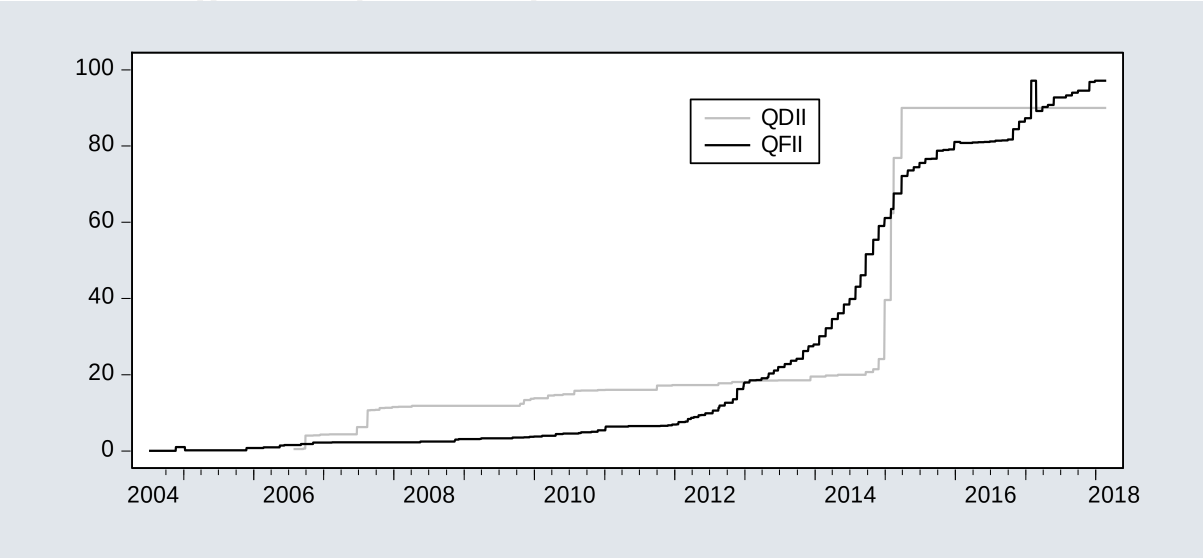
[12] *Shanghai Connect Shenzhen Connect information book for investors (2017)*, published by the Stock Exchange of Hong Kong.

[13] Calculated using the accumulated daily buy turnover minus daily sell turnover. Data is obtained from Bloomberg. The two figures reported equal to USD 32.14 billion and 91.44 billion, respectively, using the spot exchange rate as at 31 Dec 2017.

[14] The net flow is calculated using the accumulated daily buy turnover minus daily sell turnover. Data is obtained from Bloomberg. The data of total foreign holding of domestic equities are obtained from the People's Bank of China.

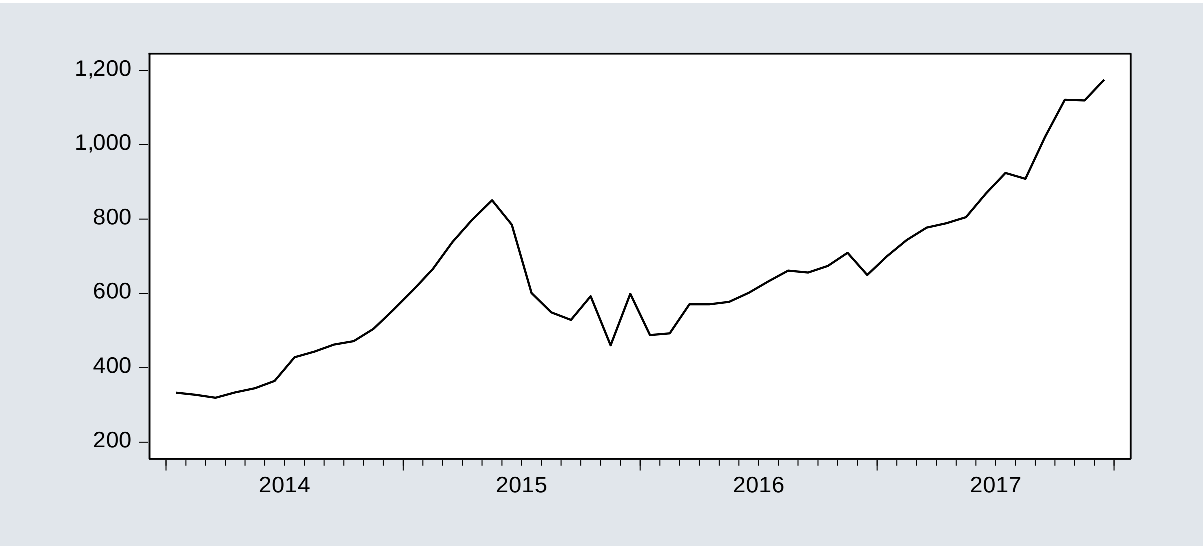
Figure 2 QFII, QDII, the Connect and the total foreign holding

(a) Accumulated approved QFII quota and QDII quota (U.S. dollar billion)



Data source: State Administration of Foreign Exchange of China.

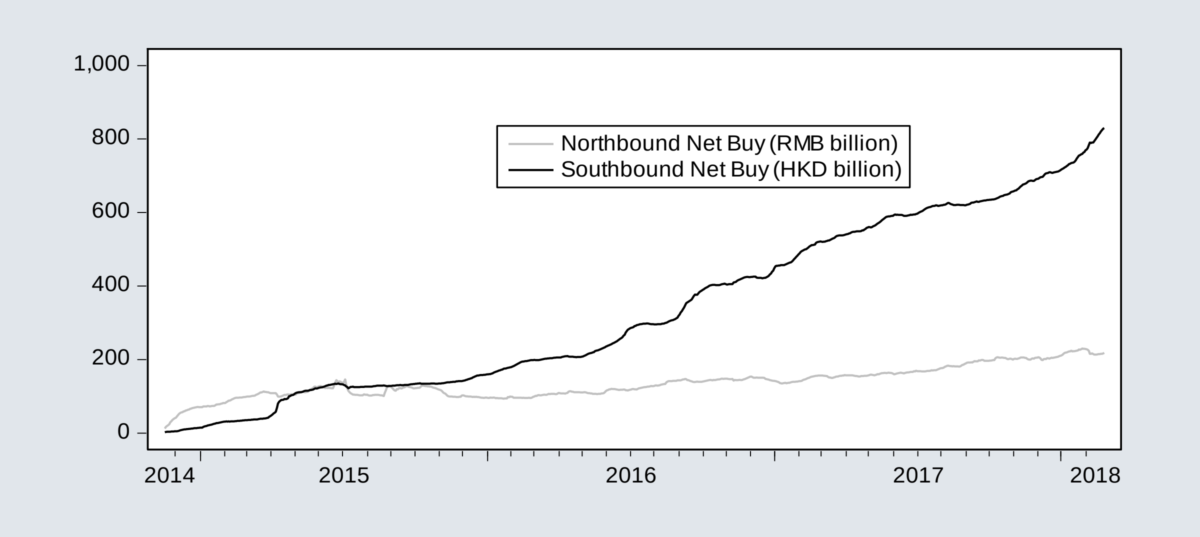
(b) Accumulated foreign holding in the Chinese mainland equity market (RMB billion)



The reported data shows China domestic RMB financial Assets Held by Overseas Entities in terms of Equities.
Data source: the People's Bank of China

Figure 2 (Continued)

(c) Accumulated net buy amount through the Connect



Northbound trades are the trades of Shanghai A-shares by Hong Kong and overseas investors, through the Connect. Southbound trades are the trades of Hong Kong shares by Chinese mainland investors. Data source: Bloomberg

1.2 Motivation

The topic of market integration and the pricing of foreign exchange risk in the Chinese mainland equity market needs more research. Previous studies on the Chinese mainland equity market's integration with global market mostly examine the spillover effects among markets. This paper examines the integration issue from an asset pricing perspective. Through literature review, I find that almost all literature on currency risk pricing in emerging equity markets has omitted the Chinese mainland equity market. Huang et al. (2014) find evidence of currency risk pricing in China A-share market. However, they assume full segmentation of the Chinese mainland equity market and omit world market risk from their unconditional pricing model. This paper intends to extend their study using an international asset pricing model including both world and local risk factors. Huang et al. (2014) study the time-varying feature of currency risk exposure, this study investigates further on the time variation of both risk exposure and risk prices using a conditional asset pricing framework.

How the Connect impacts the Chinese mainland equity market needs more research. There is literature testing the impact of the Connect on price discovery and market activeness. Sohn and Jiang (2016) found that the Connect improves the stock market function in price discovery. Huo and Ahmed (2017) show that the Connect contributes to the market efficiency and the market activeness because of the increased foreign investor participation. However, previous studies have not examined the impact of the Connect concerning asset pricing in the Chinese mainland stock market. This paper extends the survey of the Connect by employing an international asset pricing model in the Chinese mainland equity market and examining the impact of the Connect on market integration and currency risk pricing in the Chinese mainland equity market.

1.3 Purpose Statement

This research focuses on market integration and the pricing of foreign exchange risk in the Chinese mainland equity market and the impact of the Connect on the two topics. It is my objective to produce some new knowledge on the nature of equity markets segmentation and the currency risk price in an equity market like the Chinese mainland equity market, which is on its way of liberalization. Specifically, this paper applies an international asset-pricing model in both unconditional and conditional versions, to the Chinese mainland equity market. This paper seeks to answer whether the Chinese mainland market is segmented with the global market and whether foreign currency risk is compensated in the Chinese mainland equity market, as well as the impact of the Connect on these two questions.

1.4 Research Questions

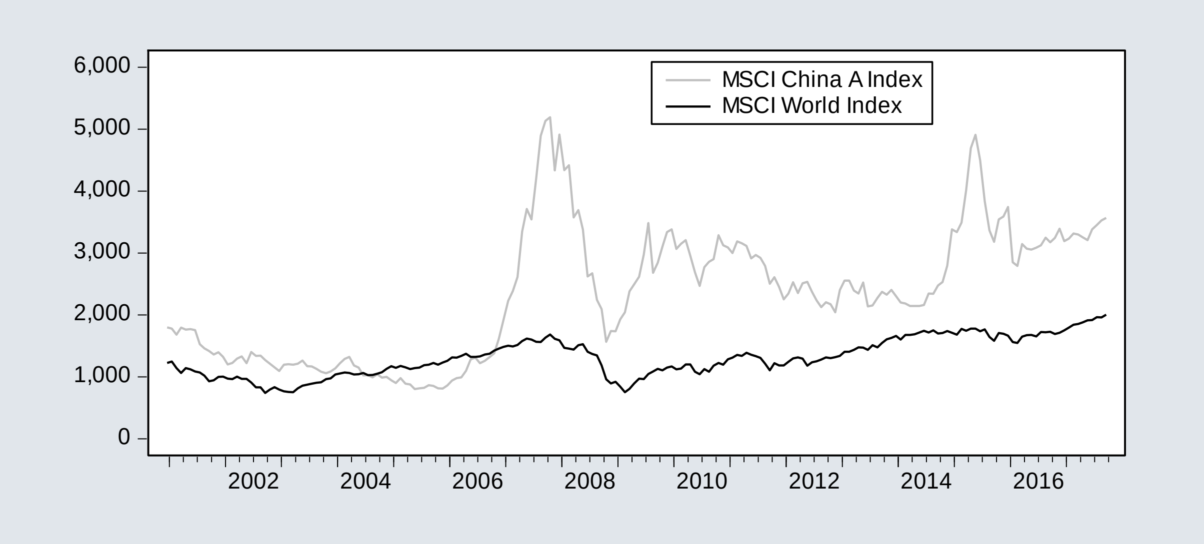
Question 1 Is the Chinese mainland equity market integrated with the world market? Should it be described as full integration, segmentation or maybe partial integration? How has the situation evolved after the Shanghai-Hong Kong Stock Connect?

Due to strict restrictions on foreign investors' access, the foreign holding of Chinese A-share market is very low, indicating that domestic investors are the dominant players in the pricing process. Similarly, Chinese investors also face strict restrictions on foreign currency conversion and foreign investment. These bidirectional restrictions probably isolate China mainland stock market from the global stock market. Evident from Figure 3, MSCI China A Index seems to fluctuate much independently against the MSCI World Index.

However, it would not be true if we say the Chinese mainland equity market is fully closed. The B share market and QFII mechanism still allow foreign participation, and the Connect further opens the Chinese mainland market. After the Connect, international investors can trade eligible Shanghai A-shares. Despite the daily quota restriction, the accumulated purchase of Chinese A-shares through the Connect has reached RMB 210.03 billion on 31 Dec 2017 (as described in section 1.1.2), and the total foreign holding in Chinese A-share market has surpassed 1 trillion yuan by the end of 2017. The increased international participation indicates that foreign investors might have a growing impact on the equity pricing of Chinese A-shares.

In summary, it is reasonable to see a growing correlation between the Chinese mainland equity market and the world market due to increasing foreign participation, but local factors will still likely dominate the pricing process considering the low-level of foreign holding in the Chinese mainland equity market.

Figure 3 MSCI China A Index versus MSCI World Index



Data source: MSCI. MSCI China A Index is a floating-value weighted index denominated in RMB and designed to track Chinese A-share market. MSCI World Index is a floating-value weighted index tracking the developed world markets performance, denominated in U.S. dollar. The graph covers monthly observations from 2001:1 to 2017:9.

Question 2 Is currency risk priced in the Chinese mainland equity market? Are there any changes on this issue after the Connect?

Theory shows that investors bear currency risk because of deviations from purchasing power parity resulting in consumer-investors facing different prices of goods. Hence, consumer-investors grant different premiums to assets based on the extent to which the assets protect their real purchasing power. These premiums could be viewed as exchange-risk hedging premium (Dumas and Solnik, 1995). Hence, investors are exposed to currency risk even under a fixed exchange rate regime, where deviation from purchasing power parity can happen due to relative changes in inflation across countries.

Above analysis takes the perspective of investors. Companies could also be exposed to currency risk in many ways, including importing, exporting, and overseas investment. Under these cases, companies have future cash flows denominated in foreign currencies, thus inevitably influenced by exchange rate changes. Companies that do not have foreign currency cash flows could also be exposed to currency risk due to competition. For example, a local manufacturer that purchases raw material locally may suffer when their competitors can import raw materials at lower prices when the domestic currency appreciates. Currency risk exists even when local currency is under a fixed regime with exchange rate pegged to a specific foreign currency, e.g., the U.S. dollar because the bilateral exchange rates with other foreign currencies can still fluctuate. Considering the relative scale of imports and exports of China[15], it is reasonable to expect substantial currency risk exposure faced by Chinese companies. Currency risk exposure could eventually be transmitted to investors through the financial market and affect their decision-making.

Empirically, a large amount of literature has shown evidence of currency risk being priced in both emerging markets and developed markets. Phylaktis and Ravazzolo (2004) find currency risk is priced during periods before and after official liberalization in some of the Pacific Basin financial markets. As for the Chinese mainland equity market, Huang et al. (2014) find currency risk is significantly priced in the Chinese mainland equity market. Due to the theory and empirical evidence, it is reasonable to expect currency risk also priced in the Chinese mainland equity market.

Deviation from purchasing power parity results in investors across countries facing different prices of goods and evaluating asset returns differently (Dumas and Solnik, 1995). Hence, domestic investors and international investors view local stock returns differently, and the fluctuation in exchange rate market may also have different implications for domestic and international investors. In this light, changes in the investor constitution for a stock market, e.g., more foreign investor participation may change the behavior of equity pricing, including currency risk pricing. Based on this analysis, it is reasonable to expect some changes in currency risk pricing after the implementation of the Connect.

1.5 Significance of This Study

This paper is expected to shed new light on the topic of market integration and currency pricing issues in the Chinese mainland equity market and the impact of the Stock Connect concerning these two issues. To my knowledge, this paper is the first in applying the international asset pricing model in its conditional form using a multivariate GARCH-in-Mean setup to the

[15] See appendix A for the ratio of imports and exports as GDP for China.

Chinese mainland equity market and revealing the time-varying risk exposures to world market risk and exchange rate risk, as well as the time-varying prices of the two risks.

1.6 Organization of the study

The remainder of this research is organized in the following way. Chapter 2 reviews relevant literature on the two topics of market integration and currency risk pricing, as well as the related topics on Chinese equity market. Chapter 3 reviews the empirical method for calculating the time-varying market integration, as well as the unconditional multi-beta pricing model and conditional pricing model. Chapter 4 reports and analyses the dataset used in this paper. Chapter 5 discusses the various estimation results. Chapter 6 is the conclusion.

CHAPTER 2 LITERATURE REVIEW

This chapter first reviews the literature on market integration and discusses various measures of market integration, then reviews the literature on the pricing of foreign currency risks from theoretical perspectives to empirical findings. Section 3.3 reviews the literature on these two topics in Chinese equity market.

2.1 Market Integration

The literature on liberalization and market integration has grown dramatically after the wave of emerging equity markets opening up in the 1980s and 1990s. As the opposite side of integration, segmentation of equity markets could be results of many kinds of barriers, including legal barriers on foreign investments, differences in information availability and institutional infrastructure, and all kinds of risks related with emerging markets, like liquidity risk, political risk, and currency risk, etc. Therefore, lifting of these barriers will probably cause integration. Many scholars have documented a higher level of market integration after the liberalization in emerging markets, e.g., Bekaert et al. (2003).

The two concepts of liberalization and integration are different, as pointed out in Bekaert et al. (2003). Liberalization is more of a change in policy to open the market of a country, while integration emphasizes more on the real effects on the market. Liberalization can be described as a process when investment barriers are lifted and foreign investors are allowed to participate in local capital markets that were once closed. However, liberalization does not necessarily lead to market integration unless international investors are convinced of the effectiveness and stability of policy changes and the removal of various other restrictions thus finally attracted to participate in the newly opened market.

Despite the vast amount of literature on capital market integration, there seems to be no unanimous idea on its definition and measurement. Some define and measure market integration using the level of foreign participation (e.g. Bekaert et al., 2003), some use the correlation between one market with another, or with the world market (e.g. Harvey, 1995). Others examine market integration by including both global and country-specific market risk factors in the pricing model (Carrieri and Majerbi, 2006, among many others).

Bekaert (1995) categorizes the tests on market integration into two major approaches. One approach tests a specific pricing model under the assumption of integration. Another approach models specific investment barriers and tests the corresponding effects. For example, Errunza and Losq (1985) find that ineligible stocks have a superior risk premium. Unlike these two approaches, Bekaert (1995) develops an integration measure calculated as the correlation of the estimated expected return on an emerging market with the U.S. market return. This measures the component of expected return common in an emerging market and the U.S. market, thus indirectly indicating the level of market integration. Similarly, Harvey (1995) measures conditional market integration using five-year rolling correlations between global market return and emerging market returns. This measure suggests that the integration of many emerging markets with the global market has increased.

However, Bekaert and Harvey (1995) pointed out that, measuring market integration based on correlation analysis is flawed. Even if a country is perfectly open to the world market, the correlation could still be low due to different industry mix from the world-average industry mix. In this light, they proposed a new measure of market integration by estimating the regime switching possibility, which allows them to draw the evolvement of market integration for many emerging markets. Bodnar et al. (2003) define integration and segmentation from the perspective of the composition of shareholders. Similarly, Bekaert et al. (2003) use the "investability index," as well as the level of foreign equity portfolio holdings to measure the openness of a country's stock market.

To sum up, before reviewing more literature, the perspectives of investigating and measuring integration are many, thus enabling multiple methods to examine the evolvement of market integration comprehensively. In chapter 1, I have analyzed the foreign participation in the Chinese mainland equity market. In following chapters, I also examine the time-varying correlation between the Chinese mainland equity market and the global market, and the prices of both global and local risks.

Errunza and Losq (1985) argue that in an equity market where investors have unequal access to different securities, a higher risk premium exists for those ineligible securities. Their theoretical model is consistent with the reality in some emerging markets, e.g. the Chinese mainland stock market. Their empirical results support the hypothesis of mild segmentation.

Bekaert (1995) includes both local factors and global factors in regression analysis and finds that local factors dominate the time variation of asset returns in 19 emerging equity markets for 1985-1992. The predictability power of global factors in expected return is higher before

1986 and lower after it, which is in contradiction with the hypothesis of higher market integration after liberalization. One explanation is that the predictability power reflects nothing but market inefficiency, which decreases through time. He thus concludes that this predictability test does not yield reliable information on integration. Instead, he develops an integration based on cross-market correlation. He analyses the linkage between this measure and some investment barriers. The empirical estimation shows that the integration levels are affected by many indirect investment barriers.

Many pieces of research assume that equity market is either perfectly segmented or integrated, some others have denied those two assumptions and assumed a partial integration with constant integration level. Bekaert and Harvey (1995) propose a model allowing for the switch of a capital market regime. Their model accounts for the switching from periods when local markets were segmented to periods when they became integrated with the world market later. They find strong integration for some countries where restrictions on foreign holding were not yet removed, such as Korea and Taiwan, while some markets appear to be segmented even if they are more open to foreign investors. However, this time-varying world market integration model is statistically rejected for some emerging markets.

De Santis and Gerard (1997) test a conditional version CAPM using a parsimonious GARCH model initially proposed by Ding and Engle (1994) in eight major equity markets. Their methodology accommodates the time variation of second moments and risk prices. They find the global market risk is equally priced across the eight equity markets, while individual country risk is not priced. Compared with an unconditional model, they find that a model allowing risk prices to vary over time has superior performance. They find that the estimated gain from international diversification is high and remains high over the sample period. Although diversification provides little protection during severe market conditions, they argue that diversification still offers long-run benefit.

Choi and Rajan (1997) jointly examine market integration and exchange risk pricing in seven developed equity markets outside of U.S., covering the period from Jan 1981 to Dec 1989. Using a three-factor model under an APT framework, they estimate both sensitivities of stock returns to risk factors and the price of these risk factors. Using individual stock data, they find that the factor structure of asset returns are different in those countries studied; both local market risk and global market risk are found to be priced in many countries, indicating a partially segmented market; exchange risk is also significantly priced.

Henry (2000) studies the influence of market liberalization on the economy and segregates it from the impacts of other factors, e.g. economic reforms. Covering 12 LDCs from 1984 to 1994, he constructs a reliable estimate of the effect of stock market openings, after constructing several variables for reform and controlling the macroeconomic fundamentals. He finds the revaluation effect of equity market liberalization exists, but is smaller in magnitude than previous works suggest. The main reason is that economic reforms also have positive impacts on revaluation of the stock market, and usually coincide with liberalization. Considering liberalization is not accomplished in one step, the paper studies the effects of subsequent liberalizations. The effects are positive, although not as big as the first liberalization, indicating the emerging markets are subject to price pressure effects. The author suggests that liberalization will create a more significant wealth effect if accompanied by economic reform.

Bekaert & Harvey (2000) assess the role of foreign speculators in influencing expected returns, volatility, and correlation. They use three indicators to measure market integration: country funds, ADRs, and direct foreign participation. They find that the capital market integration reduces the cost of capital, but the magnitude is both economically and statistically insignificant. They also find there is a small increase in market volatility following the market integration, but the effect becomes negative if controlling for other potential concurrent movements. Interestingly, they find there is only a small increase in local market's correlation with the world market, which means market integration will not reduce the attractiveness of emerging market concerning their diversification role for international investors.

Bodnar et al. (2003) present a hybrid model including both local market risk and global market risk to account for market integration. They argue that the pricing for country-specific risks is different from the way world common risks are priced. For example, investors having non-investment income in their own country care more about the country-specific risks and probably reduce the total local risk exposure by lowering the weight of investments in the domestic market. Consequently, a hybrid model is useful without first making a specific assumption on segmentation or integration. They also suggest that currency risk should be included as a separate risk factor in the international CAPM because currency risk is separately priced apart from the pricing of world market risk.

Miyakoshi (2003) examines the spillovers in return and volatility from the U.S. and Japan market to a group of stock markets in Asia. Based on the empirical results estimated using a bivariate EGARCH model, he observes that the U.S. stock market have a substantial influence on the returns in Asian markets, while Japan market seems to have no influence over other Asian markets. However, the volatility spillovers from Japan to other Asian markets are more significant than from the U.S. Their findings indicate that Asian market is influenced by the regional market as well as the world market.

Bekaert et al. (2003) analyze various optional routes of liberalizing a country's stock market, including official liberalizations, the launch of ADRs and country funds. Using the "investability index", as well as the foreign holding in the equity market to measure the openness of a national equity market, they show that the openness of the 30 emerging markets they study have improved dramatically post the liberalization. They find market liberalization results in 0.84% to 1.1% increase in GDP growth and 2.2% to 3.3% increase in investment growth for the sample countries, for which they attribute one of the reasons to the decreased cost of capital after market liberalization. They also point out the importance of dating liberalization and review the methods of doing it, including using the first sign of liberalization, official announcement and breakpoint test.

Phylaktis and Ravazzoo (2005) examine the financial linkages between Pacific-Basin countries and the two developed equity markets of U.S. and Japan. They employ a multivariate cointegration model over the sample period before and after liberalization. They observe increased linkages after the liberalization during 1990-1998, indicating that lifting restrictions on foreign holding improved the level of market integration. They also find that Taiwan and Thailand are closely linked to both Japan and US in 1980s even when foreign ownership was still in place, which supports that the financial linkages not necessarily correspond to official market liberalization, and they could correspond to alternative opening schemes, like the country funds. They point out that despite the increased financial linkages of Pacific basin equity markets with the world market, there does not seem to exist a common global growth factor that they all respond to, which leaves room for foreign investors to diversify their portfolios.

Bruner et al. (2008) test for market betas for 14,371 securities around the world and confirm that the importance of determining the market portfolio. The average absolute expected returns derived from a CAPM using local market portfolio is 5.6% higher than the average expected returns derived from a global CAPM in emerging markets. However, the difference in expected returns from the two models is only 3.6% in developed markets. They develop a measure of integration using the R-squared of local market beta regressing on global market beta and interpret a higher R-squared as a higher level of integration. Surprisingly, they find that while developed markets have become increasingly integrated with the global equity market, Asia markets' integration with the world is decreasing, and the emerging markets have seen a trend of less integration from 1996 to 2014. They recommend using single factor domestic CAPM for emerging markets and multi-factor domestic + global model for developed markets.

2.2 Currency Risk Pricing

Currency risk is one of the major concerns for investors who invest in foreign assets. Consequently, the behavior of foreign exchange rate has drawn a lot of attention and effort from international finance researchers. In general, the distribution of exchange rates is believed to be non-normal and non-stationary, as evidenced from several empirical studies, e.g., Giddy and Dufey (1975), Westerfield (1977), So (1986). As a result, mean and variance analysis and least squares method may be inefficient in coefficients estimation.

Currency risk is defined as "the systematic risk associated with a foreign currency denominated return (or cost) stream and measured by the covariance between the rate of change of the exchange rate and the domestic market return" (Wurster, 1978). This definition is proposed from the standpoints of foreign investors. However, currency risk also exists for investors who hold only local currency denominated assets: The fluctuation in currency values influences the purchasing power of a consumer-investor who earns local currency investment income and consumes both local and foreign products, and finally influence their investment and consumption decision (Huang et al., 2014). Asset returns, although denominated in a certain currency, could be generally translated using purchasing power in terms of a basket of goods, whose composition might differ for different consumer-investors. In this light, whatever currency is used to denominate the asset returns, currency risk always exists because the exchange rate fluctuation will influence the purchasing power of a consumer-investor. Hence, currency risk should be measured as the covariance between the return on an asset (in whatever currencies) and the exchange rate changes.

The topic of currency risk pricing has been widely studied in the literature. Theoretically, if purchasing power parity holds and real exchange rates never change, currency risk has no impact on real asset return. Investors are compensated for bearing currency risk due to the violation of purchasing power parity, resulting in across country differences in prices of goods faced by consumer-investors who consume goods with income from their investments (Dumas and Solnik, 1995). The performance of an investment in a foreign asset is not only decided by the performance of the foreign asset itself, but also by the change in the foreign currency value in which the foreign asset is denominated (De Santis and Gerard, 1998). Empirically, significant amount of literature has found significant currency risk premia in all kinds of asset pricing models.

Literature usually analyses currency risk from the perspective of investors of a specific country, say the U.S., defining as foreign currencies those currencies other than the denomination currency. Under such a setting, literature has revealed much evidence of negative pricing of foreign currencies. De Santis and Gerard (1998) find the negative pricing of Deutsche mark and British pound when using U.S. dollar as the reference currency, Antell and Vaihekosiki (2012) find the negative pricing of Swedish and Finnish currencies also using U.S. dollar as the reference currency. De Santis and Gerard (2003) find non-EMU currencies are negatively priced when using Deutsche mark as the reference currency.

The pricing of currency risk has important implication for hedging strategy. If currency risk cannot be eliminated through portfolio diversification, investors will command a risk premium to take the risk, or willing to grant a hedging-premium to those assets that help protect their real purchasing power. Therefore, a company's hedging strategy will affect its cost of capital. On the other hand, hedging activities are not necessary if investors can diversify the currency risk by themselves through diversification. Under this occasion, investors will not grant a premium for hedging activities taken by companies (e.g., Jorion, 1991).

Ferson and Harvey (1993) assume equal risk price across countries and risk exposures to be country-specific. They model the expected returns allowing the risk exposure to vary over time along with only country-specific information variables, and risk price to vary over time along with only global information variables, under a full market integration assumption. Their empirical tests on 18 equity markets show that such a pricing model can explain the cross-sectional difference in expected returns. Their results also show that a multi-risk factor model, where additional variables, like exchange rate risk, can improve the explanatory power of the pricing model. By decomposing the contributions of betas and risk premia, they conclude that time-varying risk premia are the most significant component contributing to the predictability in returns compared to the changes in risk exposure.

Dumas and Solnik (1995) argue that investors face different prices of goods and they grant different premiums to assets based on the extent to which the assets protect their real purchasing power. These premiums could be viewed as exchange-risk hedging premium. They generalize the "pricing kernel" method initially proposed by Hansen and Jagannathan (1991) and test both classic APM with only market risk and international APM where currency risks are also included. They find that the international APM is marginally rejected in unconditional pricing model, while in the conditional model they cannot reject the international APM but reject the classic APM. In addition, they reject the hypothesis of no currency risk pricing under the conditional model. They also reject the hypothesis of time-invariant market risk and time-invariant currency risk. Although the authors allow both risk prices and risk quantities to vary, the fashion in which the quantities of risk vary is not specified.

De Santis and Gerard (1998) test a conditional international CAPM using a parsimonious multivariate-GARCH model, which allows them to parameterize both the variance-covariance and price of risks to vary over time. They include world market risk factor and several Eurocurrencies deposit rate as the currency risk factor where the price of risk can change over time. They study four developed countries' stock markets and foreign exchange market, showing that the currency risk is significantly priced. They find long-run currency risk premium is small in magnitude compared to the total risk premium, but the short-term variation of currency risk premium often represents a significant component of variation in the total premium. They show the pricing of world market risk and currency risk is only detectable in a pricing model when both the risk exposure and price of risk are allowed to vary over time. They point out the fact that foreign exchange rate risk is priced and the compensation for it is large has direct implications for hedging strategy.

Choi et al. (1998) test currency risk pricing in Japanese equity market using the international pricing model both in its unconditional and conditional version. When the bilateral exchange rate measure (USD/JPY) is used, they find that the currency risk is unconditionally priced. However, they find that choice of sub-periods have a significant impact on the estimation results, which they interpret as evidence of time-varying price for currency risk. They also attribute the different pricing during different sub-periods to the secular exchange rate trend, which has an impact on investors' perception of the currency risk. Comparatively, when using the conditional pricing model, the currency risk is always priced no matter what exchange rate measure is used. The conditional model they used is the "pricing kernel" method.

Tai (1999) tests the time-varying currency risk in exchange rate market and equity market for five Asia-Pacific countries. He finds that when considered separately, the deviation from UIP in exchange rate market cannot be explained by conditional variances, based on GARCH(1,1)-M model. However, when including both equity markets and exchange rate markets together in the estimation, he finds significant time-varying risk premium, based on the "pricing kernel" method. He concludes that the deviation from UIP is due to the existence of currency risk pricing, rather than the irrational market participants.

Koedijk et al. (2002) compare a domestic CAPM with a multi-factor ICAPM that includes world market risk factor as well several exchange rate risk factors. They use a large sample of individual stocks from 9 countries and find that the estimated costs of capital from the two models only yield significant differences for five percent of the sample firms. They interpret this result as the strong influence of country-specific risk in forming stock returns, because of the low level of market integration. By decomposing the variance, they find the marginal contribution of the orthogonalized global market risk and currency risk is negligible on average.

De Santis et al. (2003) investigate the potential impact of currency integration of EMU from the perspective of differences in the exchange rate risk pricing of various currencies. By including several currency risks into their conditional ICAPM, they find that EMU (European Monetary Union) currency risk premium is smaller in magnitude compared to the non-EMU currency risk premium, and the risk premium on non-EMU currency risk is negative. They interpret the negative risk premium as a premium granted by investors to assets that protect their real purchasing power. Investors require less return for holding non-EMU currencies that help protect their purchasing power of goods denominated in non-EMU currencies. They also detect increasing quantities of risk concerning non-EMU currencies in the 1990s and decreasing quantities of risk concerning EMU currencies in the same period, indicating that the adoption of a single currency in EMU may have limited influence on the world equity market.

Phylaktis and Ravazzolo (2004) incorporate currency risk and allow dynamic market integration in their international asset pricing model, and apply the same to both equity markets and foreign exchange markets in Pacific basin area. They model the dynamic market integration as a one-time regime switch on the date of official liberalization, from full segmentation before the date to full liberalization after that. They find integration exists in the Pacific basin after liberalization, even for countries that maintained capital controls during the

1990s. They also find currency risk is priced both before and after the liberalization and is large in magnitude compared to the total risk premium. They also find that the currency risk premium is smaller and more stable when markets are more integrated. Their empirical evidence from the GARCH model reveals that both market risk and currency risk premium change over time.

Carrieri and Majerbi (2006) conduct an empirical test on nine emerging markets, using different levels of data: market index return, portfolio returns, and individual stock returns. They find that currency risk premium exists unconditionally in emerging equity markets. After including local market risk into the pricing model, they find currency risk pricing remains when using individual stock data, but subsumed by local market risk when using market index return. This result indicates that using market level data may fail to detect exchange rate risk in some cases. They argue that companies will have a lower cost of capital as a reward for hedging activities.

Pan et al. (2007) examine the causal relation between foreign exchange market and equity market and find fluctuations in foreign exchange market can significantly influence equity market in four of the seven East Asian countries studied. They find the casual relationship show different characters across countries and attribute the differences to factors including trade size and stock market and size, capital control, and exchange rate regime.

Tai (2008) utilizes a multivariate GARCH approach to allow for both risk price and risk exposure to be time-varying. He finds that 58% of US industries and 90% of US banks face an asymmetrical impact of USD/JPY exchange rate changes. He finds currency risk is priced and the result is robust to exchange rates measures and data intervals, at both industry portfolio level and individual stock level. He points out the reasons that previous studies fail to detect currency risk pricing maybe the lack of explicit modeling for conditional second moments, or ignoring asymmetric currency risk exposure.

Saleem and Vaihekosiki (2010) apply conditional pricing model and the multivariate GARCH-in-Mean methodology on Russian stock market. They find that Russian equity market is only partially integrated and local market risk is a separately priced factor. They also detect the pricing of currency risk and find the price to be time-varying. Compared to world market risk, they find that Russian risk premium is dominated by local market risk and currency risk.

Antell and Vaihekosiki (2012) model the change in currency regime using dummy variables in their multivariate GARCH-in-Mean setup and apply it to Finland and Sweden stock market.

They find a negative price for currency risk in the two markets. Using a dummy variable to account for the switch from fixed exchange rate regime to a free-floating, they find that the currency risk price is less negative after the regime change. They find the sample mean of currency risk premium is large and negative because of the positive correlation between the equity market and the foreign exchange rate changes and the negative pricing of currency risk.

Kodongo and Ojah (2012) conduct a comparative study on the pricing of currency risk between South Africa and Nigeria using unconditional asset pricing model. They find evidence of currency risk pricing in South Africa equity market, but not in Nigeria. They also find Nigeria is not integrated with the global stock market, while South Africa is integrated. They also find large size firms are more sensitive to both global market risk and currency risk.

Kodongo and Ojah (2014) utilize Stochastic Discount Factor (SDF) framework to estimate conditional currency risk pricing in 10 African countries and find currency risk is significantly priced in African stock markets with conditional price. In testing the components of pricing kernel, they also find exchange rate changes enter into the pricing kernel significantly. By conducting an unconditional version of the SDF framework, they conclude that conditional model captures the time-varying feature of currency risk and thus performs better than unconditional model. They also incorporate a variable to account for the relatively small and illiquid feature of African equity markets. Using what they call "Market-size-augmented" ICAPM, they find the concern over market size does enter the pricing kernel and requires a premium.

Al-Shboul and Anwar (2014) apply both multivariate GARCH and the GMM method to Canadian equity market and find that the currency risk, global market risk, and Canadian local market risks are all priced. They show that currency risk premium constitutes a substantial part of stock returns of Canadian equity market. They also show that the price of global and local market risk and currency risk are all time-varying. Their findings also support partial segmentation of Canadian market.

2.3 Chinese Stock Market

Ma (1996) presents a pricing theory to study the segmented Chinese equity market and answer the question why B-shares are traded at a discount compared to their A-share counterparts. In China, a listed company is able to issue two categories of shares: A-shares are open only to mainland investors while B-shares are open only to international investors. His theory shows that the price discount of B-shares depends on investors' attitudes toward risk: if Chinese investors are risk lovers, companies with higher market beta will see bigger overpricing in A-shares. The theory indicates that the price discount is also dependent on the correlations of B-shares with the international stock market, and investors' expectations on future returns. Their empirical results on cross-sectional regressions support the theory. Their time series analysis shows that the time variation in the discount of B-shares are highly correlated among all B-shares, and is correlated to regulatory changes, which affects investors' expectation on future returns.

Su and M.Fleisher (1998) study the risk and return features of Chinese equity market. They observe that Chinese equity market yields higher returns as well higher volatility level. They find that the returns are more positively autocorrelated than in advanced markets. They argue that Chinese stock market return is non-normally distributed. Chinese stock market return is also found to be predictable from several local and global variables. They also find that the volatility level of Chinese equity market corresponds to regulatory policy changes and market liberalization.

Sun and Tong (2000) research the segmented structure of Chinese stock market. They find B-shares that are eligible to international investors are trading at a discount compared to the ineligible A-shares that are only open to domestic investors. This fact contradicts the theory proposed by Errunza and Losq (1985), where ineligible stocks (in this case, the A-shares) should have a superior risk premium thus a lower price. They propose several potential explanations on this phenomenon. One explanation confirmed is differential demand elasticity: H-share market and red-chip stocks (Chinese companies registered outside mainland) listed in Hong Kong equity market provides an alternative channel for B-share investors, creating more elasticity for investors' demand curve for B-shares. They find that B-share discount tends to be deeper when there is an increase in H shares and red chip stocks, which draws the investors away. Another explanation is the speculative fever of Chinese investors, which is supported by the fact that volatility level can partly explain the discount of B-shares. They also explain that currency risk might be another explanation. When there is a devaluation expectation on currency value (although Chinese currency regime was a pegged regime at that time), the B-shares has a deeper discount. They also point out domestic investors' more optimistic expectations on the Chinese economy and stock market may contribute to the B-share discount.

Groenewold et al. (2004) examine the interrelationship of the Chinese mainland equity market with neighboring Hong Kong and Taiwan equity market, using Granger causality test. They find the Chinese mainland equity market is segmented from Hong Kong and Taiwan equity market, and the interrelationship between Hong Kong and Taiwan is stronger. They also find evidence that the Chinese mainland equity market has been more interrelated to the other two markets during the 1990s. However, they cannot conclude if the increased interrelationship is due to the Asian crisis in 1997-1998 or greater integration of Chinese economy into the world economy.

Wang and Firth (2004) indicate that daytime returns in developed equity market have predicting power over the overnight returns on stock indices of four Great China region equity markets: Shanghai, Shenzhen, Hong Kong and Taipei). While this spillovers in returns are in general unidirectional, an analysis on post-Asian financial crisis period shows evidence of bi-directional spillovers. They also find neither contemporaneous nor lagged “bad news” from developed markets will affect the returns on the two Chinese mainland equity markets.

Wang and Jiang (2004) examine 16 dual-listed Chinese stocks that are traded as A-shares on the Chinese mainland stock exchanges and traded as H-shares on the Stock Exchange of Hong Kong. They find H-shares react to risks and investor sentiments of both Hong Kong market and the Chinese mainland equity market, while A-shares only react to those of mainland equity market. In this sense, the Chinese mainland stock market is segmented with Hong Kong markets. They also examine the variation of H-share discount and its determinants. They find the discount of H-shares is correlated with the stock returns in mainland and Hong Kong equity market, as well as the relative market illiquidity. When the relative market illiquidity of H-shares decreases, H-share discount will also decrease, indicating that Hong Kong and international investors require an extra premium for the illiquidity of H-shares. Further, they find the discount of H-shares is positively related to the devaluation expectation of RMB, for which foreign investors also ask for a premium.

Li (2007) examines the linkage of the Chinese mainland equity markets with U.S. and Hong Kong market using a multivariate GARCH model. The author finds no direct links between the Chinese mainland equity market and U.S. market, but evidence is found for unidirectional spillovers in volatility from HK market to the Chinese mainland market, though small in magnitude. The study shows the integration of the Chinese mainland equity market with Hong Kong market is weak and no integration exists at all with the world equity market.

Su and Chong (2007) analyze the stock prices of eight Chinese stocks dual listed on NYSE and SEHK (Stock Exchange of Hong Kong). They find cointegration exists between the stock prices in the two stock exchanges and that the prices are mutually adjusting. They also find SEHK makes most of the contribution to the price-discovery process for the dual-listed stocks.

Lin et al. (2009) use DCC-GARCH model to examine the Chinese mainland equity market's variance, covariance, and correlation relative to the rest of the world. Surprisingly, they find Chinese A-share market is not correlated with global equity market, and B-share market only shows very weak correlation with global equity market and slightly higher level of correlation with the regional market.

Yi et al. (2009) investigate the link between the Chinese mainland equity market with U.S. and Hong Kong market. They show that the Chinese mainland equity market is cointegrated with both markets, but the cointegration relationship is stronger with neighboring Hong Kong market than with the U.S. market. The linkage between the Chinese mainland equity market and Hong Kong market is found to have a significant impact on Hong Kong market.

Wong et al. (2009) find Chinese renminbi and the stock returns of Chinese banks are negatively correlated. They show foreign exchange risk exposure increases with the bank size, possibly because large banks have greater foreign exchange operations, trading positions, and more businesses with large and international corporations.

Cheung et al. (2010) study the influence of the 2008 financial crisis on the financial linkages across equity markets. They document stronger interdependence among stock markets and improved influence of the U.S. market on many other markets, including Chinese equity markets in the crisis. They show that the spillovers from shocks in the U.S. market increase at least twice during the crisis.

Wang and Wang (2010) examine return and volatility spillovers between the equity markets in Greater China region and the developed equity markets (the U.S. and Japan market). They observe stronger volatility spillover effects than return spillover effects between the aforementioned equity markets. Different from previous studies, they find that there does not exist a dominant role of developed markets over developing markets. They further suggest that the influence of developed equity markets on developing markets is correlated with the degree of market liberalization.

Zhao (2010) analyses the relationship between Chinese foreign exchange market and equity market and finds no evidence of long-term equilibrium relationship between the two. While no return spillovers are found, he observes bidirectional volatility spillovers between the two markets.

Qiao and Lam (2011) use a nonlinear Granger causality test to investigate the connection among four Greater China equity markets (Shanghai, Shenzhen, Hong Kong, and Taipei). In contrast to previous studies using linear test procedure, they find strong nonlinear interdependence among the four markets. They find there are bidirectional causal relationships between Shanghai and Shenzhen market, as well as between Hong Kong and Taiwan market from 1992 to 1999. However, the two pairs of markets seem to be isolated during the same period. They further show that the interrelationships have strengthened, and the two mainland markets become well connected with and highly influential on the other two markets from 2000 to 2008.

Chong et al. (2012) examine the efficiency of the Chinese equity market by directly testing the profitability of various trading strategies. They split the sample period into sub-periods by the events of Chinese SOE (state-owned enterprise) reform and the 2008 financial crisis. They detect significant profitability of various strategies during the period before the SOE reform, indicating that the SOE reform might have improved the efficiency of Chinese stock market. They also point out that the profitable trading opportunities vanish when taking into account 0.5% transaction cost.

Huang et al. (2014) develop a consumption-based pricing model for the Chinese mainland equity market, where they assume domestic investors are restricted within the domestic financial market but not restricted on consuming foreign goods. They argue that the exchange rate change of Chinese yuan should be positively priced because of its negative correlation with consumers' marginal utility, which makes asset returns and consumptions more volatile. Their model successfully explains the cross-sectional differences of expected returns at portfolio level in the Chinese mainland equity market. By testing a simplified unconditional pricing model, they find strong evidence of currency risk premium, under both two-pass and Fama-MacBeth estimation method. Instead of testing a conditional model directly, they regress the returns and exchange rate betas on a few instrumental variables and show the time-varying property of both. They also analyze the changes in expected returns and exchange rate betas after the Chinese exchange rate reform and attributes the increase in expected returns to the increased exchange rate risk.

Huang and Kuo (2015) investigate whether the Chinese mainland equity market has been more influential over its adjacent markets, Taiwan and Hong Kong. They examine the information transmission among the three markets from 2000 to 2012. They find that the Chinese mainland equity market leads the process of volatility spillovers during the sample period. They examine the conditional correlations between the markets and find that the three markets are closely linked, and the Chinese mainland equity market is increasingly integrated with the other two.

Huo and Ahmed (2017) show that the Connect contributes to the market efficiency and the market activeness due to increased foreign investor participation. They find significant co-integration between the two markets after the Connect. They also observe that Shanghai market leads the process of mean and volatility spillovers after the Connect. Using VAR-GARCH model, they detect that lagged returns of Shanghai market contribute more to the returns in Hong Kong market after the Connect, while the contribution of lagged returns in the other direction decays. The volatility spillovers from Shanghai to Hong Kong become significant only after the implementation of the Connect. They suggest that the Chinese mainland equity market will be more influential on Hong Kong market due to its continuing opening process.

Burdekin and Siklos (2017) examine the effect of the Connect on the discount of H-shares compared to their A-share counterparts. They find the discount declines when southbound portfolio flow (from Shanghai to Hong Kong) increases, and increases when northbound portfolio flow increases, during periods the authors define as highly uncertain. They also find the southbound portfolio flow's effect on the discount is higher in magnitude than northbound flow, indicating that mainland Chinese investors have a more significant impact in forming the discount.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Market Integration

Based on literature review, this paper tests and measures integration of the Chinese mainland equity market from two perspectives. The first is to examine the extent to which the return on the Chinese mainland equity market is correlated with the world stock market return and the evolvement of this correlation. The second is to examine whether world market risk is a priced factor in the Chinese mainland equity market.

To measure the correlation between the Chinese mainland equity market and world market, the easiest way is to calculate the rolling correlation over a specific sample period, as used in Harvey (1995). In this paper, three-year rolling correlations are used as the measure of integration.

Another method is calculating the conditional correlation using a bivariate GARCH model. In this paper, a VAR-GARCH model is used to estimate the conditional second moments and calculate conditional correlation accordingly. The mean equation is shown below, following Huo and Ahmed (2017),

$$\boldsymbol{r_t} = \boldsymbol{c} + \sum_{i=1}^{n} \boldsymbol{\delta_{wi}}(r_{w,t-i}) + \sum_{i=1}^{n} \boldsymbol{\delta_{mi}}\, r_{m,t-i} + \boldsymbol{\varepsilon_t}\ ,\ \boldsymbol{\varepsilon_t}|\boldsymbol{\Omega_{t-1}} \sim (\boldsymbol{0}, \boldsymbol{H_t}) \tag{1}$$

Where $\boldsymbol{r_t}$ is a two-dimensional vector of return series, namely $r_{m,t}$ and $r_{w,t}$, which are weekly returns on the Chinese mainland equity market and world market respectively. The lag selection for $r_{m,t}$ and $r_{w,t}$ is based on Akaike Information Criterion (AIC). $\boldsymbol{c}$ is a two-dimensional vector of constants, $\boldsymbol{\varepsilon_t}$ is error terms vector, $\boldsymbol{H_t}$ is the conditional variance-covariance matrix of the error term on information set available at time *t*-1.

$\boldsymbol{H_t}$, the covariance matrix is estimated using a multivariate GARCH model. One popular method of estimating multivariate GARCH is BEKK (Baba, Engle, Kraft and Kroner), proposed by Engle and Kroner (1995). Under BEKK GARCH (1,1), the covariance matrix $\boldsymbol{H_t}$ for a k-dimensional random vector is estimated as,

$$\boldsymbol{H_t} = \boldsymbol{C} + \boldsymbol{A}'(\boldsymbol{\varepsilon_{t-1}}\boldsymbol{\varepsilon'_{t-1}})\boldsymbol{A} + \boldsymbol{G}'\boldsymbol{H_{t-1}}\boldsymbol{G} \tag{2}$$

Where C, A and B are $k \times k$ matrices of parameters, and $\boldsymbol{C}$, the constant matrices must be symmetric considering the symmetric feature of covariance matrices. For the bivariate GARCH model used in this paper, the BEKK GARCH (1,1) indicates that

$$\boldsymbol{H_t} = \begin{bmatrix} c_{11} & c_{12} \\ c_{12} & c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \begin{bmatrix} {\varepsilon^2}_{1,t-1} & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & {\varepsilon^2}_{2,t-1} \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}' \boldsymbol{H_{t-1}} \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} \tag{3}$$

Hence, there are 11 parameters to be estimated for this conditional covariance matrix.

While the existence of high correlation provides evidence of integration, this method is not without flaw. As pointed out in Bekaert and Harvey (1995), the correlation could be low due to differences in industry mix among markets, even when they are highly integrated. Considering this, it is necessary to test the price of world market risk in local markets to confirm the existence of integration. If world market risk enters significantly into investors' pricing of local market return, we can at least reject the hypothesis of segmentation. This paper implements both unconditional and conditional pricing models to detect if world market risk is priced in the Chinese mainland equity market. The methodologies are described in section 3.2 and 3.3.

3.2 Unconditional Pricing of Currency Risk and World Market Risk

3.2.1 Multi-Beta Model

This paper uses the Arbitrage Pricing Theory (APT) as the foundation of unconditional pricing model. APT is initially proposed by Ross (1976) and then extended by Solnik (1983) to an international APT. According to Solnik (1983), the return on an asset can be expressed in the matrix form below,

$$\widetilde{\boldsymbol{R}} = \overline{\boldsymbol{R}} + \boldsymbol{\beta F} + \boldsymbol{\varepsilon} \tag{4}$$

where $\widetilde{\boldsymbol{R}}$ is an n-dimensional vector of random returns on n assets, $\overline{\boldsymbol{R}}$ is an n-dimensional vector of expected returns, $\boldsymbol{F}$ is a vector of k common factors, $\boldsymbol{\beta}$ is an $n \times k$ matrix of sensitivities of n asset returns to the k common factors. We also call $\boldsymbol{\beta}$ the factor loadings. In equation (4), all the common factors are mean zero, and the error term is also mean zero and are uncorrelated with the common factors and with each other.

Ross (1976) demonstrates the relation between the expected returns $\bar{\boldsymbol{R}}$ and the factor loadings $\boldsymbol{\beta}$. Assume there exists an arbitrage opportunity: investors can generate profit by forming an arbitrage portfolio with no additional funds and no additional systematic risk. Since *n* is large enough, the residual risk of the arbitrage portfolio is negligible. These requirements can be described as below,

$$\mathbf{X}'\boldsymbol{\iota}=0 \tag{i}$$

$$\mathbf{X}'\boldsymbol{\beta}=\mathbf{0} \tag{ii}$$

$$\mathbf{X}'\boldsymbol{\varepsilon}\sim 0 \tag{iii}$$

where $\mathbf{X}$ is the vector of weights allocated to *n* different assets, and $\boldsymbol{\iota}$ is a vector of ones.

Under these three conditions, arbitrage activities will finally erase the profitability, making the return on the arbitrage portfolio to be zero. Thus,

$$\mathbf{X}'\bar{\mathbf{R}}= 0 \tag{iv}$$

Given Eq. (i) to (iv), Ross (1976) shows the $\bar{\mathbf{R}}$ must be a linear combination $\boldsymbol{\beta}$ and $\boldsymbol{\iota}$. That is to say, there must be

$$\bar{\mathbf{R}} = \lambda_0\boldsymbol{\iota} + \boldsymbol{\beta}\boldsymbol{\lambda} \tag{5}$$

where $\boldsymbol{\lambda}$, a *k*-dimensional vector, and λ_0 are the $(k+1)$ pricing coefficients.

Since the APT does not assume a risk-free rate at which investors can lend or borrow freely, λ_0 can be interpreted as the expected return with zero systematic risks, and $\boldsymbol{\lambda}$ can be interpreted as the expected returns of factor portfolios over λ_0. A factor portfolio has a beta of one with respect to one factor and a beta of zero with respect to each of all the other risk factors.

Assume the risk free rate r_f does exist, λ_0 can be substituted and equation (5) becomes,

$$\bar{\mathbf{R}} - \boldsymbol{\iota} r_f = \boldsymbol{\beta\lambda} \quad (6)$$

The left side is equal to the expected excess return, and equation (6) denotes the well know multi-beta asset pricing model. Plugging (6) into (4) and replacing the excess returns with r gives us

$$\tilde{\boldsymbol{r}} = \boldsymbol{\beta\lambda} + \boldsymbol{\beta F} + \boldsymbol{\varepsilon} \quad (7)$$

Following Ferson and Harvey (1994), the equation below is employed in estimating the unconditional multi-beta pricing model in this paper.

$$r_{it} = \sum_{j=1}^{k} \beta_{ij}(\lambda_j + f_{j,t}) + \varepsilon_{it}, \quad i = 1,2, \dots, n, \quad j = 1,2, \dots k \quad (8)$$

where $f_{j,t}$ are the demeaned returns on risk factors, thus E($f_{j,t}$)=0, which makes sure that the risk premium is not related to the means of the risk factors. Further, $E(\varepsilon_{i,t}) = 0$ and $E(\varepsilon_{i,t}, f_{j,t}) = 0$. In this model, economic variables, e.g., exchange rates can also be incorporated. This avoids the need for mimicking portfolios and simplifies the statistical inferences. The model is to be tested as a restricted seemingly unrelated regression model (SURM) under which the intercept is restricted to be zero.

3.2.2 Choice of Risk Factors

Following Kodongo and Ojah (2012) and Kodongo (2012), among many others, this paper includes four risk factors in the multi-beta pricing model for the Chinese mainland equity market. By including both world market risk and local market risk in the model, a partial integration is assumed. Besides, this paper includes a size premium as an additional risk factor as proposed in Fama and French (1996), which is calculated as the return difference between a small capitalization stocks portfolio and a large capitalization stocks portfolio. The unconditional multi-beta model used in this paper is as below,

$$r_{it} = (\lambda_w + r_{wt})\beta_{iw} + (\lambda_m + r_{mt})\beta_{im} + (\lambda_s + r_{st})\beta_{is} + (\lambda_{spr} + r_{sprt})\beta_{ispr} \quad (9)$$

Where r_i is the ith portfolio excess return, r_w is the demeaned excess return on the world market portfolio, r_m is the idiosyncratic excess return on Chinese local market portfolio, r_s is residual foreign currency risk, and r_{spr} is the residual size premium in the Chinese mainland equity market. r_i, r_m and r_{spr} are denominated in Chinese yuan, r_w is denominated in U.S. dollar. In this paper, I use several different exchange rates as foreign currency risk, including a currency index and several bilateral exchange rates.

In order to eliminate the contemporaneous correlation between the four factors (See Jorion, 1991), I use the residuals from the following models as the risk factors.

$$r_M = \gamma_0 + \gamma_w r_w + \varepsilon_m$$

$$r_S = \gamma_0 + \gamma_w r_w + \gamma_m r_m + \varepsilon_s$$

$$r_{SPR} = \gamma_0 + \gamma_w r_w + \gamma_m r_m + \gamma_s r_s + \varepsilon_{spr} \tag{10}$$

where r_M is excess return on the Chinese mainland equity market portfolio, r_S is the log change of RMB exchange rate, r_{SPR} is the size premium.

Following Antell and Vaihekoski (2012), I include two dummy variables, *Currency* and *Connect* to examine the effect of currency reform and the stock connect on the pricing of world market risk and currency risk; *Currency* takes the value of zero before the currency reform and one after it. *Connect* takes the value of zero before the launch of the Stock Connect and one after it. The multi-beta model becomes

$$\begin{aligned} r_{it} = {} & (\lambda_w + \lambda_{w1} * Currency + \lambda_{w2} * Connect + r_{wt})\beta_{iw} + (\lambda_m + r_{mt})\beta_{im} \\ & + (\lambda_s + \lambda_{s1} * Currency + \lambda_{s2} * Connect + r_{st})\beta_{is} + (\lambda_{spr} + r_{sprt})\beta_{ispr} \end{aligned} \tag{11}$$

3.2.3 Generalized Method of Moments (GMM)

In this paper, 20 size-based portfolio returns are used to estimate the systems of equations in Eq. (9) and (11) with the iterated Generalized Method of Moments (ITGMM) method (Ferson and Harvey, 1994). The ITGMM is preferred to GMM method of Hansen (1982) due to its superior finite sample properties. The pricing coefficient λ and factor sensitivities β are jointly estimated in one-step so that error-in-variables problem is avoided. Following Ferson and Harvey (1994), this paper uses a constant and the contemporaneous risk factors as instruments in the estimation. The orthogonally condition for the GMM is $E(\varepsilon_{i,t}) = E(\varepsilon_{i,t}F_{j,t})$ =0. This paper employs the Newey-West (1987) estimation as the kernel of ITGMM so that the estimated standard errors of parameters and t statistic are robust to heteroscedasticity and autocorrelation. The Newey–West kernel lags are set equal to 4, taking into account the lag structure of the dataset used in this paper.

3.3 Conditional Pricing of Currency Risk and Market Risk

The conditional pricing model used in this paper follows a parsimonious multivariate GARCH-in-Mean model of De Santis and Gerard (1998). In their paper, they assume fully integration and include only the global market risk factor and several currency risk factors, as in Eq. (12),

$$\boldsymbol{r_t} = \boldsymbol{\delta_{m,t-1}h_{m,t}} + \sum_{c=1}^{L}\boldsymbol{\delta_{c,t-1}h_{n+c,t}} + \boldsymbol{\varepsilon_t},\ \ \boldsymbol{\varepsilon_t|\Omega_{t-1}}\sim(\boldsymbol{0},\boldsymbol{H_t}) \tag{12}$$

where $\boldsymbol{r_t}$ are the excess asset returns for s= n+L+1 assets, including n national equity portfolios, L currency deposits and the world market portfolio. $\boldsymbol{h_{m,t}}$ is the covariance of r_t with the world market portfolio return. $\boldsymbol{h_{n+c,t}}$ is the covariance of $\boldsymbol{r_t}$ with the n+c's currency deposit return. $\boldsymbol{\Omega_{t-1}}$ is the information set available at time t-1, $\boldsymbol{H_t}$ is the s×s conditional variance-covariance matrix of the asset returns.

This paper focuses on the Chinese mainland equity market. Hence, I include not only the world market portfolio in the pricing model, but also the local market portfolio and five size-based portfolios. Following Antell and Vaihekoski (2012), I use exchange rate changes instead of currency deposit returns. Hence, there are nine asset returns included in the conditional model used in this paper: one world market return, one local market return, one size premium, five size-based portfolio returns and a foreign currency return. The same four risk factors as the unconditional model are used: world market risk, local market risk, currency risk, size risk factor.

De Santis and Gerard (1998) use Eurodollar rate as risk-free rate to calculate excess returns for equity market portfolio and foreign currencies. They use euro-currency deposit rate as currency risk, while in this study we directly use exchange rate changes. This difference makes it difficult to identify an appropriate risk-free rate in calculating the excess return for foreign currencies. Hence, I use gross returns (raw returns without deducting risk-free rate) in the conditional model, and a constant is included in the pricing model. Thus, a system of nine equations as shown in Eq. (13) is estimated.

$$\boldsymbol{r_t} = const + \boldsymbol{\delta}_{w,t-1}\boldsymbol{h}_{w,t} + \boldsymbol{\delta}_{m,t-1}\boldsymbol{h}_{m,t} + \boldsymbol{\delta}_{s,t-1}\boldsymbol{h}_{s,t} + \boldsymbol{\delta}_{spr,t-1}\boldsymbol{h}_{spr,t} + \boldsymbol{\varepsilon}_t,\ \ \boldsymbol{\varepsilon}_t|\boldsymbol{\Omega}_{t-1}\sim(\mathbf{0},\boldsymbol{H}_t) \tag{13}$$

Where $\boldsymbol{r_t}$ is 9×1 vector of the gross returns, $\boldsymbol{\delta}$ are the prices of the four risk factors, $\boldsymbol{\varepsilon_t}$ is the error term, $\boldsymbol{\Omega_{t-1}}$ is the information available at time t-1. $\boldsymbol{H_t}$ is the conditional covariance matrix of asset returns, and $\boldsymbol{h_{w,t}}$,$\boldsymbol{h_{m,t}}$, $\boldsymbol{h_{s,t}}$, $\boldsymbol{h_{spr,t}}$ are the covariance between $\boldsymbol{r_t}$ and the four risk factors.

To capture the time-varying feature of prices of risk δ, I use several information variables to incorporate the conditional information, thus

$$\delta_k = const_k + \sum_{i=1}^{q} \kappa_{k,i} z_{k,i} \tag{14}$$

Where $const_k$ captures the long-run unconditional part of the prices of the kth factor, z are several information variables, $\kappa_{k,i}$ are the unknown parameters to be estimated. If $\kappa_{k,i}$ are not jointly zero, we can conclude that the prices of risk is time-varying. Similar to the unconditional model, I also include two dummy variables as the information variable to investigate the impact of the currency reform and the Connect.

I use the parsimonious GARCH model generalized by De Santis and Gerard (1997) on the original version of Ding and Engle (1994) to incorporate the GARCH-in-Mean feature of the pricing model. It is assumed that the conditional second moments depend only on an autoregressive component and past cross products of residuals (for variances, on squared residuals). It is further assumed that the system is covariance stationary. Thus the model for $\boldsymbol{H_t}$ is written as below,

$$\boldsymbol{H_t} = \boldsymbol{H_0} * (\boldsymbol{\iota\iota}' - \mathbf{aa}' - \mathbf{bb}') + \mathbf{aa}' * \boldsymbol{\varepsilon}_{t-1}\boldsymbol{\varepsilon}'_{t-1} + \boldsymbol{bb}'\boldsymbol{H}_{t-1} \tag{15}$$

Where $\boldsymbol{H_0}$ is the unconditional variance-covariance matrix, $\boldsymbol{\iota}$ is a 9×1 vector of ones, $\boldsymbol{a}$, $\boldsymbol{b}$ are 9×1 vectors of parameters, and * is the Hadamard matrix product (element by element). De Santis and Gerard (1998) estimate $\boldsymbol{H_0}$ using an iterative procedure: the first iteration uses the sample covariance matrix as H_0 and following iterations replace it with the estimated residuals' covariance matrix of each previous iteration. In this paper, I use the sample covariance matrix as $\boldsymbol{H_0}$ until the iteration process achieves convergence, then replace $\boldsymbol{H_0}$ using the estimated residuals' covariance matrix and implement the iteration process again until convergence.

Compared to BEKK GARCH, the parsimonious GARCH decreases the number of parameters dramatically. For this paper, the parameters to be estimated are 212 under BEKK GARCH but only 18 under the parsimonious GARCH.

Because financial data is usually non-normally distributed, the conditional model is estimated by QML (quasi-maximum likelihood) method proposed by Bollerslev and Wooldridge (1992). The BFGS (Broyden, Fletcher, Goldfarb and Shanno) algorithm is used for the optimization.

CHAPTER 4 DATA AND DESCRIPTIVE STATISTICS

4.1 Stock Return Data

All the stock price data is obtained from Bloomberg. Individual stock data cover the period from January 2001 to September 2017, which provides 201 observations of monthly returns and 847 observations of weekly returns. Only the stocks listed for the whole sample period are selected. As at September 2017, there were 3381 A-shares listed in Shanghai and Shenzhen Stock Exchange, within which 974 stocks were listed throughout the sample period. This sampling method will inevitably have survivorship bias but, as Carrieri and Majerbi (2006) argued, this sampling method provides longer data series and preserve cross-sectional information over full period, thus is necessary given the large number of unknown parameters and the empirical method used.

To test the unconditional pricing model, the 974 stocks are grouped into 20 portfolios based on size. Portfolio 1 consists of 49 stocks with the smallest market capitalization, where they are equally weighted in the portfolio. In the same way Portfolio 2 to 20 are formed. Dividend payments, stock split, and other corporate actions are adjusted to make the stock price data comparable through time. Stock return is calculated as the log difference of stock prices. Dividend yield is not included in the return data. For the conditional model, I group the 974 stocks into five portfolios based on size because using 20 portfolios for multivariate GARCH process would make the estimation difficult to converge.

The quantity of weekly observations makes it possible to do an intra-period comparative study. Following the spirit of Chong et al. (2012), I split the sample period into four sub-periods as shown in Table 2.

Table 2 Description of the four sub-periods

	Description	Period
1	Period before the currency reform	2001/01/01-2005/07/20
2	Period pre and post financial crisis	2005/07/21-2009/12/31
3	Period before the Stock Connect	2010/01/01-2014/11/16
4	Period after the Stock Connect	2014/11/17-2017/09/30

The gross returns are used for the conditional pricing model as described in Section 3.3. To calculate excess returns used in the unconditional model (described in Section 3.2), I use weekly and monthly returns on Chinese three-month deposit rate as the risk free rate for the

Chinese mainland equity market (RFCN), and weekly and monthly returns on the Eurodollar one month rate as the risk free rate for world stock market (RFW).

The data is also obtained from Bloomberg. Following Kodongo and Ojah (2012), the annual risk-free rates are converted to monthly and weekly rates using the formula:

$$r_{f,monthly} = \exp\left(\frac{r_{f,annual}}{12}\right) - 1$$

$$r_{f,weekly} = \exp\left(\frac{r_{f,annual}}{52}\right) - 1 \qquad (16)$$

4.2 Risk Factors

Market index data is obtained from Morgan Stanley Capital International (MSCI). MSCI World Index is used as the index of world market portfolio. MSCI China A index is used as the index of the Chinese mainland market portfolio. MSCI provides indexes data both with and without dividends invested. To be comparable with stock price data, I use the indexes without dividends invested. World stock market return (RW) and the Chinese mainland equity market return (RM) are thus calculated as the log difference of the two indexes, respectively.

For exchange rate, I use both an exchange rate index and several bilateral exchange rates. The Real Effective Exchange Rate (REER) of Chinese yuan is published by Bank of international settlement (BIS). REER is a trade-weighted real currency index calculated using various bilateral exchange rates. Increase in REER means appreciation of RMB. The inverse of REER is used to be comparable with other bilateral exchange rates. For the remaining of the paper, I use $REER^{-1}$ to denote the inverse of REER to avoid misunderstanding. Thus, $REER^{-1}$ measures the value of a basket of foreign currencies against RMB. The bilateral exchange rates used in this paper are USD/CNY, EUR/CNY and JPY/CNY, all measured as the RMB price of foreign currencies. To be consistent with literature, where currency risk is said to arise because of deviations from purchasing power parity, I convert the nominal bilateral exchange rates to real ones using the relative consumer price indexes (CPI). Take USD/CNY (RMB price of U.S. dollar) for example, the real exchange rate is calculated in the following manner,

$$\mathrm{Real}_{USD/CNY} = Nominal_{USD/CNY} \times \frac{CPI_{USA}}{CPI_{CHINA}} \qquad (17)$$

Because CPI data are only available at monthly intervals, and CPI data for Euro zone is not long enough, I can only calculate the monthly real exchange rate for USD/CNY and JPY/CNY and use them as well as $REER^{-1}$ for the models using monthly data. As for models using weekly data, the three nominal exchange rates are used. In the literature, using nominal exchange rates or real exchange rates commonly yield similar results (e.g. Antell and Vaihekoski, 2012). The bilateral exchange rates are obtained from Bloomberg. Since BIS reports REER only at monthly basis, I can only use REER in the monthly return analysis. Because nominal USD/CNY is almost fixed at 8.28 before the currency reform, it is only used for periods after the currency reform. Exchange rate change, or currency risk (RS) is thus calculated as the log difference of the exchange rates.

In the literature, foreign exchange risk is usually measured using the foreign currency value changes against U.S. dollar from the perspective of the U.S. investors (e.g. Carrieri and Majerbi, 2006, Antell and Vaihekoski, 2012). Using this definition of foreign currency risk, a negative pricing is usually documented. Other literature defines foreign exchange risk using the value of U.S. dollar against foreign currency, e.g. Kodongo and Ojah (2012), and reports positive pricing. In this paper, I estimate the international asset pricing model from the perspective of Chinese investors due to the limited participation of foreign investors. Hence, I define foreign exchange risk as the foreign currency value changes against RMB. Thus, an increase of the exchange rate defined means appreciation of foreign currencies and vice versa.

The size premium or size risk factor (SPR) is calculated manually using the stock price data. Every year-end, all the listed stocks (excluding the stocks delisted during the sample period) are ranked by size from the smallest to the largest in terms of market capitalization. The stocks are included in a small stocks portfolio from the top of the list until the portfolio reaches 30% of the total market capitalization. The remaining stocks go to large stocks portfolio. The size premium is then calculated as the difference between small stock portfolio return and the large stock portfolio return.

4.3 Information Variables

Based on the literature, a bunch of different information variables is tested to see if they have any predictability power for the Chinese mainland equity market. Using the return of the Chinese mainland equity market as the dependent variable and regressing it against all the candidate information variables, the OLS estimation results are shown in Table 3. Four information variables are found to enter the model significantly and are selected for the conditional pricing model in later chapters. These four information variables are lagged local market return RM(1), lagged first difference in euro dollar one-month rate ΔEuro$, lagged first difference in default premium[16] ΔDefault, and lagged return on RMB one-month forward contract. The difference transformations on the raw data are to guarantee the data series are stationary. All the information variables data is obtained from Bloomberg.

Table 3 OLS results, the Chinese mainland equity market return explained by information variables

$$r_m = constant + \sum_{i=1}^{k} \delta_i z_i + \varepsilon_t$$

	Description	***Model(1)***		***Model(2)***	
Intercept		0.048	(0.38)	0.048	(0.39)
RW(1)	Lagged world market return	0.170	(1.23)		
RM(1)	Lagged local market return	0.053	(1.47)	0.063*	(1.83)
EUR(1)	Lagged EUR/CNY log difference	-0.123	(-1.13)		
USD(1)	Lagged USD/CNY log difference	0.512	(0.63)		
JPY(1)	Lagged JPY/CNY log difference	-0.018	(-0.19)		
SPR(1)	Lagged size factor	-0.005	(-0.12)		
ΔUSTERM	lagged first difference of US term premium (the difference between 5 Year T-Note Yield and 3 month T- bill yield)	-0.470	(-0.47)		
ΔEuro$	lagged first difference in euro dollar one month rate	1.567	(1.62)	1.765*	(1.83)
ΔDYLD	Lagged first difference of aggregate dividend yield on MSCI world market portfolio	0.902	(0.2)		
ΔAAA	Lagged yield on Moody's AAA corporate bond	0.621	(0.41)		
ΔDefault	lagged first difference in default premium (the difference between yields on Moody's BAA corporate bond and AAA corporate bond)	-4.071	(-1.57)	-5.045**	(-2.01)
FWD	lagged return on Chinese yuan 1 month forward contract	-1.468**	(-2.17)	-1.316***	(-3.41)
FWP	Lagged rate of difference between RMB 1 month forward rate and the spot rate	-0.044	(-0.17)		
Adj-R^2		0.0236		0.0238	

The table reports the OLS estimation results over the period from 2001:01–2017:09. r_m is the local market return, z_i are information variables, δ_i are unknown parameters of the information variables. Adj-R^2 is the coefficient of determination. The t-statistics are reported in parenthesis. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

[16] The default premium is calculated as the difference between the yields on Moody's BAA corporate bond and AAA corporate bond.

4.4 Summary statistics

The summary statistics of monthly data are reported in Table 4. All return figures are scaled up by 100, so the reported return figures are in percentages. The correlation matrix for risk factors and information variables are reported in Table 5. As evident from Table 4, Chinese mainland market return (RM) yields both higher average returns (0.340%) and higher standard deviation than the world market portfolio (RW, 0.246%). The behaviour of the 20 size-based portfolio returns are similar with RM, thus are omitted to avoid redundancies. All the three exchange rates have negative sample means, indicating depreciation against RMB. The positive mean of SPR (0.501%) indicates significant size premium in the Chinese mainland equity market. The risk free rates, RFW and RFCN are stable and thus highly autocorrelated, so the autocorrelation figures are not reported. Most variables have significant skewness and excess kurtosis, which necessitate the reporting of robust errors of estimation. The autocorrelation function shows that RM is serially correlated up to lag 4. RM also has significant autocorrelations at lag 13 and 14, indicative of cyclical behaviour. The 20 portfolios also show very similar autocorrelation structure. USD reveals substantial seasonal behaviour in autocorrelation, with significant high autocorrelation at lag 12 and 24. The correlation matrix is reported in Table 5. The correlation between RW and RM is low (0.34) as expected. RM is positively correlated with $REER^{-1}$ but is negatively correlated with the two real bilateral exchange rates.

Table 6 reports the summary statistics for weekly data. Different from monthly data, the exchange rates reported in Table 6 are all nominal ones. Almost all the data show significant skewness and excess kurtosis. While there is no significant autocorrelation for RW, the autocorrelation function is significant up to 3 lags for RM, indicating higher predictability, as is typical for emerging markets. ΔDefault and ΔEuro$ both see long autocorrelation lags for weekly data, even though the data series have been taken the first difference and are stationary. Table 7 reports the correlation matrix. The correlation between RW and RM is lower (0.18) for weekly data than monthly data. Overall, the correlation between risk factors and information variables are low.

Table 4 Summary statistics, monthly data

	Mean	Std. Dev.	Skew	Ex Kurt	Autocorrelation									
					1	2	3	4	5	6	12	13	14	24
RW	0.246	4.453	-0.98***	2.62***	0.172 [a]	-0.028	0.128	0.112	0.038	-0.059	0.039	-0.031	-0.043	-0.037
RM	0.340	8.471	-0.45***	1.44***	0.134 [a]	0.148 [a]	0.077	0.210 [a]	0.095	-0.051	-0.068	-0.233 [a]	-0.199 [a]	-0.073
$REER^{-1}$	-0.118	1.368	0.16	-0.11	0.335 [a]	0.058	-0.009	0.039	-0.015	-0.083	0.051	0.023	0.040	0.147 [a]
JPY	-0.256	2.969	0.01	0.12	0.068	0.152 [a]	-0.034	-0.004	-0.145 [a]	-0.053	0.027	0.107	-0.039	0.090
USD	-0.081	1.141	-0.42**	2.02***	0.142 [a]	-0.04	-0.05	0.069	0.047	0.058	0.419 [a]	0.051	-0.043	0.311 [a]
SPR	0.501	6.037	-0.22	3.79***	0.068	-0.027	-0.108	-0.070	-0.216 [a]	0.039	0.106	-0.011	-0.098	-0.014
FWD	-0.107	0.713	1.78***	14.20***	0.090	0.003	0.103	0.224 [a]	0.147 [a]	0.159 [a]	0.067	-0.008	-0.013	-0.135
RM(1)	0.340	8.471	-0.45***	1.44***	0.134 [a]	0.148 [a]	0.077	0.210 [a]	0.095	-0.051	-0.068	-0.233 [a]	-0.199 [a]	-0.073
ΔDefault	-0.001	0.131	1.41***	17.44***	0.461 [a]	0.133 [a]	0.036	0.040	0.051	-0.055	-0.077	-0.069	-0.064	-0.043
ΔEuro$	-0.026	0.410	0.16	43.27***	-0.175 [a]	0.111	-0.052	0.061	0.005	0.075	0.014	0.102	-0.003	-0.011
RFW	0.138	0.148	1.08***	-0.25										
RFCN	0.169	0.051	0.51***	-0.57										

All data is in percentages, covering period 2001:1 through 2017:9. "Skew" and "Ex Kurt," respectively, mean skewness and excess kurtosis. RW, RM are gross returns on world market portfolio and the Chinese mainland equity market portfolio. REER, JPY, USD are real exchange rates measuring the foreign currency prices against RMB. The superscript a stands for significant autocorrelation. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

Table 5 Correlation matrix, monthly data

	RW	RM	RS	JPY	USD	SPR	LGFWD	LGRM	LGDIF	LGERD
RW	1.00									
RM	0.34	1.00								
RS	0.32	0.11	1.00							
JPY	-0.16	-0.16	0.26	1.00						
USD	-0.14	-0.12	0.19	0.32	1.00					
SPR	-0.04	0.21	-0.03	0.05	0.08	1.00				
FWD	-0.06	-0.17	0.02	0.07	0.06	-0.07	1.00			
RM(1)	0.13	0.13	0.15	-0.10	0.18	0.15	-0.06	1.00		
ΔDefault	-0.12	-0.10	-0.17	0.06	-0.13	0.08	-0.04	-0.24	1.00	
ΔEuro$	-0.03	-0.15	0.00	0.07	0.08	-0.10	0.19	0.12	-0.30	1.00

Table 6 Summary statistics, weekly data

	Mean	Std. Dev.	Skew	Ex Kurt	Autocorrelation									
					1	2	3	4	5	6	12	13	14	24
RW	0.058	2.531	-2.55***	30.69***	-0.051	0.046	-0.059	0.012	0.026	0.066 [a]	0.005	0.079 [a]	0.06	-0.012
RM	0.081	3.620	-0.27***	2.28***	0.076 [a]	0.094 [a]	0.076 [a]	0.027	0.002	0.03	0.024	0.004	-0.022	-0.028
EUR	0.001	1.327	-0.47***	2.79***	0.017	0.015	0.01	0.052	-0.018	-0.02	0.000	0.037	-0.02	0.043
JPY	-0.028	1.468	0.21**	1.61***	-0.060	0.032	-0.029	0.021	0.000	-0.033	0.002	-0.040	-0.013	-0.034
USD	-0.026	0.262	1.37***	25.76***	0.119 [a]	0.053	0.051	0.16 [a]	0.043	0.081 [a]	0.011	0.076 [a]	0.038	0.048
SPR	0.114	2.835	-0.85***	4.49***	0.031	0.044	0.058	0.022	-0.034	-0.115 [a]	0.015	-0.076 [a]	-0.034	-0.072 [a]
FWD	-0.027	0.321	4.36***	71.97***	0.008	0.037	0.063	0.065	-0.008	0.036	0.007	0.057	0.018	0.066 [a]
RM(1)	0.081	3.622	-0.27***	2.27***	0.076 [a]	0.094 [a]	0.076 [a]	0.027	0.002	0.03	0.024	0.004	-0.022	-0.028
ΔDefault	-0.000	0.050	2.66***	27.37***	0.518 [a]	0.205 [a]	0.047	0.098 [a]	0.154 [a]	0.149 [a]	0.023	0.07 [a]	0.049	-0.014
ΔEuro$	-0.006	0.128	1.68***	88.84***	0.337 [a]	0.142 [a]	-0.093 [a]	-0.184 [a]	-0.075 [a]	-0.088 [a]	-0.039	0.098 [a]	0.019	0.073 [a]
RFCN	0.039	0.012	0.50***	-0.60***										
RFW	0.031	0.034	1.08***	-0.24										

All data is in percentages, covering period 2001:1 through 2017:9. "Skew" and "Ex Kurt," respectively, stand for skewness and excess kurtosis. RW, RM are gross returns on world market portfolio and the Chinese mainland equity market portfolio. EUR, JPY, USD are nominal exchange rates measuring the foreign currency prices against RMB. The superscript a means significant autocorrelation. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

Table 7 Correlation Matrix, weekly data

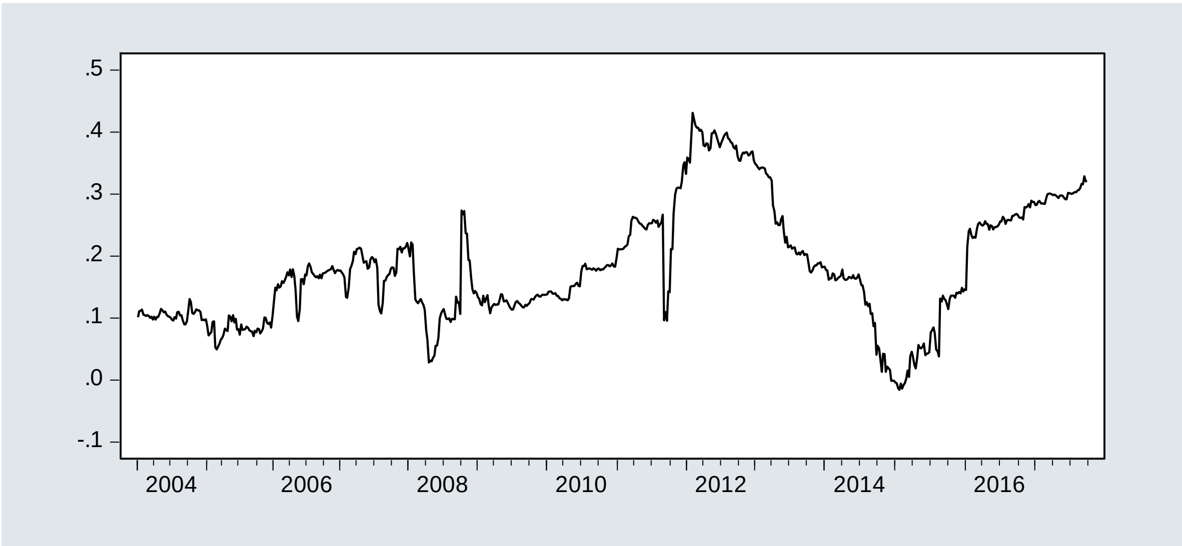
	RW	RM	EUR	JPY	USD	SPR	FWD	RM(1)	ΔDefault	ΔEuro$
RW	1.00									
RM	0.18	1.00								
EUR	0.33	0.16	1.00							
JPY	-0.21	-0.03	0.23	1.00						
USD	-0.09	0.01	-0.02	0.03	1.00					
SPR	-0.08	0.21	-0.02	0.07	0.05	1.00				
FWD	-0.02	-0.12	-0.00	-0.00	0.13	-0.03	1.00			
RM(1)	-0.05	0.08	0.04	0.05	0.01	0.16	-0.00	1.00		
ΔDefault	0.04	-0.09	-0.07	0.00	-0.02	-0.01	0.07	-0.16	1.00	
ΔEuro$	-0.09	0.06	0.02	0.04	0.06	-0.09	0.06	0.03	-0.04	1.00

CHAPTER 5 EMPIRICAL RESULTS

5.1 Measure of Market Integration

Figure 4 shows the 3-year rolling correlation coefficient between the Chinese mainland equity market return with the world market return using weekly returns. In general, the correlation is low throughout the sample period, indicative of a low level of integration. There is an upward trend until 2012 then the correlation sharply decreases and only picks up after 2014. Overall, the correlation has increased from around 0.1 in 2004 to more than 0.3 in 2017. This provides preliminary evidence of increasing correlation between the Chinese mainland equity market and the world market.

Figure 4 Three-year rolling correlation between the Chinese mainland equity market and the world market



Weekly data are used to calculate the three-year rolling correlation. The Chinese mainland equity market return is calculated as the return on MSCI China A index. World market return is calculated as the return on MSCI World index. The graph covers the period from 2001:1 to 2017:9.

As described in Section 3.1, I also estimate the conditional correlation using a VAR-GARCH(1,1) model. As explained in section 3.1, the lag selection for VAR is based on Akaike Information Criterion (AIC). For our dataset, the lag is set at one based on AIC. The model results are shown in Table 8. Model (1) and Model (2) have the same mean equations, linking RW and RM to a constant and their lagged terms respectively. Model (1) uses the conditional second moments using BEKK GARCH method, while Model (2) uses the parsimonious GARCH method as described in Section 3.3. Overall, the results are consistent. Model (1) results show that both lagged RW and RM have predicting power over the Chinese mainland equity market return, while they have no predicting power for the world market return. This indicates that Chinese market return is more predictable than the world market return, which is also consistent with the autocorrelation behavior reported in Section 4.4. The significance of most GARCH parameters means that the model is capable of capturing the dynamics of conditional second moments of RW and RM, based on which the conditional correlation between the two is calculated and plotted in Figure 5 and Figure 6, using BEKK GARCH and the parsimonious GARCH respectively. Consistent with Figure 4, the correlation is found to be low. Figure 5 shows a weak upward trend, at least for the period after the financial crisis, indicating that Chinese market is getting more integrated with the world market. Figure 6 shows no trend in the correlation, possibly due to the limit of the parsimonious GARCH model, which has imposed restrictions on the covariance process and limited the number of parameters to only four, which inevitably sacrifice the flexibility.

Table 8 Quasi maximum likelihood results for the VAR(1)-GARCH(1,1) model

$\boldsymbol{r_t} = \boldsymbol{c} + \boldsymbol{\delta_w} r_{w,t-1} + \boldsymbol{\delta_m} r_{m,t-1} + \boldsymbol{\varepsilon_t}$, $\boldsymbol{\varepsilon_t} | \boldsymbol{\Omega_{t-1}} \sim (\boldsymbol{0}, \boldsymbol{H_t})$

BEKK GARCH: $\boldsymbol{H_t} = \boldsymbol{C} + \boldsymbol{A}'(\boldsymbol{\varepsilon_{t-1}} \boldsymbol{\varepsilon'_{t-1}})\boldsymbol{A} + \boldsymbol{G}'\boldsymbol{H_{t-1}}\boldsymbol{G}$

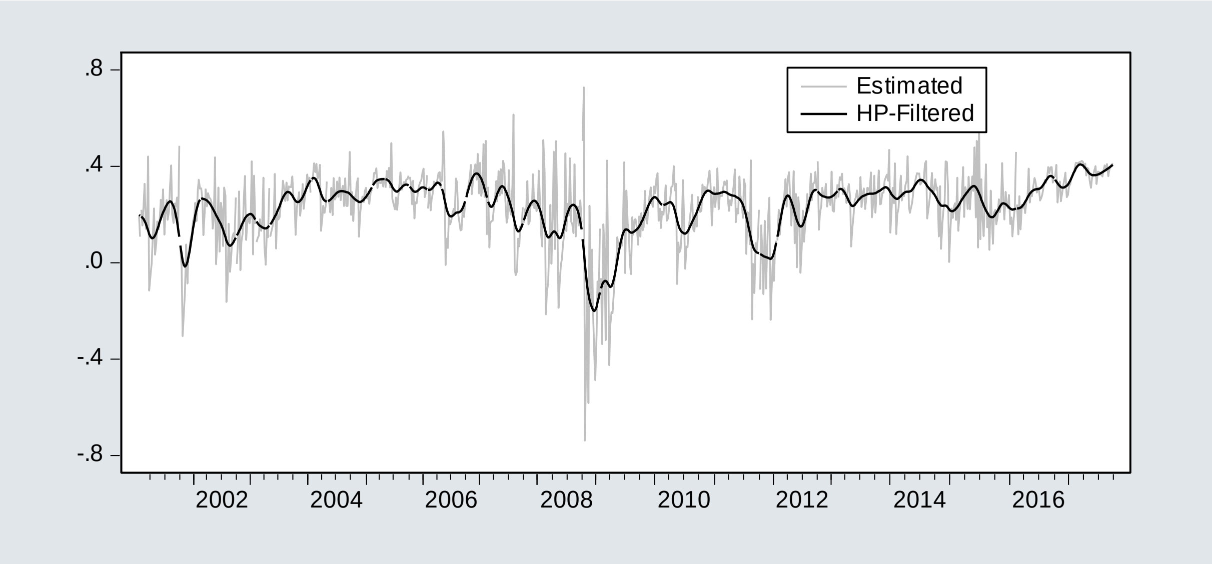
The parsimonious GARCH: $\boldsymbol{H_t} = \boldsymbol{H_0} * (\mathbf{\iota\iota}' - \mathbf{aa}' - \mathbf{bb}') + \mathbf{aa}' * \boldsymbol{\varepsilon_{t-1}} \boldsymbol{\varepsilon'_{t-1}} + \boldsymbol{bb}'\boldsymbol{H_{t-1}}$

		Model (1) BEKK GARCH				**Model (2) parsimonious GARCH**			
Dependent Variable		RW		RM		RW		RM	
Parameter estimates of mean equation	Const	0.215***	(2.73)	-0.016	-0.12	0.295***	3.33	0.062	0.66
	RW(1)	0.010	(0.25)	0.159***	2.73	0.014	0.31	0.090*	1.88
	RM(1)	0.004	(0.15)	0.082**	2.14	-0.045	-1.43	0.015	0.43
Parameter estimates of variance equation	c_{11}	0.000	(0.00			a_1	0.412***	5.66	
	c_{21}	2.033***	2.61			a_2	0.291***	11.38	
	c_{22}	12.390***	9.25			b_1	0.883***	18.35	
	a_{11}	0.567***	5.28			b_2	0.947***	96.33	
	a_{21}	-0.226***	-4.80						
	a_{12}	0.215	1.55						
	a_{22}	-0.172*	-1.70						
	g_{11}	-0.717***	-8.70						
	g_{21}	0.381***	4.01						
	g_{12}	0.341**	2.27						
	g_{22}	0.030	0.19						

The table reports the QML estimation results for the weekly returns, over the period from 2001:01–2017:09. $\boldsymbol{r_w}$ is the return on world market portfolio, $\boldsymbol{r_m}$ is the local market return. δ_w, δ_m are unknown parameters. $\boldsymbol{H_t}$ is estimated using BEKK and the parsimonious GARCH(1,1) model respectively. The GARCH models are described in Section 3.1 and 3.3. The t-statistics reported in parenthesis are robust to autocorrelation and heteroscedasticity. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

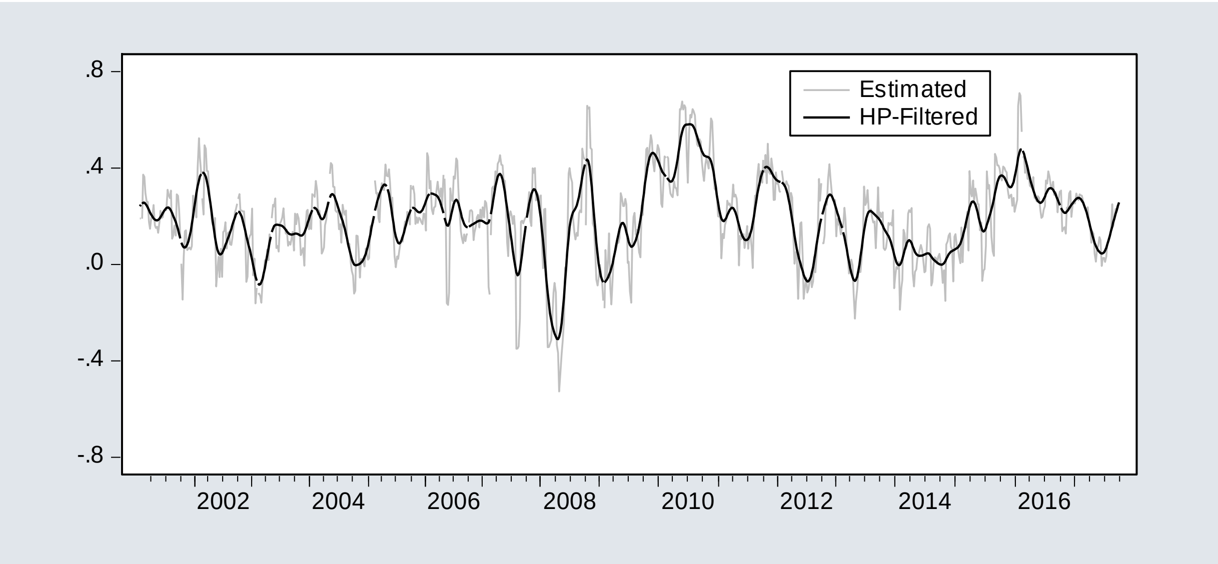
Through the analysis above, we conclude that the correlation between the Chinese mainland equity market and the world market is low. Weak evidence is found for an increasing correlation, providing some preliminary evidence for the increased level of integration. Further analysis of the pricing of world market risk is implemented in section 5.2 and 5.3.

Figure 5 Conditional correlation between the Chinese mainland equity market return and the world market return, estimated by BEKK GARCH



The series HP-filtered shows the Hodrick-Prescott filtered values, eliminating the high-frequency components of the time series of estimated conditional correlation.

Figure 6 Conditional correlation between the Chinese mainland equity market return and the world market return, estimated by the parsimonious GARCH



The series HP-filtered shows the Hodrick-Prescott filtered values, eliminating the high-frequency components of the time series of estimated conditional correlation.

5.2 Unconditional Asset Pricing

I estimate the unconditional model in Eq. (9) using first monthly return data and then weekly return data. For monthly returns, I use the $REER^{-1}$ and other two real bilateral exchange rates (USD/CNY and JPY/CNY) as the currency risk factor and test them separately. EUR/CNY is not included because there is no CPI statistics for Eurozone during the sample period. Three nominal bilateral exchange rates (USD/CNY, JPY/CNY and EUR/CNY) are used as currency risk factor in the models for weekly return data.

5.2.1 Using Monthly Return Data

Table 9 reports the estimated betas for the 20 portfolios and risk premia using $REER^{-1}$ as the currency risk factor. The *J*-test statistic indicates that the model cannot be rejected. The adjusted R-squared range from 0.769 to 0.949, the average pricing errors and RMSE are low. Figure 7 plots the average actual returns on the 20 portfolios against the estimated average returns, indicating a reasonably good model fit. The high R-squared statistics indicate the four risk factors are able to capture most of the time variation in the portfolio returns. All the portfolio returns are highly correlated to local market return, with β_m ranges in a narrow band around one. The low average pricing errors and RMSE indicate that the model is able to explain much of the cross-sectional differences in the portfolios' expected returns.

The world market risk betas vary from 0.49 to 0.66 and are significant for all the 20 portfolios. Interestingly, the size factor betas show a declining trend with respect to the size-ranked portfolios, with the highest beta 0.72 for portfolio 8 and the lowest beta of 0.07 for portfolio 20, which is consistent with the existence of size risk premium. Differently, the currency risk betas are generally low (-0.11 to 0.28) and only 1 of the 20 is significant. Comparatively, when using the two real bilateral exchange rates as the currency risk factor, almost all currency risk betas are significant (17 out of 20 for USD/CNY, and 10 out of 20 for USD/JPY, the results are not reported to avoid redundancies). This comparison indicates that while Chinese stock returns are sensitive to bilateral real exchange rates, they are less sensitive to a comprehensive trade-weighted real exchange rate. The reason might be that foreign exchange market is comprised of various bilateral exchange rate markets where bilateral rates are closely monitored by market participants. In contrast, trade-weighted real exchange rates are more of macroeconomic data rather than high-frequency financial market data.

Table 9 GMM results for the unconditional model, monthly returns

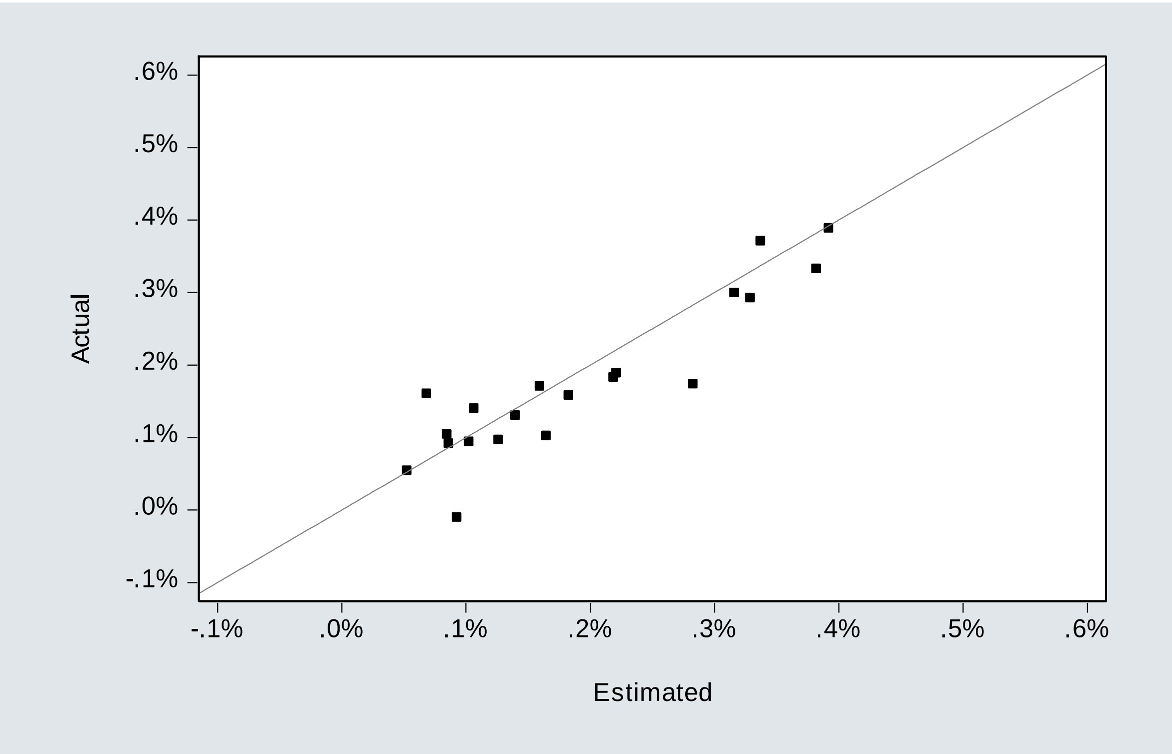
$$r_{it} = (\lambda_w + r_{wt})\beta_{iw} + (\lambda_m + r_{mt})\beta_{im} + (\lambda_s + r_{st})\beta_{is} + (\lambda_{spr} + r_{sprt})\beta_{ispr} + \varepsilon_{it}$$

Portfolio	β_w	β_m	$\beta_s reer$	β_{spr}	RMSE	Adj-R^2	APE
1	0.604*** (11.21)	1.007*** (27.02)	0.121 (0.92)	0.492*** (6.87)	4.821	0.769	-0.002
2	0.606*** (21.96)	1.063*** (40.1)	-0.016 (-0.14)	0.678*** (16.98)	2.641	0.930	-0.108
3	0.491*** (22.89)	0.974*** (40.6)	0.016 (0.14)	0.633*** (21.38)	2.535	0.922	0.093
4	0.656*** (23.5)	1.054*** (60.93)	-0.072 (-0.74)	0.582*** (19.61)	2.384	0.942	-0.036
5	0.54*** (26.51)	1.031*** (45.12)	0.114 (1.04)	0.63*** (21.19)	2.286	0.942	-0.031
6	0.545*** (23)	1.052*** (56.56)	0.082 (0.85)	0.597*** (20.83)	2.474	0.936	-0.028
7	0.639*** (25.1)	1.033*** (43.96)	-0.115 (-1.3)	0.528*** (15.67)	2.269	0.944	-0.035
8	0.547*** (19)	1.025*** (33.79)	-0.042 (-0.42)	0.72*** (19.57)	2.765	0.923	-0.061
9	0.595*** (24.02)	1.053*** (61.36)	-0.109 (-1.36)	0.562*** (23.09)	2.167	0.949	0.002
10	0.61*** (22.86)	0.965*** (49.53)	-0.041 (-0.47)	0.481*** (20.25)	2.053	0.946	-0.016
11	0.558*** (23.91)	1.022*** (53.79)	-0.03 (-0.35)	0.567*** (24.46)	2.253	0.943	0.007
12	0.575*** (24.46)	1.058*** (35.11)	0.072 (0.83)	0.526*** (18.28)	2.441	0.937	-0.008
13	0.617*** (24.54)	0.983*** (64.84)	0.103 (1.06)	0.392*** (10.95)	2.406	0.924	-0.048
14	0.649*** (25.11)	1.094*** (48.11)	-0.034 (-0.43)	0.477*** (16.54)	2.270	0.947	0.012
15	0.57*** (24.41)	0.957*** (42.56)	-0.066 (-0.73)	0.503*** (23.19)	2.249	0.935	-0.023
16	0.569*** (25.83)	1.001*** (56.97)	-0.06 (-0.75)	0.516*** (23.37)	2.397	0.929	-0.102
17	0.591*** (29.13)	1.02*** (53.19)	0.278*** (3.06)	0.318*** (12.33)	2.038	0.949	0.035
18	0.621*** (21.3)	1.063*** (57.22)	0.015 (0.21)	0.365*** (8.38)	2.386	0.936	0.021
19	0.617*** (22.65)	1.037*** (61.93)	0.137 (1.47)	0.181*** (7.53)	2.238	0.939	-0.007
20	0.645*** (28.21)	0.926*** (49.21)	-0.086 (-0.83)	0.068*** (2.63)	1.946	0.945	0.035
	λ_w	λ_m	$\lambda_s reer$	λ_{spr}	*J*-statistic		
	3.603*** (2.62)	-2.353** (-2.33)	1.150*** (2.68)	0.908* (1.70)	3.68 [0.9994]		

The table reports the GMM estimation results for the unconditional model for monthly returns, over the period from 2001:01–2017:09. r_{wt} is the excess return on world market portfolio, r_{mt} is the orthogonalized local market excess return, r_{st} is the orthogonalized currency risk measured by $REER^{-1}$ (inverted Chinese yuan real effective exchange rate), r_{sprt} is the orthogonalized size factor. The estimated betas are reported for each of the portfolios. β_w, β_m, $\beta_s reer$ and β_{spr} are sensitivities of portfolio returns to world market return, local market return, currency risk factor and size factor, respectively. λ_w, λ_m, $\lambda_s reer$, λ_{spr} are the prices of the four risk factors, in percentages. RMSE is the root mean squared error; APE the average pricing error, both reported in percentages. Adj-R^2 is the coefficient of determination. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. The number of lags of the Newey–West kernel is set at 4. The probability value of the *J*-test is reported in square braces. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

The estimates of unconditional risk pricing parameters are all significant. The price of world market risk is 3.603% (the figures reported in Table 9 are in percentages), which is large compared to the sample mean of Chinese domestic market return (0.340%). The local market price is negative and offsets the positive price of world market risk. Despite the insignificant betas, currency risk is significantly priced with a price of 1.150%. The positive pricing of $REER^{-1}$ is inconsistent with the findings in Huang et al. (2014), where the currency value of Chinese yuan (measured by REER, while in this paper we measure currency risk by $REER^{-1}$) is found to be positively priced. This inconsistency may be due to the different empirical method and sample period used in this paper. In Huang et al. (2014), Two-pass and Fama-Macbeth method are used for sample period 1997:01 to 2010:10. To check whether there is substantial time variation in the price of real exchange risk, I test the model in Eq. (9) for period 2001:01 to 2010:10 and find that $REER^{-1}$ is negatively priced, though not significantly. The positive pricing of $REER^{-1}$ could also result from the fact that $REER^{-1}$ is actually proxying for other local sources of risks, as argued by Carrieri and Majerbi (2006) and confirmed in Huang et al. (2014) that REER changes are positively related to the economic status in China. The price of size factor is 0.908%, indicating the existence of size premium in the Chinese mainland equity market.

Figure 7 Actual returns versus estimated returns by the unconditional model, monthly data, over the whole sample period, using $REER^{-1}$ as currency risk



This graph use the estimation results in Table 9.

Table 10 shows estimation results of several different model settings. Model (1) in Table 10 is the same model we reported in Table 9. Model (2) and (3) use the real bilateral exchange rates, USD/CNY and JPY/CNY as the currency risk factors, respectively. Model (4) to Model (6) test the same models over the sub-period after the currency reform (2005:08-2017:09).

Table 10 GMM results for various unconditional models, monthly returns

$$r_{it} = (\lambda_w + r_{wt})\beta_{iw} + (\lambda_m + r_{mt})\beta_{im} + (\lambda_s + r_{st})\beta_{is} + (\lambda_{spr} + r_{sprt})\beta_{ispr} + \varepsilon_{it}$$

	Whole sample period 2001:01-2017:09			**Period after the currency reform 2005:08-2017:09**		
	Model(1)	**Model(2)**	**Model(3)**	**Model(4)**	**Model(5)**	**Model(6)**
λ_w	3.603***	-0.290	-0.985	3.096***	3.870*	1.597**
	(2.62)	(-0.45)	(-1.01)	(2.70)	(1.83)	(2.14)
λ_m	-2.353**	0.500	1.017	-1.972*	-3.339	-0.544
	(-2.33)	(1.09)	(1.45)	(-1.87)	(-1.57)	(-0.77)
$\lambda_s reer$	1.150***			1.022***		
	(2.68)			(2.69)		
$\lambda_s usd$		-0.309			2.486**	
		(-1.60)			(2.05)	
$\lambda_s jpy$			-0.778			0.482
			(-1.10)			(0.81)
λ_{spr}	0.908*	0.028	-0.357	1.340**	1.940**	0.840**
	(1.70)	(0.09)	(-1.10)	(2.51)	(2.50)	(1.98)
Observations	201	201	201	146	146	146
Adj-R^2 Range	0.769	0.771	0.769	0.755	0.756	0.759
	0.949	0.948	0.949	0.949	0.948	0.948
J-statistic	3.68	7.42	8.54	5.82	7.53	9.56
	(0.9994)	(0.9643)	(0.9311)	(0.9899)	(0.9615)	(0.8885)
APE	-0.108	-0.240	-0.200	-0.210	-0.243	-0.265
Range	0.093	0.353	0.101	0.291	0.037	0.275
RMSE	1.946	1.954	1.967	2.148	2.146	2.142
Range	4.821	4.804	4.822	5.389	5.382	5.351

The table shows the GMM estimates for the unconditional model for monthly returns. r_{wt} is the excess return on world market portfolio, r_{mt} is the orthogonalized local market excess return, r_{st} is the orthogonalized currency risk measured by REER^{-1} , USD/CNY, JPY/CNY respectively, r_{sprt} is the orthogonalized size factor. The estimated betas are reported for each for the portfolio. β_w, β_m, β_s and β_{spr} are sensitivities of portfolio returns to world market return, local market return, currency risk factor and size factor, respectively. λ_w, λ_m, λ_s, λ_{spr} are the prices of the four risk factors, in percentages. RMSE is the root mean squared error; APE the average pricing error, both reported in percentages. Adj-R2 is the coefficient of determination. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. The number of lags of the Newey–West kernel is set at 4. Probability value of the *J*-test is reported in parenthesis. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

In model (1) and (4), where REER^{-1} is used as the currency risk factor, all four risk factors are found priced significantly during both the whole sample period and the sub-period. The results become much different when the two real bilateral exchange rates are used as currency risk factors: Japanese yen is priced in neither periods. U.S. dollar is priced only after the currency reform; No evidence is found for other risk factors being priced for the whole sample period as reported in Model(2) and (3) in Table 10. The big differences indicate that REER^{-1} plays a critical role in the pricing of the Chinese mainland equity market. By the way it is calculated, REER^{-1} is able to measure the value of currency of China's major trade partners against Chinese yuan, thus making it a comprehensive benchmark of the exchange rate risk faced by Chinese consumer-investors. When using USD/CNY and JPY/CNY as the currency risk factor, the currency risk price is found to be negative but not significant for the whole sample period.

The negative pricing of currency risk is consistent with theory that consumer-investors grant premium for assets that help preserve their real purchasing power (Dumas and Solnik, 1995); however, since the premium is not significant, we cannot infer that this is the case for the Chinese market. This partly motivates my estimation of conditional asset pricing models in Section 5.3. For the period after the currency reform, there is more evidence of risk pricing. The world market risk is significantly priced in all the three models. While local market risk pricing is not significant in Model (5) and (6), the size factor is significantly priced in all the three models with positive prices. In addition, Model (4) and (5) indicate significant currency risk pricing.

5.2.2 Structural Stability Test

To test the unconditional model specification and justify the sub-period regression in Table 10, a structural stability test is performed to examine whether the parameters are constant over time. A simple method of structural test is by assuming a known breakpoint. In this paper, accordingly, I test the null hypothesis that there is no structural break around the time of the currency reform. To perform this test, I include a dummy variable *Currency* in the pricing function of each risk factor and then test the joint significance of the coefficients of the interacted variables. *Currency* assumes the value of zero before the currency reform and a value of one after it. Compared to Chow test, which is only applicable if the model is estimated appropriately by ordinary least squares[17], this approach of using dummy variables is applicable in the unconditional models of this paper, where instrumental variables are used and estimates are corrected for heteroscedasticity or autocorrelation. The regression results are shown in Table 11. The four coefficients of interest $\lambda_{w1}, \lambda_{m1}, \lambda_{reer1}, \lambda_{spr1}$ are all significant. Further, a joint Wald test of the four coefficients shows that the null hypothesis of the four parameters all being zero is rejected at 10% significance level, indicating that there indeed exists structural break around the time of the currency reform. The finding lends credence to sub-period regressions as a supplement to the full period regression.

[17] RATS 9 User Guide, Chapter 3: Hypothesis Testing

Table 11 Structural stability test on GMM results, monthly returns
$r_{it} = (\lambda_w + \lambda_{w1} * Currency + r_{wt})\beta_{iw} + (\lambda_m + \lambda_{m1} * Currency + r_{mt})\beta_{im} + (\lambda_{reer} + \lambda_{reer} * Currency + r_{st})\beta_{is} + (\lambda_{spr} + \lambda_{spr1} * Currency + r_{sprt})\beta_{ispr} + \varepsilon_{it}$

	r_{it}	
λ_w	-1.692	(-1.01)
λ_m	1.911	(1.48)
$\lambda_s reer$	-1.867***	(-2.65)
λ_{spr}	-1.302*	(-1.90)
λ_{w1}	6.981*	(1.90)
λ_{m1}	-5.762**	(-2.03)
$\lambda_s reer1$	4.372***	(2.75)
λ_{spr1}	3.398**	(2.31)
Observations	201	
Adj-R^2 Range	0.766 – 0.949	
J-statistic	11.40 (0.9997)	
APE Range	-0.170 – 0.123	
RMSERange	1.968 – 4.858	
	χ^2	p-value
Wald test: λ_{w1}=λ_{m1}=λ_{reer1}=λ_{spr1}=0	7.95	0.0934

The table shows the GMM estimates for the unconditional model for monthly returns. r_{wt} is the excess return on world market portfolio, r_{mt} is the orthogonalized local market excess return, r_{st} is the orthogonalized currency risk measured by REER^{-1}, r_{sprt} is the orthogonalized size factor. The estimated betas are reported for each for the portfolio. β_w, β_m, β_s and β_{spr} are sensitivities of portfolio returns to world market return, local market return, currency risk factor and size factor, respectively. D is a dummy variable which assume the value of 0 before the currency reform and a value of 1 after the currency reform. $\lambda_w + \lambda_{w1} * Currency$, $\lambda_m + \lambda_{m1} * Currency$, $\lambda_{reer} + \lambda_{reer1} * Currency$, $\lambda_{spr} + \lambda_{spr1} * Currency$ are the prices of the four risk factors, in percentages. RMSE is the root mean squared error; APE the average pricing error, both reported in percentages. Adj-R2 is the coefficient of determination. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. The number of lags of the Newey–West kernel is set at 4. Probability value of the *J*-test is reported in parenthesis. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

5.2.3 Weekly Returns

Table 12 shows the GMM results using weekly returns under various model settings. The world market risk price is not significant in any cases, which contradicts the estimation results on monthly data. However, when combined with the two dummy variables, *Currency* and *Connect*, the price of world market risk is significantly lower after the currency reform and higher after the Stock Connect.[18] Limited evidence is found for the pricing of currency risk for the whole sample period: only the currency risk price for JPY increases significantly after the currency reform. For the period after the currency reform, there is more evidence on currency risk pricing: currency risk is found to be priced in Model (5) and (9). Surprisingly, none of the local risk

[18] When the conditional model is used, I find world market risk price is significantly higher after the currency reform, contradicting the findings reported here, potentially indicating that the unconditional model has probably mispriced the world market risk, because its failure in incorporating adequate information.

factors is priced in any model setting, indicating the assumption of unconditional pricing of risk factors may be incorrect.

In order to examine the potential time-varying features of expected returns and risk prices, I run the unconditional pricing model over the four sub-periods, as described in section 4. The estimates are reported in Table 13. The world market risk is found to be priced only for the period after the Connect. The evidence for currency risk pricing is relatively weak: only JPY/CNY is priced in the first period. In contrast, the local risk factors are priced for all the four periods and the estimated risk prices change a lot across periods, supporting the view of time-varying prices of risk.

Figure 8 shows the actual average return against the estimated return by the unconditional model using nominal EUR/CNY as the currency risk factor. While the pricing errors for the whole period regression are relatively large, the unconditional model fits the sub-periods data reasonably well. This comparison indicates that there is substantial variation in risk premium across different periods, suggesting a conditional model is required to capture these dynamics.

Based on sub-periods' regressions, it is also observed that the betas with world market risk and currency risk are not constant. Notably, the world market betas have increased a lot over the four periods, as evident in Figure 9. Besides, currency risk betas vary a lot across periods.

Table 12 GMM results for various unconditional models, weekly returns

Without dummy variables: $r_{it} = (\lambda_w + r_{wt})\beta_{iw} + (\lambda_m + r_{mt})\beta_{im} + (\lambda_s + r_{st})\beta_{is} + (\lambda_{spr} + r_{sprt})\beta_{ispr} + \varepsilon_{it}$

With dummy variables: $r_{it} = (\lambda_w + \lambda_{w1} * Currency + \lambda_{w2} * Connect + r_{wt})\beta_{iw} + (\lambda_m + r_{mt})\beta_{im} + (\lambda_s + \lambda_{s1} * Currency + \lambda_{s2} * Connect + r_{st})\beta_{is} + (\lambda_{spr} + r_{sprt})\beta_{ispr} + \varepsilon_{it}$

	Whole Period 2001:01-2017:09				**Period after the Currency Reform 2005:08-2017:09**					
Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
λ_w	0.298	0.213	0.436	0.223	-0.098	0.156	0.093	-0.347	0.177	0.015
	(0.74)	(0.54)	(1.32)	(0.70)	(-0.19)	(0.38)	(0.21)	(-0.72)	(0.44)	(0.04)
λ_m	-0.041	0.000	0.005	0.031	0.234	0.131	0.167	0.239	0.071	0.137
	(-0.35)	(0.00)	(0.06)	(0.35)	(1.42)	(1.01)	(1.17)	(1.54)	(0.58)	(1.09)
$\lambda_s usd$					-0.327*			-0.263		
					(-1.89)			(-1.65)		
$\lambda_s jpy$	0.395		-0.347			0.389			0.806**	
	(0.91)		(-0.70)			(1.08)			(2.13)	
$\lambda_s eur$		-0.013		-0.001			0.007			0.107
		(-0.05)		(-0.00)			(0.03)			(0.43)
λ_{spr}	0.022	0.026	-0.009	0.000	0.197	0.100	0.140	0.261	0.094	0.198
	(0.25)	(0.26)	(-0.12)	(0.00)	(1.09)	(0.85)	(1.06)	(1.53)	(0.81)	(1.63)
λ_{w1}			-0.667***	-0.283**						
			(-2.91)	(-2.14)						
λ_{w2}			0.300	0.359**				0.440**	0.361*	0.352**
			(1.12)	(1.97)				(2.18)	(1.71)	(2.05)
λ_{s1}			1.501**	-0.248						
			(2.20)	(-0.56)						
λ_{s2}			0.101	0.102				-0.303	-0.117	0.020
			(0.13)	(0.18)				(-1.37)	(-0.26)	(0.05)
Observations	847	847	847	847	621	621	621	621	621	621
Adj-R^2	0.822	0.822	0.822	0.822	0.818	0.818	0.818	0.818	0.817	0.818
range	0.941	0.941	0.941	0.941	0.938	0.938	0.938	0.938	0.938	0.938
APE	-0.040	-0.052	-0.043	-0.051	-0.044	-0.057	-0.071	-0.052	-0.060	-0.065
	0.053	0.044	0.062	0.040	0.036	0.046	0.041	0.035	0.077	0.051
RMSE	0.909	0.910	0.908	0.909	0.991	0.990	0.991	0.990	0.989	0.990
	1.875	1.874	1.877	1.874	2.063	2.065	2.061	2.064	2.066	2.061
J-statistic	7.38	7.67	19.57	24.06	7.86	8.40	9.04	13.88	13.74	16.03
	(0.9652)	(0.9580)	(1.0000)	(0.9997)	(0.9529)	(0.9362)	(0.9117)	(0.9991)	(0.9992)	(0.9962)

The table shows the GMM estimates for the unconditional model for monthly returns. r_{wt} is the excess return on world market portfolio, r_{mt} is the orthogonalized local market excess return, r_{st} is the orthogonalized currency risk measured by USD/CNY, JPY/CNY, EUR/CNY respectively, r_{sprt} is the orthogonalized size factor, *Currency* is a dummy variable with value of zero before the currency reform and value of one thereafter. *Connect* is also a dummy variable with a value of zero before the Stock Connect and value of one thereafter. The estimated betas are reported for each for the portfolio. β_w, β_m, β_s and β_{spr} are sensitivities of portfolio returns to world market return, local market return, currency risk factor and size factor, respectively. λ_w, λ_m, λ_s, λ_{spr} are the prices of the four risk factors, in percentages. RMSE is the root mean squared error; APE the average pricing error, both reported in percentages. Adj-R2 is the coefficient of determination. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. The number of lags of the Newey–West kernel is set at 4. Probability value of the *J*-test is reported in parenthesis. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

Table 13 GMM results for sub-periods, weekly returns

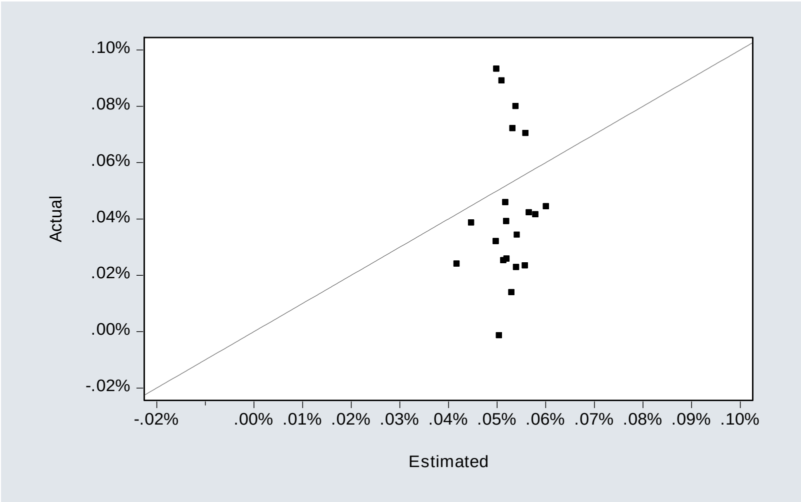
$$r_{it} = (\lambda_w + r_{wt})\beta_{iw} + (\lambda_m + r_{mt})\beta_{im} + (\lambda_s + r_{st})\beta_{is} + (\lambda_{spr} + r_{sprt})\beta_{ispr} + \varepsilon_{it}$$

	Before Currency Reform 2001/01/01-2005/07/20		Pre and During Financial Crisis 2005/07/21-2009/12/31			Before Stock Connect 2010/01/01-2014/11/16			After Stock Connect 2014/11/17-2017/09/30		
Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	(11)
λ_w	0.270	6.909	-0.189	-0.002	-0.320	-0.300	-0.002	0.254	0.627***	0.379	0.488**
	(0.47)	(1.54)	(-0.35)	(-0.00)	(-0.55)	(-0.67)	(-0.01)	(0.52)	(2.68)	(1.53)	(2.06)
λ_m	-0.430***	-1.291**	0.524***	0.477***	0.541***	0.003	-0.105	-0.198	-0.268	-0.049	-0.166
	(-5.74)	(-2.27)	(3.75)	(3.28)	(3.48)	(0.02)	(-0.66)	(-1.14)	(-1.33)	(-0.22)	(-0.83)
$\lambda_s usd$			0.049			0.027			-0.077		
			(1.23)			(0.68)			(-0.89)		
$\lambda_s jpy$	0.730**			-0.170			0.224			-0.330	
	(2.31)			(-0.50)			(1.07)			(-1.22)	
$\lambda_s eur$		-3.153			-0.233			0.150			0.112
		(-1.35)			(-0.99)			(1.00)			(0.52)
λ_{spr}	-0.134**	0.155	0.248	0.318	0.211	0.134	0.202*	0.312**	-0.152	-0.157	-0.208**
	(-2.29)	(0.61)	(1.11)	(1.30)	(0.89)	(1.18)	(1.91)	(2.59)	(-1.50)	(-1.59)	(-2.37)
Observations	226	226	223	223	223	251	251	251	147	147	147
Adj-R^2	0.876	0.876	0.739	0.739	0.742	0.891	0.891	0.890	0.896	0.897	0.899
$range$	0.969	0.969	0.958	0.959	0.958	0.936	0.937	0.936	0.963	0.963	0.963
APE	-0.060	-0.046	-0.084	-0.096	-0.089	-0.073	-0.049	-0.066	-0.102	-0.126	-0.134
	0.033	0.018	0.054	0.067	0.065	0.058	0.061	0.047	0.138	0.101	0.114
RMSE	0.495	0.491	1.120	1.112	1.121	0.815	0.814	0.815	0.897	0.897	0.878
	1.087	1.086	3.170	3.172	3.156	1.202	1.202	1.204	1.440	1.439	1.441
J-statistic	9.52	12.02	4.46	5.16	4.60	8.98	8.61	8.82	7.97	7.84	7.82
	(0.8907)	(0.7423)	(0.9979)	(0.9949)	(0.9974)	(0.9144)	(0.9287)	(0.9205)	(0.9497)	(0.9534)	(0.9540)

The table reports the GMM estimation results for the unconditional model for monthly returns. $\boldsymbol{r_{wt}}$ is the excess return on world market portfolio, $\boldsymbol{r_{mt}}$ is the orthogonalized local market excess return, $\boldsymbol{r_{st}}$ is the orthogonalized currency risk measured by USD/CNY, JPY/CNY, EUR/CNY respectively, $\boldsymbol{r_{sprt}}$ is the orthogonalized size factor. The estimated betas are reported for each for the portfolio. β_w, β_m, β_s and β_{spr} are sensitivities of portfolio returns to world market return, local market return, currency risk factor and size factor, respectively. λ_w, λ_m, λ_s, λ_{spr} are the prices of the four risk factors, in percentages. RMSE is the root mean squared error; APE the average pricing error, both reported in percentages. Adj-R2 is the coefficient of determination. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. The number of lags of the Newey–West kernel is set at 4. Probability value of the *J*-test is reported in parenthesis. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.Model (2) does not converge under ITGMM after 500 iterations. I use GMM instead.

Figure 8 Actual returns versus estimated returns using unconditional model, weekly data, using EUR/CNY as currency risk

(a) Over the whole sample period



(b) Over four sub-periods

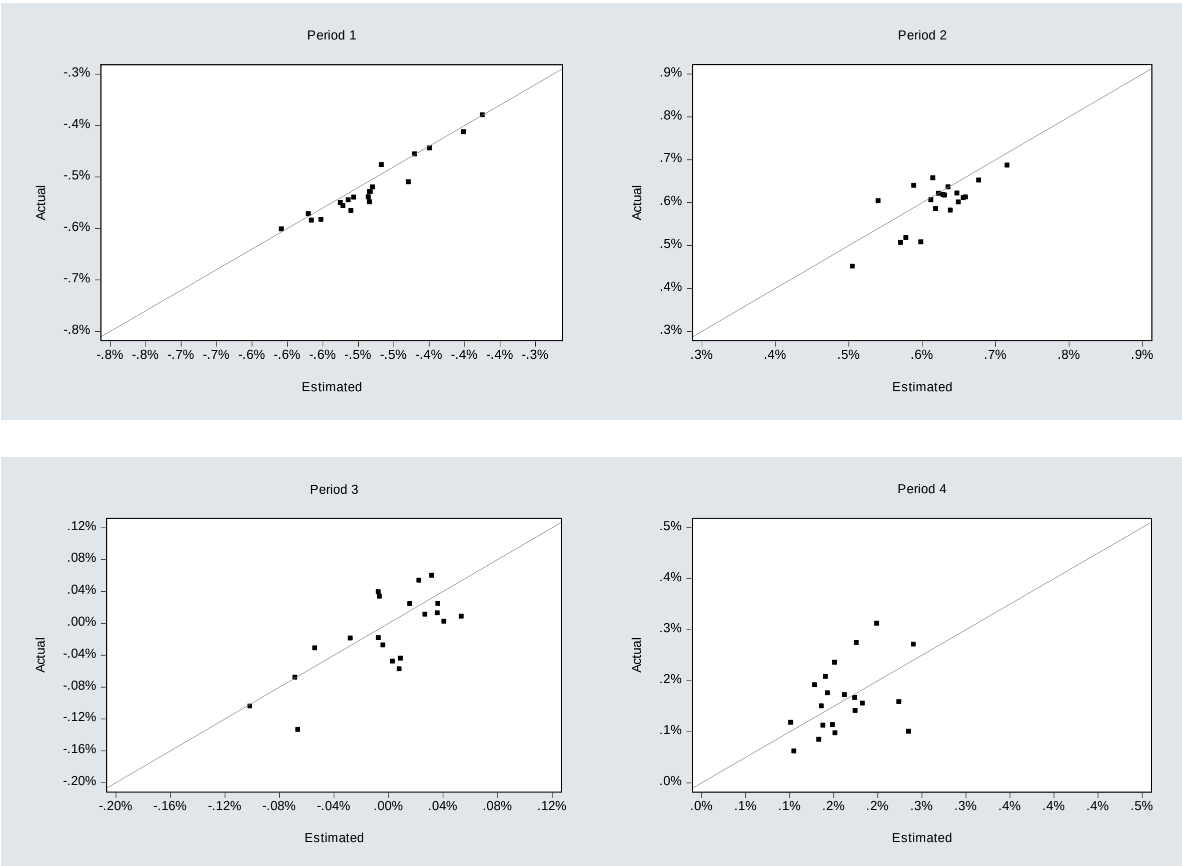
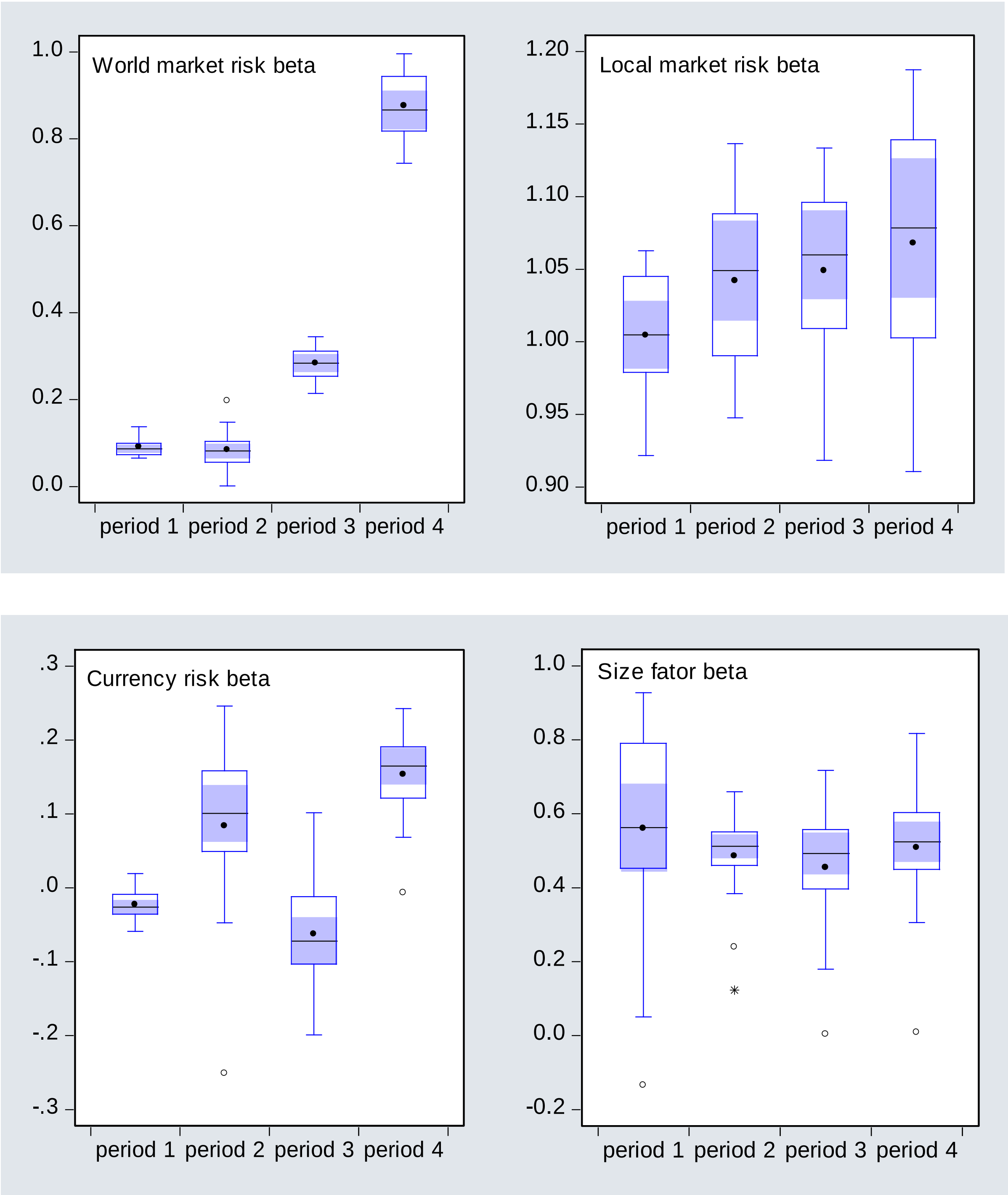


Figure 9 Betas of risk factors, estimated by unconditional model, weekly data, using EUR/CNY as currency risk



5.3 Conditional Asset Pricing

In this section, I use the parsimonious GARCH model described in Section 3.3 to test conditional asset pricing model first for monthly data, and then for weekly data. To avoid redundancy, I only report the estimation results of the model using $REER^{-1}$ as the currency risk factor for monthly data and include the estimation results using the two real bilateral exchange rates in the Appendix. For weekly data, only the estimation results of the model using EUR/CNY as the currency risk is reported. The estimation results using other two bilateral exchange rates are reported in Appendix. [19] To be comparable with the results of the unconditional model, I first test the conditional model only allowing the second moments to vary over time, and assuming the risk price is constant, then move to a conditional model allowing both to be time-varying.

5.3.1 Using Monthly Data

5.3.1.1 Constant price of risk

Panel A of Table 14 shows the estimated pricing coefficients of the conditional model assuming a constant price of risk. The point estimate of world market risk price $const_w$ is 0.036%, but the robust *t* statistic is 1.54, suggesting that the constant price cannot significantly explain the cross-sectional difference in asset returns. As for local market risk and size factor, there is no evidence of constant pricing either. However, currency risk is significantly priced with a negative price of -0.222%, which is consistent with the theory that consumer-investors grant a premium on holding assets that protect their purchasing power (Dumas and Solnik, 1995). This finding is also consistent with the findings in Huang et al. (2014). They find RMB appreciation is positively priced in Chinese A-share market, indicating negative pricing of foreign currency appreciation. When using the other two real bilateral exchange rates as the currency risk, the estimated pricing coefficient is also negative (the results are reported in Appendix). The point estimate of the intercept is equal to 0.260% and is significant. As an estimate of the risk-free rate, it is higher in magnitude than the observed proxy of risk-free rate (the sample mean of Chinese 3-month deposit rate is 0.169%).

Compared to the estimation results of the unconditional pricing model reported in Table 10, the conditional model assuming a constant price of risk offers consistent estimation on the pricing of currency risk: the signs of the pricing coefficients are all significantly negative for all the three currency risk measures. The conditional model results do not support the constant pricing of other three risk factors, as revealed by the unconditional model (1) in Table 10.

[19] As explained in section 4.1, because of data availability, I can only use USD/CNY and JPY/CNY real exchange rate and $REER^{-1}$ for the models using monthly data, and the three nominal bilateral exchange rate (USD/CNY, JPY/CNY, and EUR/CNY) for the models using weekly return. Because USD/CNY nominal exchange rate was fixed before the currency reform, I can only use it for the period after the currency reform.

Table 14 Quasi-maximum likelihood estimates of the conditional model assuming constant price of risk, monthly returns

$r_{it} = const + \delta_w cov_{t-1}(r_{it}, r_{wt}) + \delta_m cov_{t-1}(r_{it}, r_{mt}) + \delta_s cov_{t-1}(r_{it}, r_{st}) + \delta_{spr} cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t,\ \ \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$

$\boldsymbol{H_t} = \boldsymbol{H_0} * (\mathbf{\iota\iota' - aa' - bb'}) + \mathbf{aa'} * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s reer^{-1}$		δ_{spr}	
	0.260**	(2.37)	0.036	(1.54)	-0.003	(-0.43)	-0.222***	(-2.96)	0.005	(0.41)

Panel B GARCH parameters

	r_w	r_m	$r_s reer^{-1}$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	0.270	-0.027***	0.027	0.146***	-0.090***	0.079***	0.047***	-0.019***	0.014*
	(1.45)	(-3.28)	(0.34)	(8.38)	(-6.44)	(11.48)	(6.78)	(-2.65)	(1.73)
b	-0.783*	0.627***	-0.996***	0.911***	0.629***	-0.603***	0.719***	-0.758	0.916***
	(-1.76)	(2.78)	(-56.08)	(32.29)	(4.32)	(-10.80)	(10.66)	(-1.06)	(18.55)

Panel C Diagnostic check

	r_w	r_m	$r_s reer^{-1}$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.28	0.38	-0.11	0.51	0.49	0.36	0.36	0.39	0.39
APE	-0.19	0.12	-0.02	0.09	0.17	0.04	0.03	0.07	0.14
RMSE	4.44	8.48	1.37	6.04	9.38	9.56	9.22	8.92	8.80
Mean(z)	-0.036	0.014	-0.011	0.003	0.017	0.004	0.003	0.007	0.016
SD(z)	0.954	1.002	0.998	0.981	1.000	1.000	1.001	1.002	1.002
Kurtosis(z)	1.50***	1.42***	-0.121	3.68***	1.23***	1.18***	1.48***	1.41***	1.53***
B-J (z)	44.55***	23.80***	0.786	>99.00***	14.37***	19.51***	26.32***	21.26***	24.05***
Q12(z)	0.40	0.01	0.00	0.01	0.62	0.44	0.40	0.29	0.09
Q12(z^2)	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00

Likelihood function value: -3906.03

The table reports the QML estimation results for the conditional model with constant price of risk for monthly returns, over the period from 2001:01–2017:09.All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland equity market portfolio return, r_{st} is the currency risk measured by REER^{-1} (Chinese yuan real effective exchange rate), r_{sprt} is size factor. δ_w, δ_m, $\delta_s reer^{-1}$, δ_{spr} are the risk pricces. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

The failure of the conditional model with constant price of risk in detecting significant pricing of the risk factors drives me to test a conditional model not only allowing second moments to vary over time, but also allowing the price of risks to vary over time. The results are reported in section 5.3.1.2.

Panel B of Table 14 reports estimation results for the GARCH model. The results suggests that the multivariate GARCH(1,1) process describes the time-varying second moments reasonably well, using the parsimonious parameterization described in Section 3.3. Most of the estimated parameters are significant. The GARCH parameter estimates show that all the variance and covariance processes in $\mathbf{H}_t$ are stationary because $a_i a_j + b_i b_j < 1$ is true for all i and j. Also, most estimated b coefficients are close to one and are considerably larger than the estimates of a coefficients, indicating lagged terms are more important in the variance-covariance process than past innovations. Panel C shows the diagnostic statistics for the residuals ε_t and standardized residuals z ($\varepsilon_t / {h_t}^{1/2}$, error term divided by its conditional standard deviation). The average pricing error is relatively small compared to the average return. Theoretically, the standardized residuals have mean zero and standard deviation of one. All the standardized residuals reported in Table 14 are in conformity with the theoretically suggested mean and standard deviation. All the standardized residuals except for RS are non-normal and have high excess kurtosis. Generally, the index of kurtosis and Bera-Jarque test of normality is lower for the standardized residuals than the returns. Even so, the normality hypothesis is still rejected for eight of the nine standardized residual series. As argued in De Santis and Gerard (1998), such evidence warrants the use of Quasi-maximum likelihood procedures. The Ljung-Box Q statistics show that there are no significant autocorrelation in the standardized residual series up to 12 lags, but the autocorrelation in squared standardized residual series are highly significant, indicating the limitation of the parsimonious GARCH (1,1) process in explaining the dynamics of variance and covariance process.

5.3.1.2 Time-varying price of risk

As shown in Eq. (14), the risk prices δ is modelled as a linear combination of a constant and several information variables, z. Under the null hypothesis of constant price of risk, all the coefficients, κ, on information variables should be zero.

Table 15 shows the estimation results of the conditional asset pricing model. Panel A reports the parameter estimates for the mean equations. Only one estimate of the κ coefficients is significant in isolation. To test the existence and time-varying feature of risk price, joint tests on several κ coefficients are performed. The results are shown in Panel C of Table 15.

Table 15 Quasi-maximum likelihood estimates of the conditional model assuming time-varying price of risk, monthly returns

$$r_{it} = const + \delta_{w,t-1}cov_{t-1}(r_{it}, r_{wt}) + \delta_{m,t-1}cov_{t-1}(r_{it}, r_{mt}) + \delta_{s,t-1}cov_{t-1}(r_{it}, r_{st}) + \delta_{spr,t-1}cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$$

$$\delta_k = const_k + \kappa_{FWD,k}FWD + \kappa_{RM(-1),k}RM(1) + \kappa_{\Delta Default,k}\Delta Default + \kappa_{\Delta Euro\$}\Delta Euro\$$$

$$\boldsymbol{H_t} = \boldsymbol{H_0} * (\boldsymbol{\iota\iota'} - \mathbf{aa'} - \mathbf{bb'}) + \mathbf{aa'} * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s reer^{-1}$		δ_{spr}	
$const.$	0.286**	(2.22)	0.033	1.50	-0.002	-0.24	-0.237***	-2.96	0.003	0.26
κ_{FWD}			0.006	0.25	-0.013	-1.41	0.054	0.77	-0.001	-0.05
$\kappa_{RM(1)}$			0.001	0.68	-0.001	-1.43	0.008	1.39	0.003	1.31
$\kappa_{\Delta Default}$			-0.101	-0.28	-0.046	-0.47	-0.724*	-1.86	0.194	1.45
$\kappa_{\Delta Euro\$}$			-0.077	-0.24	-0.020	-0.29	-0.082	-0.93	-0.021	-0.22

Panel B GARCH parameters

	r_w	r_m	$r_s reer^{-1}$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	-0.377	0.028	-0.047	-0.145***	0.073***	-0.082***	-0.048*	0.012	-0.015
	-1.47	0.84	-0.98	-10.24	2.91	-3.10	-1.87	0.92	-1.09
b	0.550*	-0.625***	0.996***	-0.915***	-0.760*	0.600**	-0.703***	0.652	-0.855***
	1.71	-4.15	148.46	-25.70	-1.90	2.06	-4.25	1.61	-9.98

Panel C Hypothesis testing

Null Hypothesis	χ^2	*df*	*p-value*
World market risk is not priced.	6.35	5	0.274
The price of world market risk is constant.	0.67	4	0.955
Local market risk is not priced.	10.96	5	0.052
The price of local market risk is constant.	10.24	4	0.037
Currency risk is not priced.	17.90	5	0.003
The price of currency risk is constant.	8.28	4	0.082
Size risk is not priced.	13.69	5	0.018
The price of size risk is constant.	13.53	4	0.009

Table 15 (Continued)

Panel D Diagnostic check

	r_w	r_m	$r_s reer^{-1}$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.28	0.38	-0.11	0.51	0.49	0.36	0.36	0.39	0.39
APE	-0.22	-0.06	-0.01	0.02	-0.02	-0.12	-0.14	-0.11	-0.03
RMSE	4.32	8.33	1.34	5.92	9.25	9.32	8.99	8.78	8.61
Mean(z)	-0.043	-0.008	-0.010	-0.005	-0.003	-0.013	-0.015	-0.013	-0.003
SD(z)	0.962	0.995	0.984	0.981	0.994	0.992	0.993	0.996	0.994
Kurtosis(z)	0.72**	1.08***	-0.22	4.20***	0.95***	0.88**	1.19***	1.22***	1.22***
B-J (z)	19.63***	13.20***	2.98	162.44***	8.04**	11.86***	16.86***	15.02***	14.22***
Q12(z)	0.64	0.00	0.02	0.12	0.40	0.28	0.21	0.12	0.02
Q12(z^2)	0.00	0.00	0.33	0.32	0.00	0.00	0.00	0.00	0.00
				Likelihood function value		-3892.35			

The table reports the QML estimation results for the conditional model assuming time-varying price of risk for monthly returns, over the period from 2001:01–2017:09.All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland market return, r_{st} is the currency risk measured by REER^{-1} (Chinese yuan real effective exchange rate), r_{sprt} is size factor. δ_w, δ_m, $\delta_s reer^{-1}$, δ_{spr} are the prices of the four risk factors, in percentages. The four information variables are lagged local market return RM(1), lagged change in euro dollar one month rate (ΔEuro$), lagged change in default premium(ΔDefault), and FWD, lagged return on Chinese yuan 1 month forward contract. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is the average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

First, I test the null hypothesis that world market risk is not priced in Chines stock market, namely, H0: $constant_w$= 0 and $\kappa_{w,i}$= 0 for each i. The *p*-value for the robust Wald test is 0.274, and therefore, the null hypothesis cannot be rejected. I then test the null hypothesis that world market risk is constant, namely, H0: $\kappa_{w,i}$= 0 for each i. Again, the null cannot be rejected. However, when estimating the conditional model over the period after currency reform, the world market risk is found to be significantly priced, and the constant-pricing hypothesis is rejected (the results are not reported to avoid redundancies). These findings on the price of world market risk are in general consistent with the findings of the unconditional models reported in Table 10. As for currency risk pricing, both the zero-pricing hypothesis and constant-pricing hypothesis are rejected, indicating that currency risk is significantly priced in the Chinese mainland equity market and the price is time-varying. Similarly, local market risk and size factor are also found to be priced with time-varying price, as shown in Panel C.

Compared to the results of the unconditional model and the conditional model assuming constant price of risk, the conditional model assuming a time-varying price of risk provides more details on risk pricing and explains why the unconditional model is unable to detect the pricing of several risk factors. In addition, as De Santis and Gerard (1998) argues, apart from allowing for the time-variation of second moments, it is also required to allow the price of risk to vary over time to detect currency risk as a priced factor.

Panel B of Table 15 shows that most of the estimated coefficients of the GARCH process are significant. All the variance and covariance process of $\boldsymbol{H_t}$ is stationary because $a_i a_j + b_i b_j < 1$ holds for each i and j. Besides, most estimates of b coefficients are close to one in their absolute value and are much larger than estimated a. The estimates of the GARCH parameters are different with those for the conditional model with a constant price of risk, yet a detailed comparison reveals that the variance and covariance processes of the two models show similar patterns (not reported).

Panel D in Table 15 reports some diagnostic statistics. Results are similar with those for the conditional model with a constant price of risk thus I omit a detailed description.

5.3.1.3 The evolution of currency risk price and risk premium

Based on the estimation results in Table 15, I can draw the evolution of both prices of risk and risk premium. To be comparable with the unconditional model results, I transform the estimated δ and covariance to corresponding λ and β used in the unconditional model. Thus, currency risk premium on portfolio *i* is,

$$S_i = \delta_s Cov(r_i, r_s) = \delta_s Var(r_s) Cov(r_i, r_s) Var^{-1}(r_s) = \lambda_s \beta_{s,i} \tag{18}$$

where $\lambda_s = \delta_s Var(r_s)$ is the price of risk, $\beta_{s,i} = Cov(r_i, r_s)Var^{-1}(r_s)$ is interpreted as the risk exposure of portfolio *i* to currency risk. The risk premium on other three risk factors can be calculated in the same way, and the total risk premium is the summation of the risk premiums on the four risk factors.

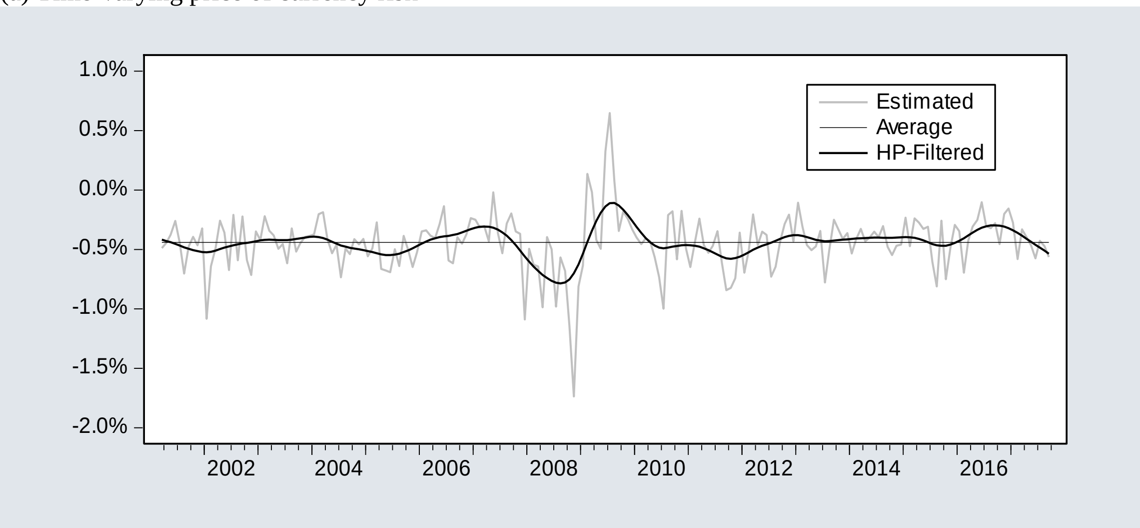
Figure 10 (a) shows the time-varying prices of currency risk for the 3rd size-based portfolio over the period after currency reform, based on estimation results reported in Table 15. Graphs for other portfolio and assets are omitted to avoid redundancies. The Hodrick-Prescott filtered risk prices are also shown, having eliminated the high-frequency components of the time series. The sample mean of the currency risk price is -0.44%. The negative price of exchange risk is justified in Dumas and Solnik (1995) as an exchange-risk hedging premium granted by investors to protect their real purchasing power. The currency risk price has seen high volatility during the 2008 financial crisis and is relatively stable for other periods. As explained by De

Santis and Gerard (1998), a more in-depth economic interpretation of the dynamics of the risk prices is not feasible due to lack of a general equilibrium model that identifies the information variables.

Figure 10 (b) shows time-varying currency risk premium as defined in Eq. (18) for the 3rd size-based portfolio. The sample mean of currency risk premium is -0.18% due to the negative currency risk price and a positive currency risk beta. The currency risk premium is large in magnitude compared to the total risk premium (0.21%). When plotting currency risk premium together with the total risk premium, it is evident that currency risk premium is relatively stable over the period, contributing little to the short-term variation of total risk premium, as shown in Figure 10 (c). In fact, it is the local market risk that dominates the short-term variation of the total risk premium.

Figure 10 Time-varying price of currency risk and risk premium, monthly returns

(a) Time-varying price of currency risk



(b) Time-varying currency risk premium for the 3rd size-based portfolio

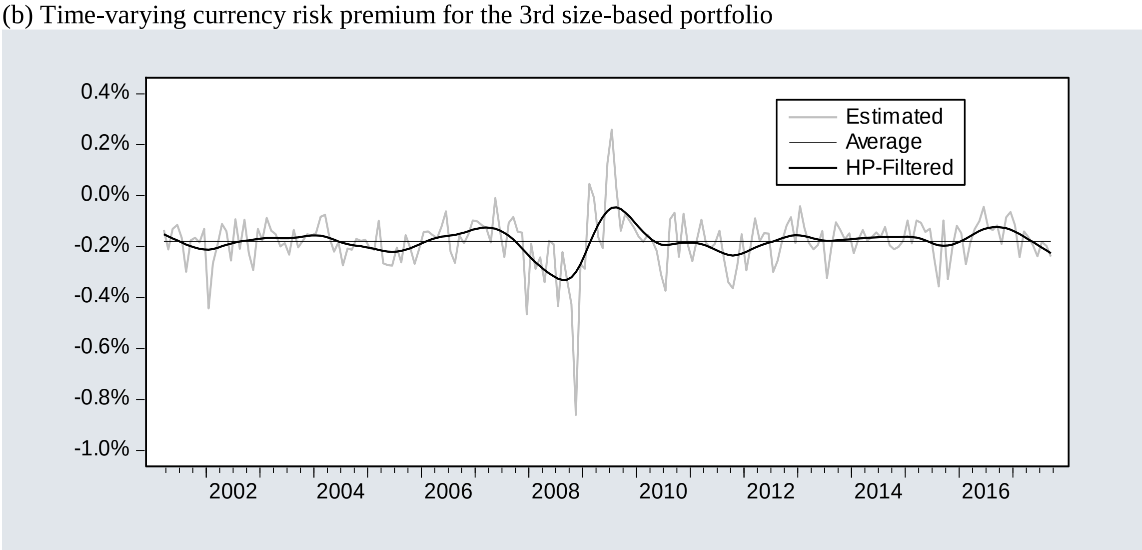
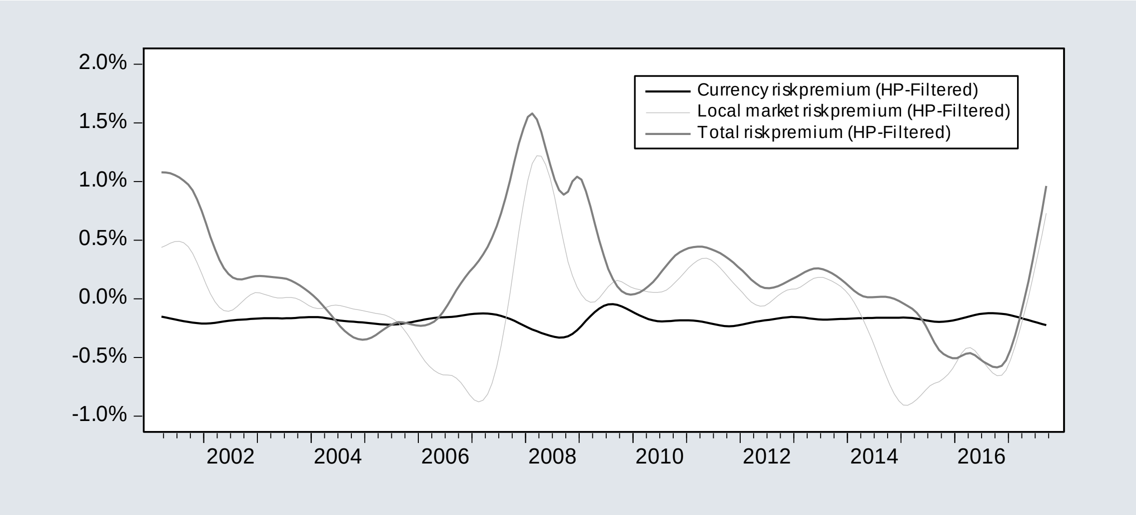


Figure 10 (Continued)

(c) Time-varying currency risk premium against total risk premium, for the 3rd size-based portfolio



5.3.2 Using Weekly Data

Similar to the conditional model using monthly data, this section first shows estimation results for the model with a constant price of risk and then the model assuming a time-varying price of risk. Since the estimation methodology is the same and the reported results are in similar fashion with those for the monthly data, I omit most of the repeating analysis and focus on the differences.

5.3.2.1 Constant Price of Risk

Panel A of Table 16 shows the estimates of the pricing coefficients. While the unconditional model reveals little evidence on risk pricing for the whole sample period as shown in Table 12, I find the world market risk and the size risk factor are significantly priced under the conditional model. The difference indicates that allowing for the time-variation of the second moments are essential in detecting the price of risk.

Table 16 Quasi-maximum likelihood estimates of the conditional model with constant price of risk, weekly returns

$r_{it} = const + \delta_w cov_{t-1}(r_{it}, r_{wt}) + \delta_m cov_{t-1}(r_{it}, r_{mt}) + \delta_s cov_{t-1}(r_{it}, r_{st}) + \delta_{spr} cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t,\ \ \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$

$\boldsymbol{H_t} = \boldsymbol{H_0} * (\boldsymbol{\iota\iota}' - \mathbf{aa}' - \mathbf{bb}') + \mathbf{aa}' * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb}'^{\boldsymbol{H_{t-1}}}$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s eur$		δ_{spr}	
Const.	-0.003	(-0.11)	0.028**	(2.25)	-0.000	(-0.03)	-0.005	(-0.18)	0.021**	(1.98)

Panel B GARCH parameters

	r_w	r_m	$r_s eur$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	-0.162***	0.203***	-0.143***	0.236***	0.220***	0.208***	0.208***	0.202***	0.209***
	-41.49	>99.00	-4.20	>99.00	>99.00	>99.00	>99.00	>99.00	>99.00
b	0.970***	-0.969***	0.965***	-0.965***	-0.966***	-0.967***	-0.968***	-0.970***	-0.969***
	>99.00	<-99.00	69.08	<-99.00	<-99.00	<-99.00	<-99.00	<-99.00	<-99.00

Panel C Diagnostic check

	r_w	r_m	$\delta_s eur$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.06	0.08	-0.00	0.11	0.10	0.07	0.08	0.08	0.08
APE	-0.10	-0.00	-0.02	-0.03	-0.06	-0.09	-0.08	-0.07	-0.04
RMSE	2.53	3.62	1.33	2.83	4.19	4.27	4.09	3.97	3.88
Mean(z)	-0.040	0.002	-0.015	-0.038	-0.018	-0.023	-0.021	-0.017	-0.008
SD(z)	0.963	0.960	0.980	0.968	0.956	0.957	0.957	0.960	0.957
Kurtosis(z)	41.74***	0.91***	2.19***	1.87***	0.77***	1.11***	1.01***	1.01***	0.92***
B-J (z)	>99.00***	28.96***	>99.00***	>99.00***	33.00***	62.74***	50.79***	45.00***	35.30***
Q12(z)	0.64	0.00	0.84	0.15	0.00	0.00	0.00	0.00	0.00
Q12(z^2)	1.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00

Likelihood function value: -11319.59

The table reports the QML estimation results for the conditional model with constant price of risk for weekly returns, over the period from 2001:01–2017:09.All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland market return, r_{st} is the currency risk measured by nominal exchange rate change of EUR/CNY, r_{sprt} is size factor. δ_w, δ_m, $\delta_s eur$, δ_{spr} are the prices of the four risk factors, in percentages. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. ***a*** and ***b*** are 9×1 vectors of parameters and **ι** is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is the average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

To examine the impact of the currency reform and the Connect on the price of world market risk and currency risk, I include two dummy variables in the conditional model. Hence,

$$\delta_w = const_w + \kappa_{w,1} Currency + \kappa_{w,2} Connect$$
$$\delta_s = const_s + \kappa_{s,1} Currency + \kappa_{s,2} Connect \quad (19)$$

The estimation results are reported in Table 17. The point estimates of the coefficients of dummy variable *Currency* are significantly different from zero. Specifically, the price of world market risk increased significantly after the currency reform. This is opposite to the results of the unconditional models (Model (3) and (4) in Table 12). The opposite signs may be due to the failure of the unconditional model in allowing for conditional betas. The price of currency risk is found to have decreased significantly after the currency reform, which makes the negative pricing even more negative. To sum up, both world market risk and currency risk play more important roles in the pricing process after the currency reform, though in different directions. Differently, there are no significant changes in the prices of the two risk factors after the Connect. This could be justified by the fact that the Chinese mainland equity market opening is an ongoing process, and foreign participation increases gradually.

Table 17 Quasi-maximum likelihood estimates of the conditional model with dummy variables, weekly returns

$r_{it} = const + \delta_w cov_{t-1}(r_{it}, r_{wt}) + \delta_m cov_{t-1}(r_{it}, r_{mt}) + \delta_s cov_{t-1}(r_{it}, r_{st}) + \delta_{spr} cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$

$\boldsymbol{H_t} = \boldsymbol{H_0} * (\mathbf{\iota\iota' - aa' - bb'}) + \mathbf{aa'} * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s eur$		δ_{spr}	
Const..	0.096***	(3.73)	0.024**	(2.49)	-0.008	(-1.08)	-0.035	(-1.27)	-0.005	(-0.45)
Currency			0.033**	(2.28)			-0.077***	(-3.60)		
Connect			-0.042	(-1.14)			0.067	(0.98)		

Panel B GARCH parameters

	r_w	r_m	$r_s eur$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	-0.360***	0.024**	-0.231***	0.075***	0.080***	-0.006***	-0.003***	0.009***	0.011***
	-13.18	2.56	-8.64	8.45	9.02	-5.53	-4.29	5.45	3.65
b	0.887***	0.158	0.946***	-0.972***	0.846***	0.990***	0.996***	0.990***	- 0.985***
	40.09	0.74	>99.00	<-99.00	20.89	>99.00	>99.00	>99.00	<-99.00

Table 17 (Continued)

Panel C Diagnostic check

	r_w	r_m	$r_s eur$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.06	0.08	-0.00	0.11	0.10	0.07	0.08	0.08	0.08
APE	-0.21	0.09	-0.00	0.09	0.15	0.14	0.13	0.13	0.12
RMSE	2.56	3.62	1.33	2.84	4.20	4.27	4.10	3.98	3.89
Mean(z)	-0.077**	0.026	-0.002	0.029	0.036	0.032	0.031	0.032	0.032
SD(z)	0.990	1.000	0.983	0.970	0.990	1.000	1.000	0.999	0.999
Kurtosis(z)	30.42***	2.26***	1.72***	3.74***	2.01***	2.91***	2.63***	2.26***	2.84***
B-J (z)	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***
Q12(z)	0.81	0.00	0.81	0.07	0.00	0.00	0.00	0.00	0.00
Q12(z^2)	1.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Likelihood function value: -11,641.62									

The table reports the QML estimation results for the conditional model with constant price of risk for weekly returns, over the period from 2001:01–2017:09.All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland market return, r_{st} is the currency risk measured by nominal exchange rate change of EUR/CNY, r_{sprt} is size factor. δ_w, δ_m, $\delta_s eur$, δ_{spr} are the prices of the four risk factors, in percentages. *Currency* is a dummy variable, taking the value of 0 before the currency reform and value of 1 thereafter. *Connect* is a dummy variable, taking the value of 0 before the Connect and value of 1 thereafter. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is the average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic of order 12. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

The diagnostic statistics show that the average pricing errors are larger than the model without dummy variables, indicative of worse model fitting. The average pricing error of r_w is large, and standardized residual of r_w is significantly different from zero. This result is reasonable because the risk factors used in this paper are more relevant to the Chinese mainland equity market, rather than the world market.

5.3.2.2 Time-varying Price of Risk

Table 18 shows the estimation results of the conditional pricing model assuming a time-varying price of risk for weekly data. Compared to the same model for monthly data, more of the estimates on κ coefficients are significant, at least in isolation. Joint tests on several κ coefficients show similar results with those of the same model for monthly data. All the four risk factors are significantly priced assuming time-varying prices. Both world market risk and local market risks (including local market risk and size factor) are significantly priced, indicating that the Chinese mainland equity market is partially integrated.

Table 18 Quasi-maximum likelihood estimates of the conditional model assuming time-varying price of risk, weekly returns

$r_{it} = const + \delta_{w,t-1}cov_{t-1}(r_{it}, r_{wt}) + \delta_{m,t-1}cov_{t-1}(r_{it}, r_{mt}) + \delta_{s,t-1}cov_{t-1}(r_{it}, r_{st}) + \delta_{spr,t-1}cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$

$\delta_k = const_k + \kappa_{FWD,k}FWD + \kappa_{RM(-1),k}RM(-1) + \kappa_{\Delta Default,k}\Delta Default + \kappa_{\Delta Euro\$}\Delta Euro\$$

$\boldsymbol{H_t} = \boldsymbol{H_0} * (\boldsymbol{\iota\iota}' - \mathbf{aa}' - \mathbf{bb}') + \mathbf{aa}' * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s eur$		δ_{spr}	
Const.	0.086***	(2.93)	0.048***	(3.89)	-0.006	(-0.69)	-0.066***	(-2.72)	-0.003	(-0.22)
FWD			0.000	(0.01)	-0.089***	(-3.73)	0.083	(1.50)	0.004	(0.10)
RM			-0.001	(-0.59)	-0.000	(-0.17)	0.010*	(1.76)	0.014***	(5.21)
$\Delta Default$			0.218**	(2.42)	-0.424**	(-2.26)	-0.964***	(-3.35)	-0.048	(-0.25)
$\Delta Euro\$$			-0.012	(-0.15)	0.220***	(2.71)	0.497***	(2.89)	-0.467***	(-8.04)

Panel B GARCH parameters

	r_w	r_m	$r_s eur$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	-0.412***	0.022**	-0.245***	0.090***	0.052***	-0.009**	-0.007*	0.004	0.011*
	-8.53	2.17	-9.58	5.22	6.83	-2.19	-1.70	0.52	1.72
b	0.856***	0.203	0.941***	-0.960***	0.952***	0.945***	0.914***	0.815***	-0.917***
	23.02	0.93	81.19	-51.53	67.03	41.22	12.68	3.16	-8.80

Panel C Hypothesis testing

Null Hypothesis	χ^2	*df*	*p-value*
World market risk is not priced.	38.29	5	0.000
The price of world market risk is constant.	9.11	4	0.058
Local market risk is not priced.	43.09	5	0.000
The price of local market risk is constant.	38.78	4	0.000
Currency risk is not priced.	44.74	5	0.000
The price of currency risk is constant.	36.11	4	0.000
Size risk is not priced.	93.00	5	0.000
The price of size risk is constant.	88.99	4	0.000

Table 18 (continued)

Panel D Diagnostic check

	r_w	r_m	$r_s eur$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.06	0.08	-0.00	0.11	0.10	0.07	0.08	0.08	0.08
APE	-0.23	0.02	-0.01	0.06	0.06	0.03	0.03	0.04	0.04
RMSE	2.63	3.57	1.35	2.79	4.13	4.20	4.03	3.92	3.83
Mean(z)	-0.089***	0.006	-0.010	0.016	0.014	0.008	0.008	0.009	0.010
SD(z)	0.958	1.000	0.981	0.970	0.991	1.000	1.000	1.001	1.000
Kurtosis(z)	14.53***	2.47***	1.94***	3.62***	2.01***	2.84***	2.59***	2.21***	2.96***
B-J (z)	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***
Q12(z)	0.83	0.03	0.84	0.08	0.05	0.01	0.03	0.04	0.05
Q12(z^2)	0.88	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00

Likelihood function value -11610.10

The table reports the QML estimation results for the conditional model assuming time-varying price of risk for weekly returns, over the period from 2001:01–2017:09.All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland market return, r_{st} is the currency risk measured by nominal exchange rate of EUR/CNY, r_{sprt} is size factor. δ_w, δ_m, $\delta_s reer^{-1}$, δ_{spr} are the prices of the four risk factors, in percentages. The four information variables are lagged local market return RM(1), lagged change in euro dollar one month rate (ΔEuro$), lagged change in default premium(ΔDefault), and FWD, lagged return on Chinese yuan 1 month forward contract. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is the average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

The big differences in risk pricing between the pre- and post- currency reform periods, as evident from earlier analysis, drives me to test the conditional model for the period after the reform. Table 19 shows the estimation results, which are largely consistent with the results reported in Table 18, but the pricing errors are considerably narrower: the average pricing error for the 5 portfolios is 0.03%. It is also evident in Figure 11 that the model fits the actual returns reasonably well.

Table 19 Quasi-maximum likelihood estimates of the conditional model assuming time-varying price of risk, weekly returns, over the period after the currency reform

$$r_{it} = const + \delta_{w,t-1}cov_{t-1}(r_{it}, r_{wt}) + \delta_{m,t-1}cov_{t-1}(r_{it}, r_{mt}) + \delta_{s,t-1}cov_{t-1}(r_{it}, r_{st}) + \delta_{spr,t-1}cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$$

$$\delta_k = const_k + \kappa_{FWD,k}FWD + \kappa_{RM(-1),k}RM(-1) + \kappa_{\Delta Default,k}\Delta Default + \kappa_{\Delta Euro\$}\Delta Euro\$$$

$$\boldsymbol{H_t} = \boldsymbol{H_0} * (\boldsymbol{\iota\iota' - aa' - bb'}) + \boldsymbol{aa'} * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s eur$		δ_{spr}	
Const.	0.065*	(1.73)	0.040***	(3.76)	0.005	(0.61)	-0.061	(-1.63)	0.007	(0.59)
FWD			-0.035**	(-2.13)	-0.080***	(-3.70)	0.116***	(2.65)	0.009	(0.29)
RM			-0.002	(-0.78)	-0.001	(-0.70)	0.004	(0.61)	0.010***	(3.61)
$\Delta Default$			0.146	(1.04)	-0.425**	(-2.33)	-0.803	(-1.51)	-0.023	(-0.11)
$\Delta Euro\$$			-0.135***	(-3.26)	0.535***	(4.39)	0.656***	(5.90)	-0.495***	(-11.41)

Table 19 (continued)

Panel B GARCH parameters

		r_w	r_m	$r_s eur$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a		0.466***	0.011	0.296***	-0.185***	-0.073***	0.003	0.002	-0.009*	0.017*
		14.21	0.73	11.60	-7.35	-4.28	1.36	1.27	-1.69	1.87
b		-0.806***	0.777***	-0.911***	0.081	0.915***	0.996***	0.998***	0.984***	-0.822***
		-25.11	3.37	-45.55	0.57	19.41	>99.00	>99.00	>99.00	-4.27

Panel C Hypothesis testing

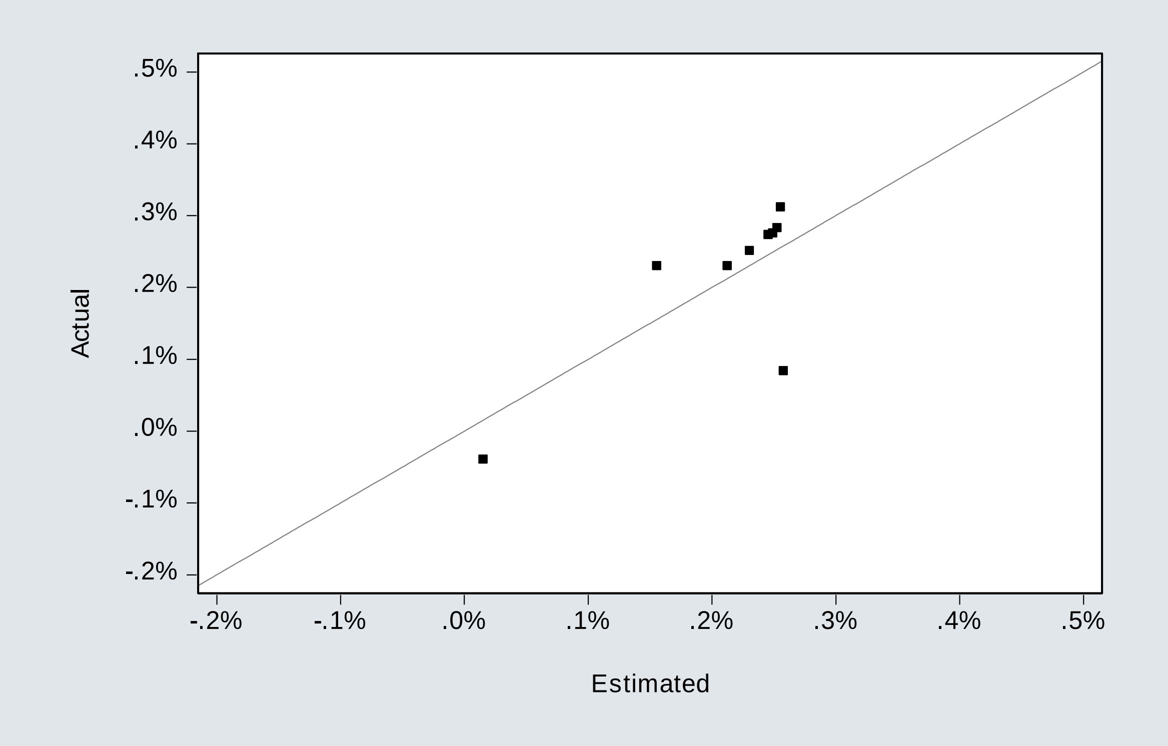
Null Hypothesis	χ^2	*df*	*p*-value
World market risk is not priced.	49.11	5	0.000
The price of world market risk is constant.	22.91	4	0.000
Local market risk is not priced.	62.02	5	0.000
The price of local market risk is constant.	52.75	4	0.000
Currency risk is not priced.	42.26	5	0.000
The price of currency risk is constant.	42.05	4	0.000
Size risk is not priced.	151.35	5	0.000
The price of size risk is constant.	142.69	4	0.000

Panel D Diagnostic check

	r_w	r_m	$r_s eur$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.08	0.23	-0.04	0.23	0.31	0.28	0.28	0.27	0.25
APE	-0.17	0.02	-0.05	0.08	0.06	0.03	0.03	0.03	0.02
RMSE	2.74	3.90	1.34	3.12	4.46	4.56	4.39	4.25	4.19
Mean(z)	-0.055	0.005	-0.044	0.021	0.012	0.007	0.006	0.007	0.005
SD(z)	0.929	0.999	0.964	0.984	0.987	0.997	0.998	0.998	0.998
Kurtosis(z)	8.52***	3.19***	2.09***	3.25***	2.18***	3.21***	2.98***	2.18***	3.48***
B-J (z)	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***
Q12(z)	0.79	0.04	0.63	0.16	0.18	0.07	0.10	0.15	0.12
Q12(z^2)	0.31	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Likelihood function value: -8855.26									

The table above reports the QML estimation results for the conditional model assuming a time-varying price of risk for weekly returns, over the period after the currency reform. All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland market return, r_{st} is the currency risk measured by nominal exchange rate of EUR/CNY, r_{sprt} is size factor. δ_w, δ_m, $\delta_s reer^{-1}$, δ_{spr} are the prices of the four risk factors, in percentages. The four information variables are lagged local market return RM(1), lagged change in euro dollar one month rate (ΔEuro$), lagged change in default premium(ΔDefault), and FWD, lagged return on Chinese yuan 1 month forward contract. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is the average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

Figure 11 Actual returns versus estimated returns, weekly data, over the period after the currency reform, using EUR/CNY as currency risk



5.3.2.3 The evolution of risk exposure and prices of risk

Based on the estimation results in Table 19, I can draw the evolvement of both prices of risk and risk exposure. To be comparable with the unconditional model results, I transform the estimated δ and covariance to corresponding λ and β used in the unconditional model. Take the world market risk premium for example, its risk premium on portfolio *i* is *W*,

$$W_i = \delta_w Cov(r_i, r_w) = \delta_w Var(r_w) Cov(r_i, r_w) Var^{-1}(r_w) = \lambda_w \beta_{w,i} \quad (20)$$

where $\lambda_w = \delta_w Var(r_w)$ is the price of risk, $\beta_{w,i} = Cov(r_i, r_w) Var^{-1}(r_w)$ is the risk exposure of portfolio *i* to world market risk.

Figure 12 shows the changes of various risk betas for the 3rd size-based portfolio returns over time. While local market risk beta and size factor beta are very stable, world market risk beta and currency risk beta show much volatility.

Figure 12 Conditional Betas, weekly data, the 3rd size-based portfolio

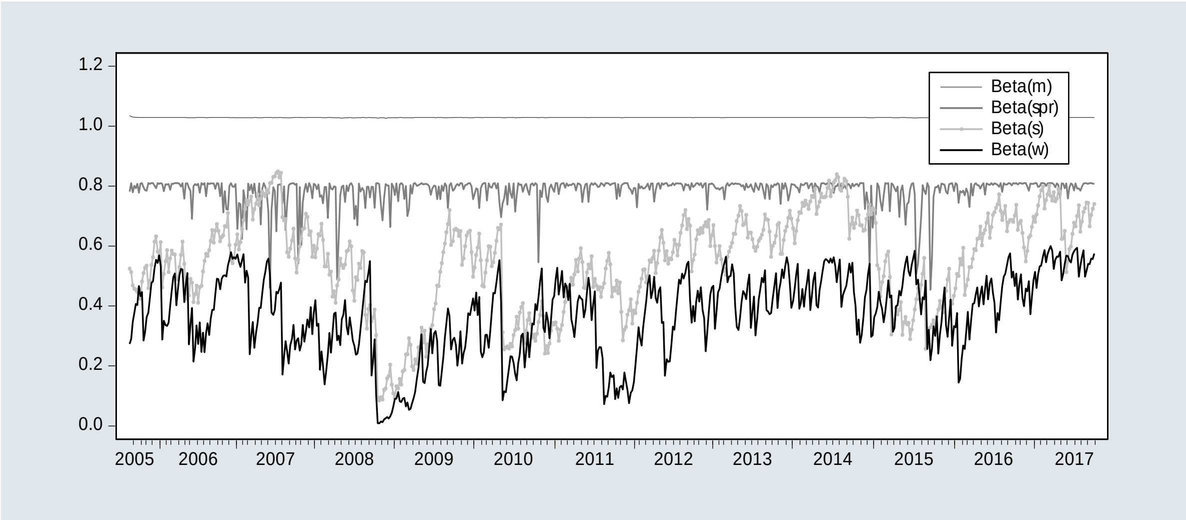


Figure 13 shows the time-varying prices of the four risk factors. The Hodrick-Prescott filtered values eliminate the high-frequency components of the time series. The sample mean of the world market risk, local market risk and size factor are 0.04%, 0.09%, 0.11% respectively. The sample mean of the currency risk is -0.07%. The negative pricing of exchange risk is consistent with the findings for monthly data and is justified in Dumas and Solnik (1995) as exchange-risk hedging premium. A common feature shared by the prices of the four risk factors is that they all have seen high volatility during the 2008 financial crisis, then calm down to a stable period until 2015.

Figure 13 Time-varying prices of risk, weekly data, the 3rd size-based portfolio

(a) Price of world market risk

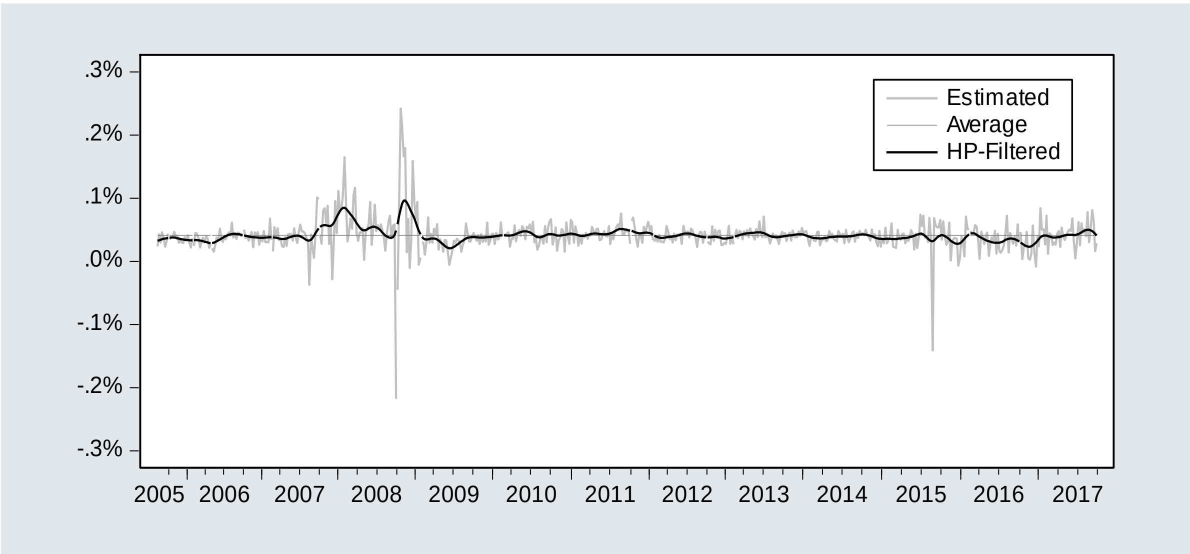
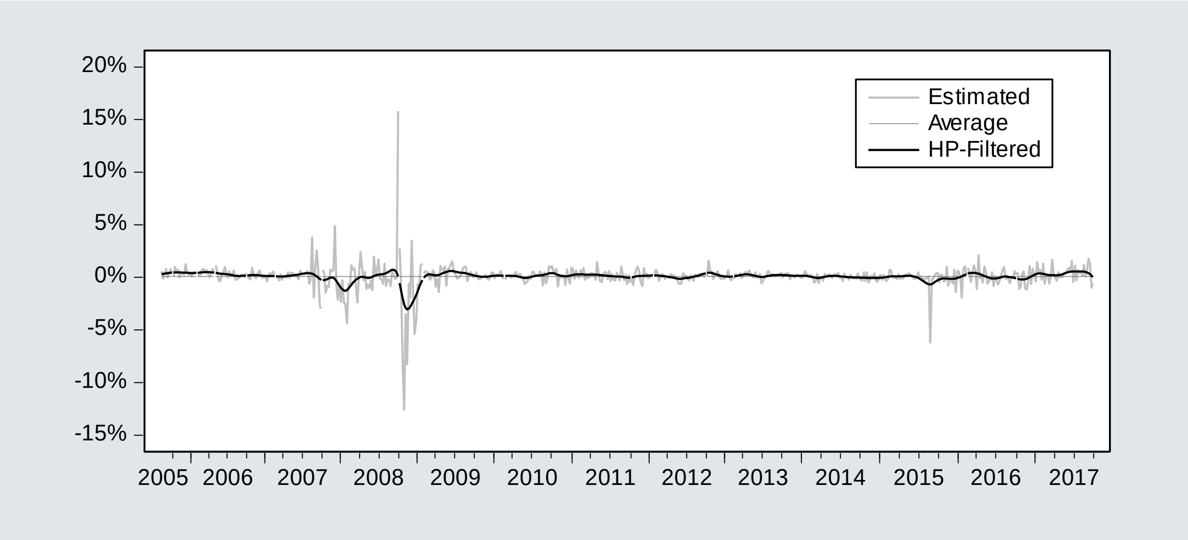
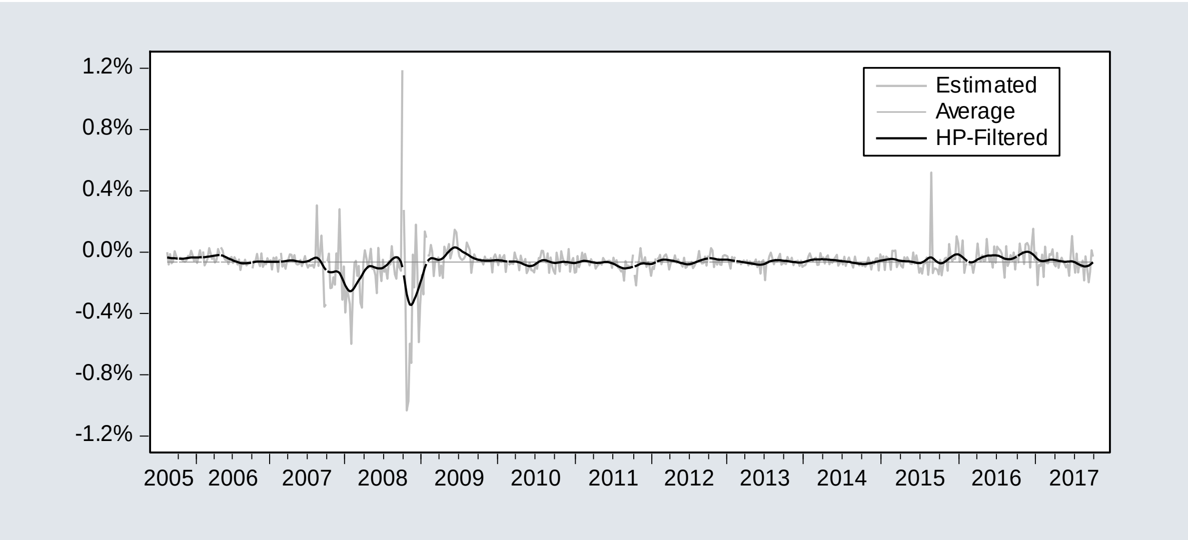


Figure 13 (continued)

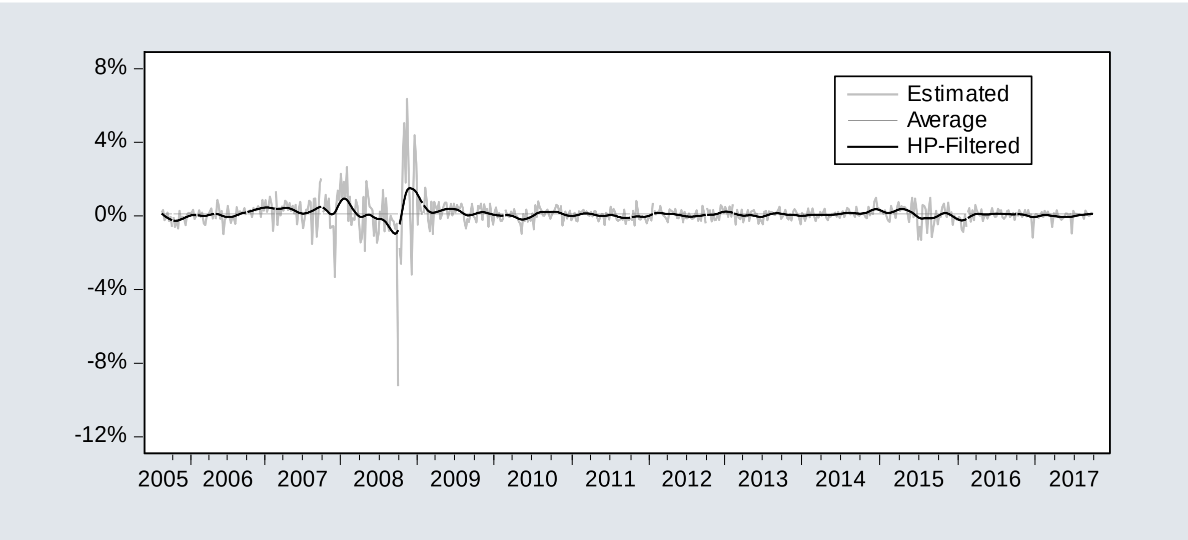
(b) Price of local market risk



(c) Price of currency risk



(d) Price of size risk



5.3.2.4 Time-varying risk premiums

Since both the conditional prices of risk and risk exposure are explicitly parameterized, the time-varying risk premium for all of the four sources of risk can be plotted. The risk premium for each risk is calculated in the same way defined in Eq. (20). The total risk premium is the summation of the risk premiums of the four risk factors. Figure 14 plots the risk premiums for the 3rd size-based portfolio over the period after the currency reform, based on the estimation results in Table 19. Graphs for other portfolio and assets are omitted to avoid redundancies. As for the 3rd portfolio, the average risk premium for world market risk, local market risk and size factor are 0.07%, 0.09% and 0.09%, respectively. The average risk premium for the currency risk is -0.06%. The sample mean of total risk premium is equal to 0.19%. On average, both the risk premium for world market risk and currency risk are large in magnitude compared to the total risk premium. However, when plotting each risk premium together with the total risk premium, it is evident that local market risk and size factor is the dominant factors affecting the time variation of total risk premium, while world market risk premium and currency risk premium are relatively stable and contribute little to the short-term variation in total risk premium. The results indicate that local factors are the dominant power in the pricing of the Chinese mainland equity market, while the world market risk and currency risk also play important roles, especially in the long term.

Figure 14 Time-varying risk premium, weekly data, the 3rd size-based portfolio

(a) World market risk premium

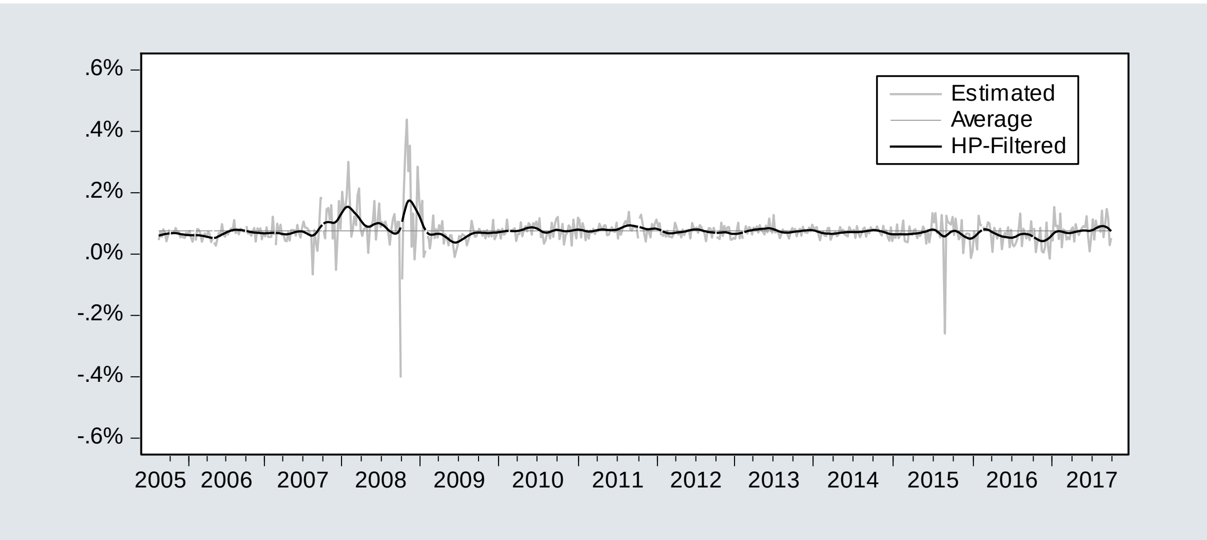
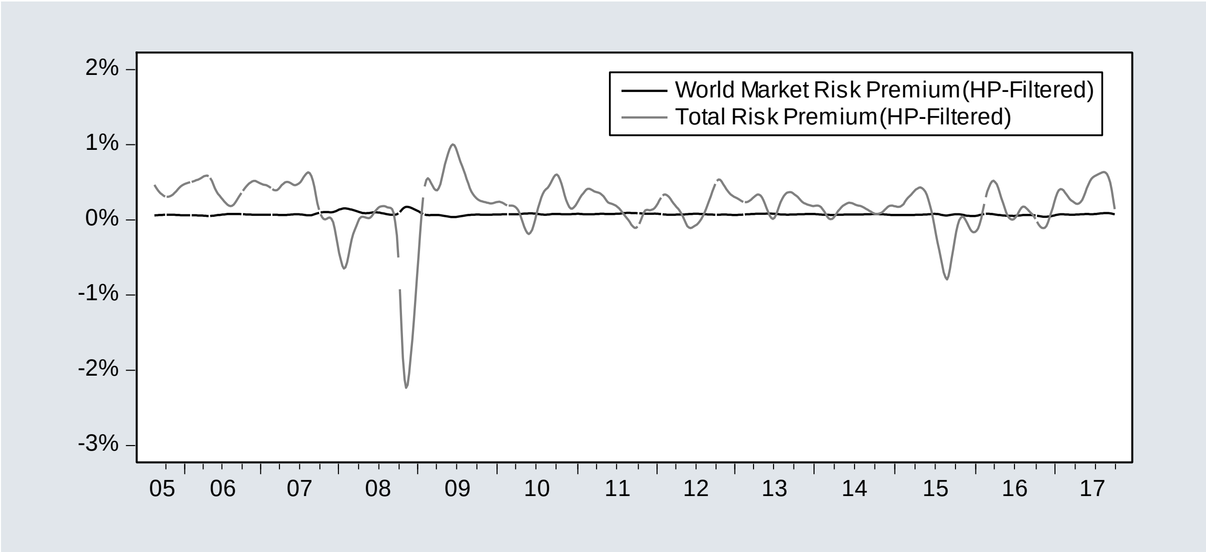
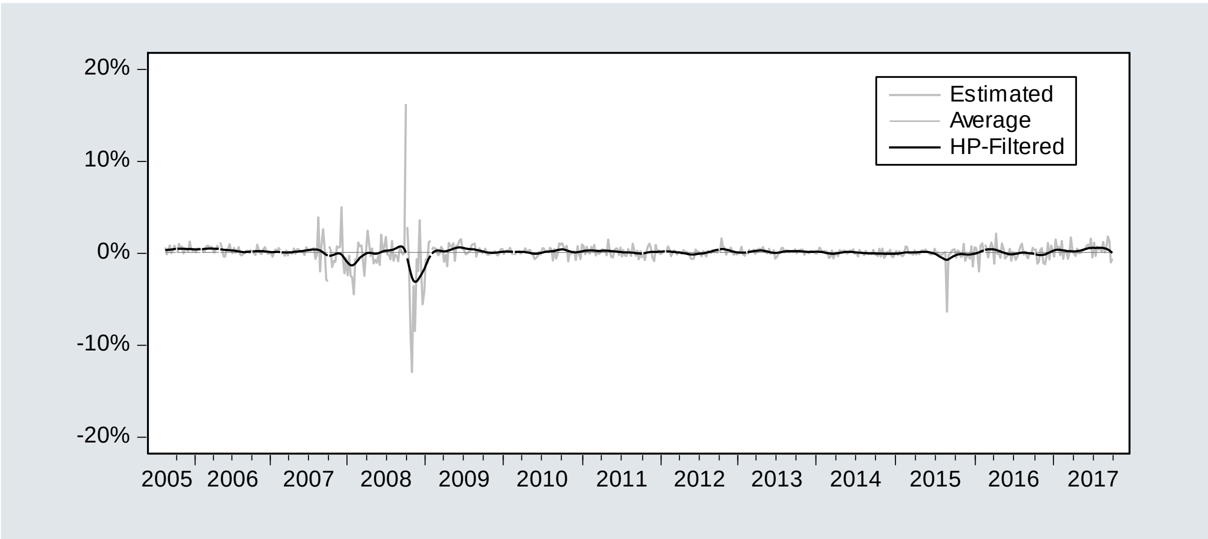


Figure 14 (continued)



(b) Local market risk premium



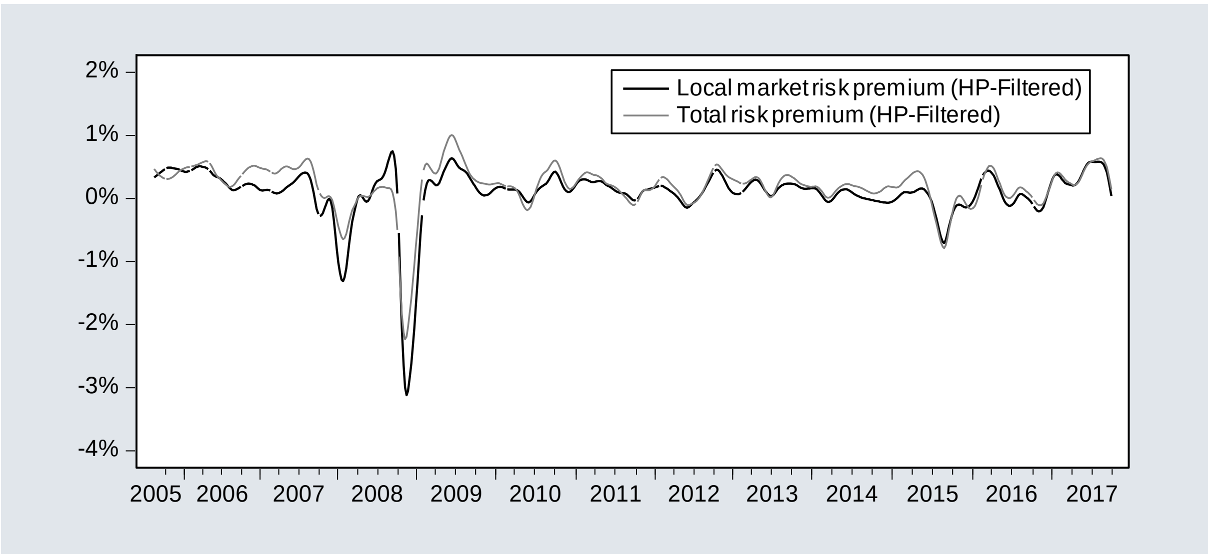
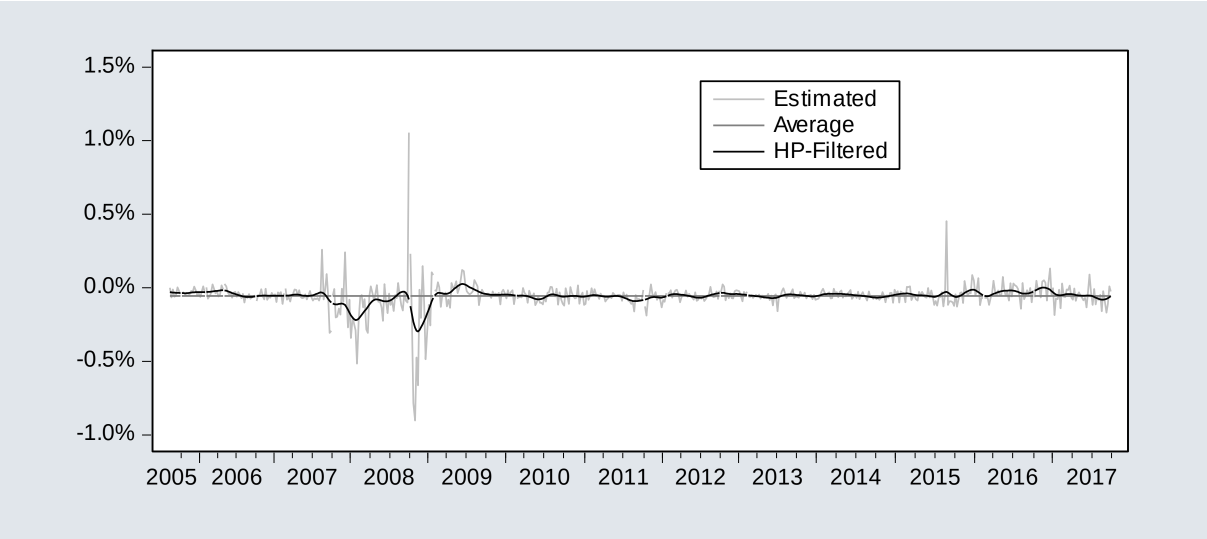
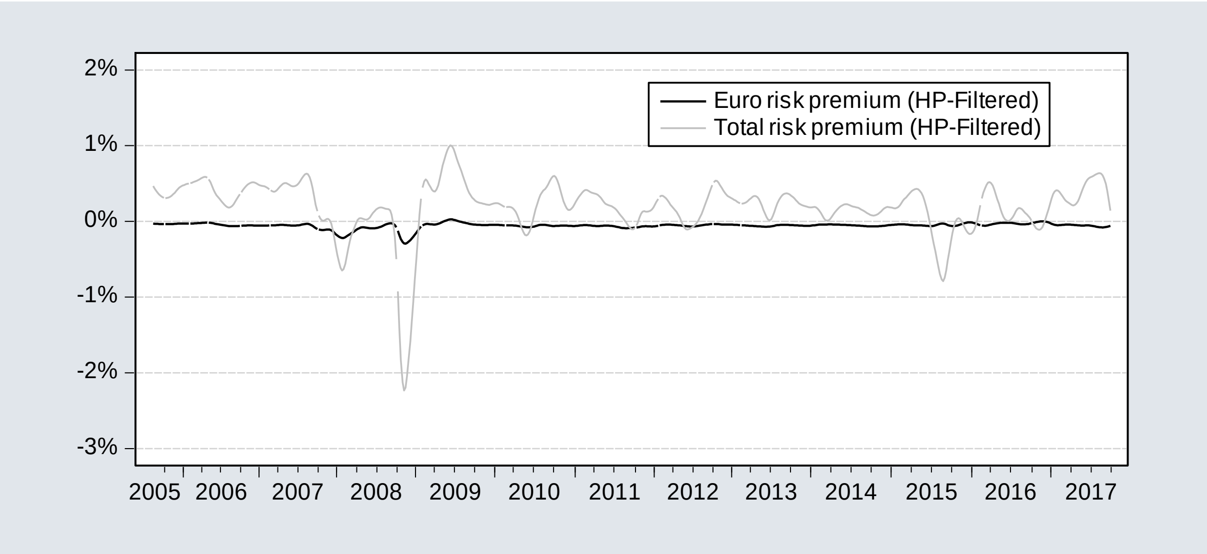


Figure 14 (continued)

c) Currency risk premium





(d) Size Premium

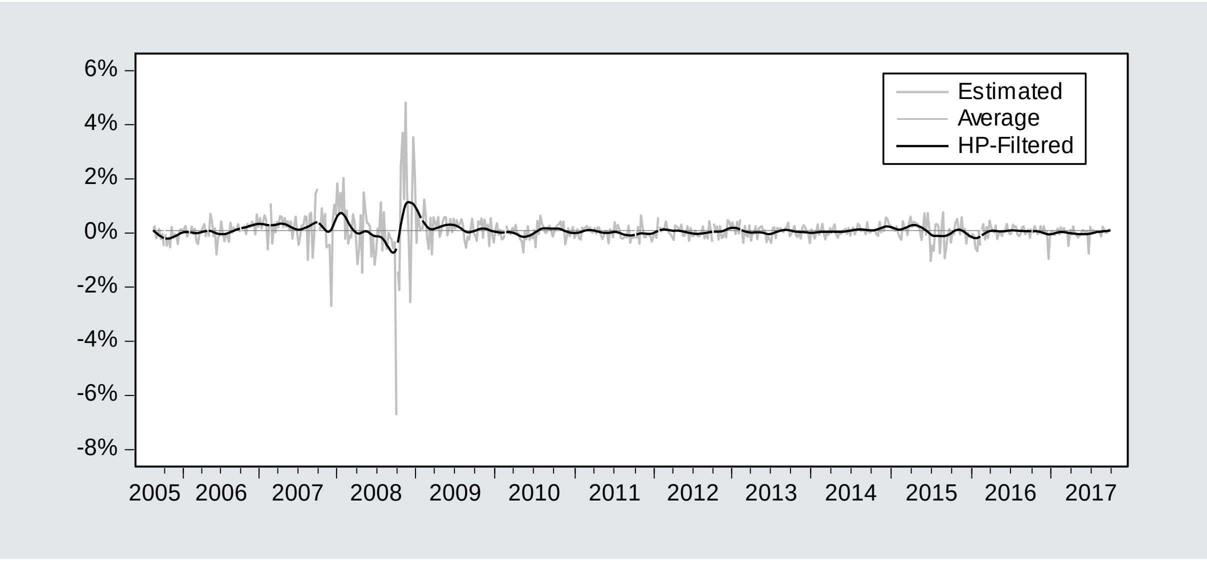
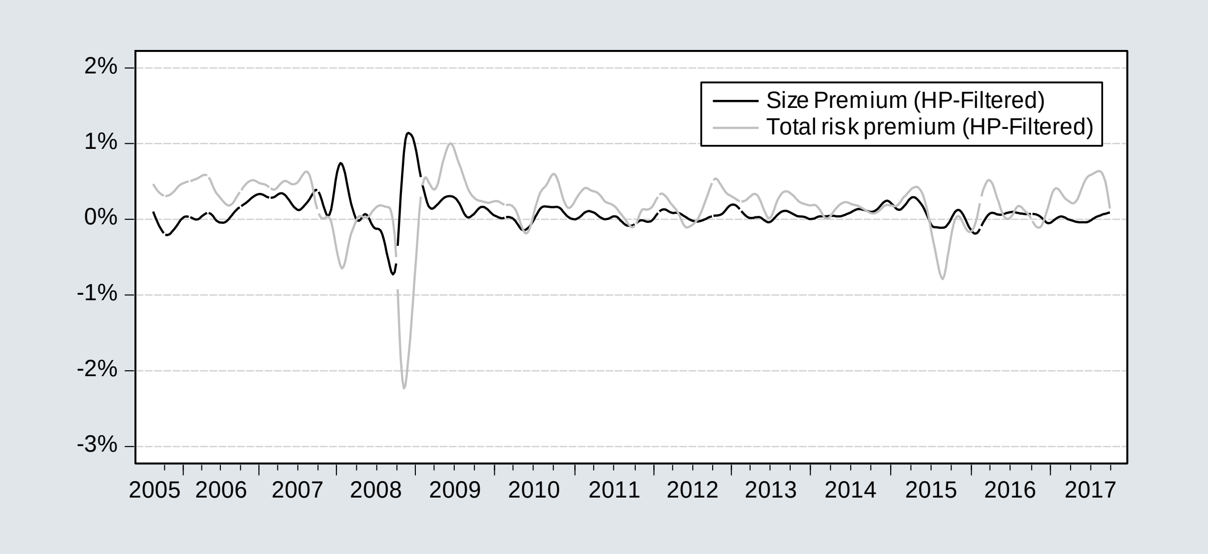


Figure 14 (continued)



5.3.3 Structural Stability Test

To test the specification of the conditional models, Nyblom's Parameter Stability Test (Nyblom, 1989) is employed to test for the constancy of parameter over time. The null hypothesis of Nyblom's test is that the parameters are constant. RATS software allows both joint test of the stability of all the parameters and a separate test of each. Table 20 shows the testing results of three conditional models tested in prior sections of this paper. The joint test statistic of Model (1), which works with monthly data, shows that the null hypothesis of constant parameter estimates cannot be rejected. The separate test statistics show that almost all of the parameters are constant on their own. By contrast, the parameters stability hypotheses, based on the joint test statistic, are rejected for Model (2) and (3) where weekly data are used. However, the hypothesis of stability cannot be rejected when looking at the individual parameters in most cases, especially the pricing coefficients. A closer look at the test statistics shows that the rejection of stability for model (2) and (3) as a whole are mainly caused by the rejection of the GARCH coefficients, indicating the incapability of GARCH (1,1) process in capturing the dynamics of weekly returns. Generally, the stability test lends credence to the conditional model specification used in this paper and the analysis on the pricing coefficients in section 5.3.

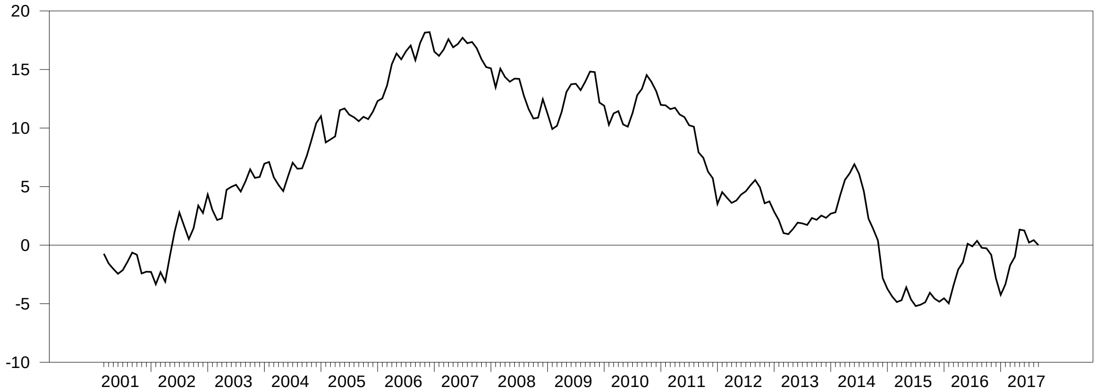
Table 20 Nyblom's Parameter Stability Test on Quasi-maximum likelihood estimates of the conditional models

Parameters			**Model (1)** Monthly returns Over full period As in Table 15		**Model (2)** Weekly returns Over period after currency reform As in Table 19		**Model (3)** Weekly returns Over full period As in Table 18	
			Test statistic	p-value	Test statistic	p-value	Test statistic	p-value
Joint Test			5.814	0.76	9.218	0.01	11.310	0.00
1	Const		**0.415**	**0.07**	0.508	0.04	0.647	0.02
2		Const	0.103	0.55	0.037	0.94	0.024	0.99
3		κ_{FWD}	0.175	0.31	0.037	0.95	0.142	0.40
4	δ_w	$\kappa_{RM(1)}$	0.062	0.79	0.058	0.82	0.042	0.92
5		$\kappa_{\Delta Default}$	0.039	0.94	0.002	1.00	0.009	1.00
6		$\kappa_{\Delta Euro\$}$	0.048	0.88	**0.003**	**1.00**	0.012	1.00
7		Const	0.082	0.66	0.139	0.41	0.106	0.54
8		κ_{FWD}	0.078	0.69	0.072	0.73	0.107	0.53
9	δ_m	$\kappa_{RM(1)}$	0.053	0.85	0.207	0.25	0.179	0.30
10		$\kappa_{\Delta Default}$	0.038	0.94	0.122	0.47	0.202	0.26
11		$\kappa_{\Delta Euro\$}$	0.042	0.92	0.003	1.00	0.006	1.00
12		Const	0.461	0.05	0.088	0.63	0.128	0.45
13		κ_{FWD}	0.046	0.90	**0.416**	**0.07**	0.280	0.15
14	δ_s	$\kappa_{RM(1)}$	0.064	0.78	0.024	0.99	0.144	0.39
15		$\kappa_{\Delta Default}$	**0.038**	**0.94**	0.006	1.00	0.014	1.00
16		$\kappa_{\Delta Euro\$}$	0.021	1.00	0.006	1.00	0.005	1.00
17		Const	0.226	0.22	0.038	0.94	0.299	0.13
18		κ_{FWD}	0.069	0.74	0.105	0.54	0.047	0.89
19	δ_{spr}	$\kappa_{RM(1)}$	0.063	0.79	0.374	0.08	0.416	0.07
20		$\kappa_{\Delta Default}$	0.078	0.69	0.011	1.00	0.023	0.99
21		$\kappa_{\Delta Euro\$}$	0.015	1.00	0.007	1.00	0.014	1.00
22		r_w	0.095	0.59	0.347	0.10	0.311	0.12
23		r_m	0.087	0.63	0.374	0.08	0.086	0.64
24		r_s	0.104	0.55	0.212	0.24	0.334	0.11
25		r_{spr}	0.129	0.44	0.090	0.62	0.878	0.00
26	a	r_1	0.273	0.16	0.087	0.63	0.178	0.30
27		r_2	0.149	0.38	0.356	0.09	1.131	0.00
28		r_3	0.136	0.42	0.084	0.65	0.078	0.69
29		r_4	0.078	0.69	0.202	0.26	0.039	0.93
30		r_5	0.054	0.84	0.048	0.88	0.044	0.91
31		r_w	0.076	0.70	0.939	0.00	0.413	0.07
32		r_m	0.073	0.72	0.815	0.01	0.120	0.48
33		r_s	0.114	0.50	0.315	0.12	0.275	0.16
34		r_{spr}	0.114	0.50	0.040	0.93	1.443	0.00
35	b	r_1	0.192	0.27	0.108	0.53	0.242	0.19
36		r_2	0.100	0.56	1.180	0.00	0.455	0.05
37		r_3	0.079	0.68	0.223	0.22	0.018	1.00
38		r_4	0.085	0.65	0.269	0.16	0.063	0.79
39		r_5	0.223	0.22	0.028	0.98	0.465	0.05

A detailed check on the stability of each parameter can be conducted by drawing the cumulated gradient, namely the cumulated partial derivatives of the likelihood function with respect to each parameter. If the parameter is stable over time, the gradient should stay close to zero. If, conversely, there is a structural break, the gradient will deviate from zero in a specific direction because part of the data set needs a higher or lower value for the parameter. Figure 15 shows the cumulated gradient for four parameters reported in Table 20. The cumulated gradient for the 1st parameter in Model (1) rises sharply from 2001 to 2007 and then drops back to zero, indicating the gradient is consistently positive during this period and turn negative in the latter period. Thus, the earlier period needs a higher parameter than the latter period, which provides evidence of structural break. Similarly, the cumulated gradient for the 13th parameter in Model (2) also strays from zero for a long period. Consistent with the gradient graph, the stability hypotheses for the two parameters are rejected, as is evident from the test statistics in Table 20. As a comparison, Figure 15 also shows the cumulated gradients for two stable parameters, the 15th parameter in model (1) and the 6th parameter in Model (2). Despite short periods of deviations from zero, the gradient for both parameters are considerably stable around zero.

Figure 15 Cumulated gradient of parameters

a) Cumulated gradient for 1st parameter in Model (1)



b) Cumulated gradient for 13th parameter in Model (2)

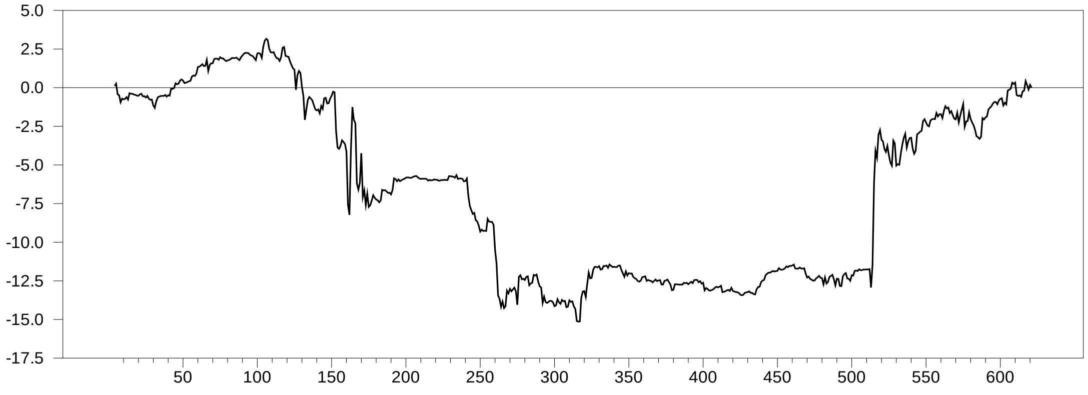
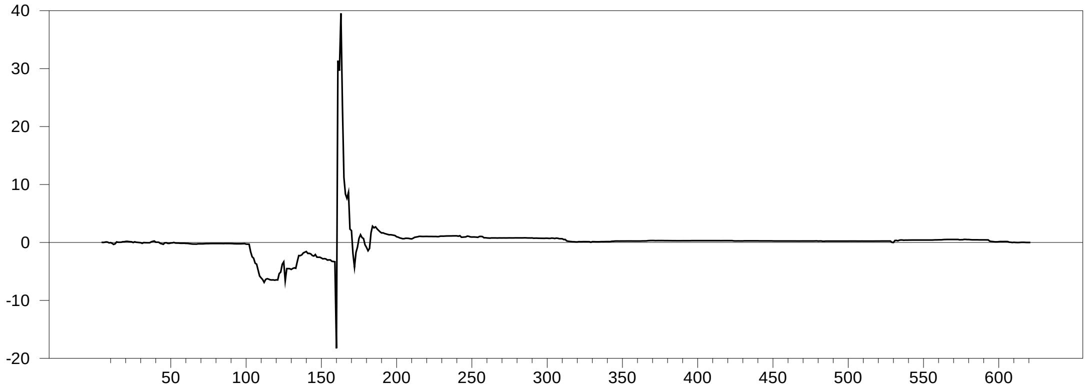


Figure 15 (Continued)

c) Cumulated gradient for 15th parameter in Model (1)

d) Cumulated gradient for 6th parameter in Model (2)



CHAPTER 6 CONCLUSIONS

In this paper I study the integration of the Chinese mainland equity market with the world market and the pricing of four risk factors in the context of China's gradual move to a more flexible exchange rate and the ongoing opening of the stock market, covering a sample period of 2001:1-2017:9. With an emphasis on the two topics of market integration and currency risk pricing, this paper answers the questions of whether the Chinese mainland equity market is segmented from the world market, and whether currency risk is priced in the Chinese mainland equity market. The fact that both monthly data and weekly data are used, and both an unconditional pricing model and a conditional pricing model allowing for time-variation of both second moments and price of risk are employed helps reveal many interesting findings on the topics examined.

This paper finds evidence of partial integration of the Chinese mainland equity market. The correlation between the Chinese mainland equity market with the world market is still low, but reveals a weak upward trend, as estimated using both three-year rolling correlation and a conditional correlation using bivariate GARCH model. In addition, running the unconditional model over the period after the Stock Connect shows a much higher world market risk beta than previous periods. These results confirm that the Chinese mainland equity market has been more exposed to the world market risk. Both unconditional model and conditional model reveal the coexistence of risk premium for world market risk and local market risk, suggesting that the Chinese mainland equity market is partially integrated with the world market. The low level of correlation indicates that the Chinese mainland equity market still provides diversification benefit for international investors.

The world market risk is found to be significantly priced in some of the unconditional models and all of the conditional models, with a positive price. As revealed by the conditional model, the price of world market risk is time-varying. It's also found that world market risk premium constitutes a significant component of the total risk premium on average, but contributes little to the time variation of the total risk premium. These findings indicate that omitting world market risk factor from the pricing model for the Chinese mainland equity market may result in misspecification. These findings also have important implications for Chinese domestic investors: they must take into account the global risks when analyzing Chinese stocks.

As expected, the local market risk factor is the dominant source of risk in the Chinese mainland equity market, which is evident from the estimated time-varying risk premium using the conditional pricing model. The total risk premium almost coincides with local market risk premium at each point of time. Similar with local market risk, size factor, which is also a local source of risk, contributes significantly to both short-run variation and the long-run average of the total risk premium through the sample period. The significant pricing of size factor is in line with the results of the three-factor model proposed by Fama and French (1996). The pricing of local risk factors is not unusual for emerging markets (see, e.g., Carrieri and Majerbi, 2006 for nine emerging markets) and some of the developed markets (see, e.g., Antell and Vaihekosiki, 2012 for Sweden and Finland). Now international investors have more than ever chances to invest in the Chinese mainland equity market, they must pay most of their attention to Chinese local risks.

Literature has documented much evidence of negative pricing of currency risk and justified it from the perspective of consumer-investors forgoing part of the return on holding assets that help protect their purchasing power of goods denominated in foreign currencies (see, e.g., De Santis and Gerard, 2003 for non-EMU currencies). This is also true in the Chinese mainland equity market. This paper analyses currency risk from the perspective of Chinese investors, for whom RMB is the reference currency, and other currencies are viewed as foreign currencies. This paper finds strong evidence of negative and time-varying pricing of currency risk when using the conditional pricing model. The results are robust to different exchange rate measures and data intervals. Similar to world market risk, currency risk price constitutes a large component of the total risk premium in Chinese stock portfolio on average but contributes little to the short-term variation. For foreign investors, this negative pricing of foreign currencies against RMB in the Chinese mainland equity market should be viewed as positive pricing of RMB risk against other currencies. The implication is foreign investors are compensated for taking RMB currency risk by investing in the Chinese mainland equity market. Hence, extra hedging is not a necessity.

This paper also finds some preliminary evidence of a structural shift in risk exposure and risk pricing due to market liberalization policies. After the currency reform, the price of world market risk becomes more positive (by 0.033%) and the price of currency risk becomes more negative (by 0.077%). Weak evidence is found for an increased exposure to world market risk after the Connect, yet there are no significant changes in the pricing of world market risk in the Chinese mainland equity market at the same time.

This study contributes to the literature by shedding new light on market integration and currency risk pricing in the Chinese mainland equity market, and on the impact of the Stock Connect of these two issues. To my knowledge, this study is the first of directly testing the time-varying feature of the exposures to and prices of both world market risk and currency risk in the Chinese mainland equity market by applying the conditional international asset pricing model using the multivariate GARCH-in-Mean setup.

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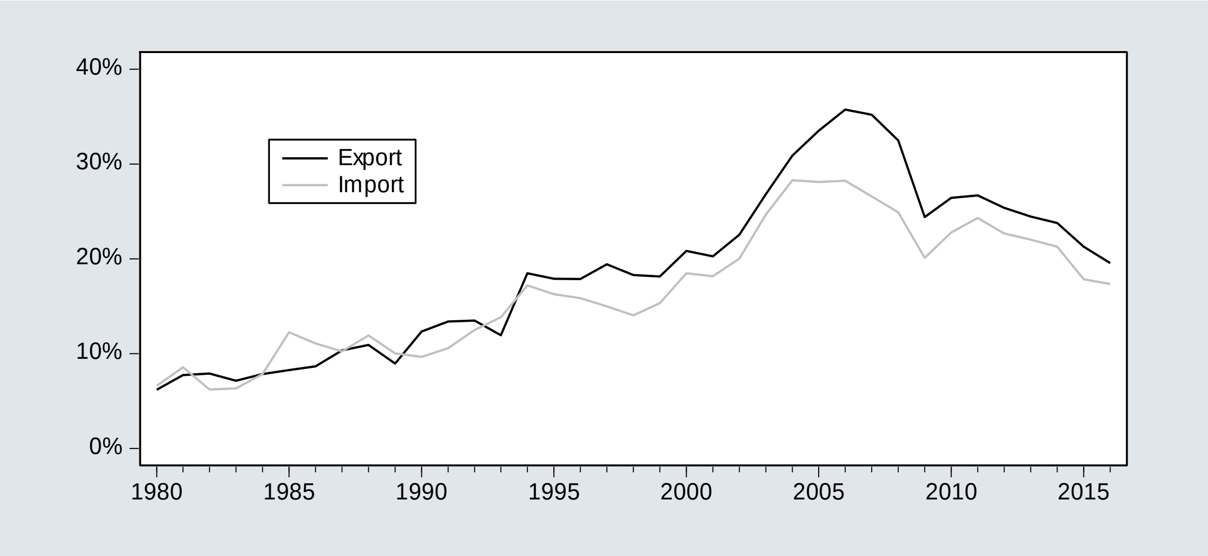
Appendix

Appendix I Export and Import of China

Figure 16 Export and import as % of GDP in China



The graph above shows Chinese export and import as percent of GDP during 1980 to 2016. Data is obtained from IMF IFS. I use nominal value in domestic currency of export, import, and GDP in calculation of the percentage. Import and export figures include both goods and services.

Appendix II Estimation Results of Various Conditional Models

Table 21 Quasi-maximum likelihood estimates of the conditional model assuming constant price of risk, monthly returns, using USD/CNY as currency risk

$$r_{it} = const + \delta_w cov_{t-1}(r_{it}, r_{wt}) + \delta_m cov_{t-1}(r_{it}, r_{mt}) + \delta_s cov_{t-1}(r_{it}, r_{st}) + \delta_{spr} cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$$
$$\boldsymbol{H_t} = \boldsymbol{H_0} * (\boldsymbol{\iota\iota'} - \mathbf{aa'} - \mathbf{bb'}) + \mathbf{aa'} * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$$

Panel A Estimates of pricing coefficients

const.		δ_w		δ_m		$\delta_s usd$		δ_{spr}	
0.259***	(4.26)	0.010	(0.63)	-0.010	(-1.52)	-0.188***	(-3.50)	0.008	(0.80)

Panel B GARCH parameters

	r_w	r_m	$r_s usd$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	0.166***	0.025***	0.208***	-0.135***	0.104***	-0.072***	-0.043***	0.020***	-0.018***
	(4.14)	(3.56)	(6.70)	(-9.71)	(17.16)	(-7.51)	(-5.94)	(3.89)	(-4.30)
b	-0.943***	-0.590***	0.972***	-0.913***	-0.467***	0.614***	-0.740***	0.949***	-0.892***
	(-45.55)	(-2.67)	(>99.00)	(-43.01)	(-4.47)	(6.66)	(-15.35)	(40.09)	(-21.49)

Panel C Diagnostic check

	r_w	r_m	$r_s usd$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.28	0.38	-0.09	0.51	0.49	0.36	0.36	0.39	0.39
APE	-0.15	0.40	-0.12	0.20	0.51	0.34	0.36	0.38	0.44
RMSE	4.43	8.49	1.15	6.04	9.40	9.57	9.23	8.93	8.81
Mean(z)	-0.034	0.047	-0.124*	0.024	0.053	0.035	0.039	0.042	0.050
SD(z)	0.962	1.001	1.009	0.983	0.999	1.000	1.001	1.001	1.001
Kurtosis(z)	2.31	1.42	1.57	3.63	1.225	1.170	1.48	1.41	1.53
B-J (z)	77.44	23.87	25.60	113.55	14.24	19.21	26.30	21.24	24.06
Q12(z)	0.45	0.01	0.00	0.01	0.63	0.44	0.40	0.28	0.09
Q12(z^2)	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00

Likelihood function value: -3868.71

The table reports the QML estimation results for the conditional model with constant price of risk for monthly returns, over the period from 2001:01–2017:09.All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland equity market portfolio return, r_{st} is the currency risk measured by REER^{-1} (Chinese yuan real effective exchange rate), r_{sprt} is size factor. δ_w, δ_m, $\delta_s reer^{-1}$, δ_{spr} are the risk pricces. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

Table 22 Quasi-maximum likelihood estimates of the conditional model assuming constant price of risk, monthly returns, using JPY/CNY as currency risk

$r_{it} = const + \delta_w cov_{t-1}(r_{it}, r_{wt}) + \delta_m cov_{t-1}(r_{it}, r_{mt}) + \delta_s cov_{t-1}(r_{it}, r_{st}) + \delta_{spr} cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$

$\boldsymbol{H_t} = \boldsymbol{H_0} * (\boldsymbol{\iota\iota'} - \mathbf{aa'} - \mathbf{bb'}) + \mathbf{aa'} * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$

Panel A Estimates of pricing coefficients

	const.		δ_w		δ_m		$\delta_s jpy$		δ_{spr}	
	0.304***	(3.43)	0.010	(0.74)	-0.011	(-1.32)	-0.061***	(-2.79)	0.007	(0.78)

Panel B GARCH parameters

	r_w	r_m	$r_s jpy$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	0.236***	0.044***	-0.029	-0.156***	0.085***	-0.068***	-0.029***	0.022***	0.014
	(7.35)	(3.72)	(-0.90)	(-24.73)	(5.14)	(-5.56)	(-3.64)	(2.71)	(0.91)
b	-0.946***	-0.680***	1.007***	0.903***	-0.840***	0.647***	0.863***	-0.953***	0.139
	(-58.44)	(-9.01)	(>99.00)	(65.22)	(-9.61)	(3.81)	(18.91)	(-35.07)	(0.63)

Panel C Diagnostic check

	r_w	r_m	$r_s jpy$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.28	0.38	-0.24	0.51	0.49	0.36	0.36	0.39	0.39
APE	-0.20	0.42	0.00	0.13	0.42	0.33	0.34	0.37	0.45
RMSE	4.41	8.49	2.96	6.05	9.38	9.57	9.23	8.93	8.81
Mean(z)	-0.044	0.049	0.001	0.009	0.043	0.034	0.036	0.041	0.051
SD(z)	0.954	1.001	0.967	0.980	0.997	1.001	1.001	1.001	1.001
Kurtosis(z)	1.79***	1.42***	0.07	3.69***	1.21***	1.17***	1.48***	1.41***	1.53***
B-J (z)	57.47***	23.87***	0.04	>99.00***	13.75***	19.25***	26.20***	21.18***	24.11***
Q12(z)	0.56	0.01	0.06	0.01	0.61	0.44	0.40	0.29	0.09
Q12(z^2)	0.01	0.00	0.26	0.10	0.00	0.00	0.00	0.00	0.00

Likelihood function value: -4055.32

The table reports the QML estimation results for the conditional model with constant price of risk for monthly returns, over the period from 2001:01–2017:09.All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland equity market portfolio return, r_{st} is the currency risk measured by REER^{-1} (Chinese yuan real effective exchange rate), r_{sprt} is size factor. δ_w, δ_m, $\delta_s reer^{-1}$, δ_{spr} are the risk pricces. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

Table 23 Quasi-maximum likelihood estimates of the conditional model assuming time-varying price of risk, monthly returns, using USD/CNY as currency risk

$r_{it} = const + \delta_{w,t-1}cov_{t-1}(r_{it}, r_{wt}) + \delta_{m,t-1}cov_{t-1}(r_{it}, r_{mt}) + \delta_{s,t-1}cov_{t-1}(r_{it}, r_{st}) + \delta_{spr,t-1}cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$

$\delta_k = const_k + \kappa_{FWD,k}FWD + \kappa_{RM(-1),k}RM(-1) + \kappa_{\Delta Default,k}\Delta Default + \kappa_{\Delta Euro\$}\Delta Euro\$$

$\boldsymbol{H_t} = \boldsymbol{H_0} * (\boldsymbol{\iota\iota}' - \mathbf{aa}' - \mathbf{bb}') + \mathbf{aa}' * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s usd$		δ_{spr}	
$const$	0.320***	(3.25)	-0.004	(-0.20)	-0.007	(-0.87)	-0.355***	(-3.53)	0.013	(1.32)
κ_{FWD}			-0.004	(-0.19)	-0.018**	(-2.04)	0.100	(1.34)	-0.007	(-0.50)
$\kappa_{RM(1)}$			0.002	(1.38)	0.000	(0.19)	0.020***	(2.66)	0.003**	(2.52)
$\kappa_{\Delta Default}$			-0.130	(-1.27)	-0.115*	(-1.87)	-0.765	(-1.54)	0.231***	(3.40)
$\kappa_{\Delta Euro\$}$			-0.059	(-1.54)	-0.019	(-1.11)	0.051	(0.34)	0.012	(0.79)

Panel B GARCH parameters

	r_w	r_m	$r_s usd$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	-0.251***	-0.009	-0.253***	0.164***	-0.077***	0.067***	0.048***	-0.003	0.028***
	(-9.97)	(-0.51)	(-3.15)	(15.01)	(-3.95)	(5.06)	(6.17)	(-0.20)	(2.99)
b	-0.936***	-0.475**	-0.631***	0.908***	-0.681***	0.804***	0.855***	-0.503***	0.853***
	(-73.65)	(-2.27)	(-4.83)	(67.34)	(-8.52)	(9.20)	(18.22)	(-1.06)	(22.51)

Panel C Hypothesis testing

Null Hypothesis	χ^2	*df*	*p-value*
World market risk is not priced.	4.74	5	0.448
The price of world market risk is constant.	4.48	4	0.345
Local market risk is not priced.	11.84	5	0.037
The price of local market risk is constant.	11.82	4	0.019
Currency risk is not priced.	18.43	5	0.002
The price of currency risk is constant.	10.51	4	0.033
Size risk is not priced.	20.80	5	0.001
The price of size risk is constant.	20.65	4	0.000

Table 23 (continued)

Panel D Diagnostic check

	r_w	r_m	$r_s usd$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.28	0.38	-0.09	0.51	0.49	0.36	0.36	0.39	0.39
APE	-0.25	-0.21	0.00	-0.11	-0.18	-0.35	-0.30	-0.29	-0.16
RMSE	4.31	8.19	1.10	5.93	9.09	9.20	8.87	8.64	8.49
Mean(z)	-0.053	-0.026	0.014	-0.029	-0.020	-0.038	-0.034	-0.034	-0.019
SD(z)	0.952	0.996	1.006	0.980	0.995	0.995	0.996	0.998	0.996
Kurtosis(z)	0.61*	1.23***	2.85***	4.07***	0.99***	0.89**	1.24***	1.29***	1.32***
B-J (z)	17.85***	18.97***	67.33***	>99.00***	9.92***	14.22***	20.22***	18.72***	18.18***
Q12(z)	0.77	0.03	0.00	0.07	0.91	0.68	0.57	0.40	0.18
Q12(z²)	0.02	0.00	0.0	0.47	0.00	0.00	0.00	0.00	0.00
				Likelihood function value		-3,844.38			

The table reports the QML estimation results for the conditional model assuming time-varying price of risk for monthly returns, over the period from 2001:01–2017:09.All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland market return, r_{st} is the currency risk measured by REER^{-1} (Chinese yuan real effective exchange rate), r_{sprt} is size factor. δ_w, δ_m, $\delta_s reer^{-1}$, δ_{spr} are the prices of the four risk factors, in percentages. The four information variables are lagged local market return RM(1), lagged change in euro dollar one month rate (ΔEuro$), lagged change in default premium(ΔDefault), and FWD, lagged return on Chinese yuan 1 month forward contract. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is the average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

Table 24 Quasi-maximum likelihood estimates of the conditional model assuming time-varying price of risk, monthly returns, using JPY/CNY as currency risk

$r_{it} = const + \delta_{w,t-1}cov_{t-1}(r_{it}, r_{wt}) + \delta_{m,t-1}cov_{t-1}(r_{it}, r_{mt}) + \delta_{s,t-1}cov_{t-1}(r_{it}, r_{st}) + \delta_{spr,t-1}cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$

$\delta_k = const_k + \kappa_{FWD,k}FWD + \kappa_{RM(-1),k}RM(-1) + \kappa_{\Delta Default,k}\Delta Default + \kappa_{\Delta Euro\$}\Delta Euro\$$

$\boldsymbol{H_t} = \boldsymbol{H_0} * (\boldsymbol{\iota\iota'} - \mathbf{aa'} - \mathbf{bb'}) + \mathbf{aa'} * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s jpy$		δ_{spr}	
$const$	0.372***	(2.98)	-0.002	(-0.12)	0.001	(0.20)	-0.072**	(-2.37)	0.013	(1.30)
κ_{FWD}			-0.005	(-0.25)	-0.023**	(-2.19)	0.020	(0.67)	-0.006	(-0.51)
$\kappa_{RM(1)}$			0.001	(0.32)	0.001	(0.59)	-0.004	(-1.36)	0.005***	(4.38)
$\kappa_{\Delta Default}$			-0.143	(-1.47)	-0.047	(-0.62)	0.131	(0.72)	0.227**	(2.41)
$\kappa_{\Delta Euro\$}$			-0.026	(-0.72)	0.014	(0.65)	0.106**	(2.11)	-0.015	(-0.88)

Panel B GARCH parameters

	r_w	r_m	$r_s jpy$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	-0.264***	0.027**	-0.216*	-0.193***	-0.109***	0.043***	0.025*	-0.022**	0.023
	(-9.11)	(2.28)	(-1.70)	(-5.97)	(-4.94)	(2.94)	(1.93)	(-2.23)	(0.97)
b	0.937***	-0.899***	0.499**	-0.803***	0.142	-0.523***	0.463	-0.880***	-0.860***
	(62.89)	(-11.53)	(2.16)	(-9.13)	(0.55)	(-3.84)	(1.51)	(-14.77)	(-3.20)

Panel C Hypothesis testing

Null Hypothesis	χ^2	*df*	*p-value*
World market risk is not priced.	2.84	5	0.725
The price of world market risk is constant.	2.77	4	0.598
Local market risk is not priced.	9.81	5	0.081
The price of local market risk is constant.	9.54	4	0.049
Currency risk is not priced.	12.38	5	0.030
The price of currency risk is constant.	7.35	4	0.119
Size risk is not priced.	26.71	5	0.000
The price of size risk is constant.	26.71	4	0.000

Table 24 (continued)

Panel D Diagnostic check

	r_w	r_m	r_sjpy	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.28	0.38	-0.24	0.51	0.49	0.36	0.36	0.39	0.39
APE	-0.24	-0.65	0.05	-0.41	-0.81	-0.92	-0.88	-0.82	-0.69
RMSE	4.37	8.32	2.92	5.92	9.20	9.38	9.03	8.77	8.64
Mean(z)	-0.055	-0.078	0.019	-0.078	-0.089	-0.097	-0.097	-0.093	-0.079
SD(z)	0.952	0.992	1.003	0.986	0.994	0.992	0.992	0.993	0.993
Kurtosis(z)	0.78**	1.36***	0.03	4.19***	0.99***	0.93***	1.27***	1.24***	1.40***
B-J (z)	21.11***	25.40***	0.07	>99.00***	11.92***	16.77***	22.89***	20.08***	22.79***
Q12(z)	0.85	0.14	0.04	0.16	0.94	0.62	0.51	0.32	0.25
Q12(z^2)	0.03	0.00	0.33	0.43	0.00	0.00	0.00	0.00	0.00
Likelihood function value					-4,062.99				

The table reports the QML estimation results for the conditional model assuming time-varying price of risk for monthly returns, over the period from 2001:01–2017:09.All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland market return, r_{st} is the currency risk measured by REER^{-1} (Chinese yuan real effective exchange rate), r_{sprt} is size factor. δ_w, δ_m, $\delta_s reer^{-1}$, δ_{spr} are the prices of the four risk factors, in percentages. The four information variables are lagged local market return RM(1), lagged change in euro dollar one month rate (ΔEuro$), lagged change in default premium(ΔDefault), and FWD, lagged return on Chinese yuan 1 month forward contract. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is the average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

Table 25 Quasi-maximum likelihood estimates of the conditional model with constant price of risk, weekly returns, using JPY/CNY as currency risk

$$r_{it} = const + \delta_w cov_{t-1}(r_{it}, r_{wt}) + \delta_m cov_{t-1}(r_{it}, r_{mt}) + \delta_s cov_{t-1}(r_{it}, r_{st}) + \delta_{spr} cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$$
$$\boldsymbol{H_t} = \boldsymbol{H_0} * (\boldsymbol{\iota\iota}' - \mathbf{aa}' - \mathbf{bb}') + \mathbf{aa}' * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s jpy$		δ_{spr}	
Const.	0.0812**	(2.55)	0.025	(1.51)	-0.012	(-1.51)	-0.057**	(-2.02)	0.004	(0.34)

Panel B GARCH parameters

	r_w	r_m	$r_s jpy$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	-0.393***	0.004	0.014	0.099***	0.045***	0.040***	0.037***	0.058***	0.010**
	(-8.19)	(0.34)	(0.15)	(6.28)	(4.26)	(2.76)	(4.74)	(3.28)	(2.01)
b	-0.833***	0.818	0.990***	-0.964***	0.948***	-0.954***	-0.954***	-0.760***	-0.983***
	(-18.98)	(1.59)	(24.93)	(-79.68)	(40.56)	(-28.57)	(-41.61)	(-7.23)	(<-99.00)

Panel C Diagnostic check

	r_w	r_m	$\delta_s jpy$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.06	0.08	-0.02	0.11	0.10	0.07	0.08	0.08	0.08
APE	-0.21	0.10	0.03	0.06	0.14	0.12	0.12	0.12	0.12
RMSE	2.55	3.62	1.46	2.84	4.20	4.27	4.10	3.98	3.88
Mean(z)	-0.082**	0.029	0.023	0.016	0.033	0.027	0.028	0.029	0.032
SD(z)	0.976	1.000	1.000	0.961	0.992	0.993	0.995	0.997	0.999
Kurtosis(z)	29.81***	2.27***	1.59***	3.55***	2.09***	2.81***	2.56***	2.20***	2.85***
B-J (z)	>99.00***	>99.00***	97.82***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***
Q12(z)	0.81	0.00	0.21	0.07	0.00	0.00	0.00	0.00	0.00
Q12(z^2)	1.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00

Likelihood function value: -11777.22

The table reports the QML estimation results for the conditional model with constant price of risk for weekly returns, over the period from 2001:01–2017:09.All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland market return, r_{st} is the currency risk measured by nominal exchange rate change of EUR/CNY, r_{sprt} is size factor. δ_w, δ_m, $\delta_s eur$, δ_{spr} are the prices of the four risk factors, in percentages. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. ***a*** and ***b*** are 9×1 vectors of parameters and **ι** is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is the average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

Table 26 Quasi-maximum likelihood estimates of the conditional model with dummy variables, weekly returns, using JPY/CNY as currency risk

$r_{it} = const + \delta_w cov_{t-1}(r_{it}, r_{wt}) + \delta_m cov_{t-1}(r_{it}, r_{mt}) + \delta_s cov_{t-1}(r_{it}, r_{st}) + \delta_{spr} cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$

$\boldsymbol{H_t} = \boldsymbol{H_0} * (\boldsymbol{\iota\iota'} - \mathbf{aa'} - \mathbf{bb'}) + \mathbf{aa'} * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s jpy$		δ_{spr}	
Const.	0.059***	(2.83)	0.030***	(3.14)	-0.014	(-2.02)	-0.028	(-1.29)	0.012	(1.13)
Currency			0.007	(0.70)			-0.045*	(-1.79)		
Connect			-0.020	(-0.57)			0.079	(1.19)		

Panel B GARCH parameters

	r_w	r_m	$r_s jpy$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	-0.340***	0.045***	-0.145***	0.114***	0.128***	0.060***	0.053***	0.062***	0.054***
	(-45.67)	(27.42)	(-7.58)	(70.72)	(14.03)	(37.29)	(31.84)	(23.33)	(13.20)
b	-0.903***	0.867***	-0.955***	0.962***	-0.136***	0.939***	0.948***	0.870***	0.918***
	(<99.00)	(50.29)	(-75.05)	(>99.00)	(-4.57)	(>99.00)	(>99.00)	(>99.00)	(>99.00)

Panel C Diagnostic check

	r_w	r_m	$r_s jpy$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.06	0.08	-0.02	0.11	0.10	0.07	0.08	0.08	0.08
APE	-0.23	0.12	0.04	0.02	0.12	0.09	0.10	0.10	0.12
RMSE	2.57	3.62	1.46	2.84	4.20	4.27	4.09	3.97	3.88
Mean(z)	-0.079**	0.033	0.025	0.001	0.029	0.022	0.023	0.025	0.031
SD(z)	0.990	0.997	0.990	0.954	0.992	0.989	0.991	0.994	0.993
Kurtosis(z)	31.26***	2.22***	1.47***	3.37***	2.05***	2.72***	2.50***	2.15***	2.71***
B-J (z)	>99.00***	>99.00***	88.39***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***
Q12(z)	0.77	0.00	0.27	0.08	0.00	0.00	0.00	0.00	0.00
Q12(z^2)	1.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00

Likelihood function value: -11,756.96

The table reports the QML estimation results for the conditional model with constant price of risk for weekly returns, over the period from 2001:01–2017:09.All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland market return, r_{st} is the currency risk measured by nominal exchange rate change of EUR/CNY, r_{sprt} is size factor. δ_w, δ_m, $\delta_s eur$, δ_{spr} are the prices of the four risk factors, in percentages. *Currency* is a dummy variable, taking the value of 0 before the currency reform and value of 1 thereafter. *Connect* is a dummy variable, taking the value of 0 before the Connect and value of 1 thereafter. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is the average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic of order 12. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

Table 27 Quasi-maximum likelihood estimates of the conditional model assuming time-varying price of risk, weekly returns, using JPY/CNY as currency risk

$r_{it} = const + \delta_{w,t-1}cov_{t-1}(r_{it}, r_{wt}) + \delta_{m,t-1}cov_{t-1}(r_{it}, r_{mt}) + \delta_{s,t-1}cov_{t-1}(r_{it}, r_{st}) + \delta_{spr,t-1}cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$

$\delta_k = const_k + \kappa_{FWD,k}FWD + \kappa_{RM(-1),k}RM(-1) + \kappa_{\Delta Default,k}\Delta Default + \kappa_{\Delta Euro\$}\Delta Euro\$$

$\boldsymbol{H_t} = \boldsymbol{H_0} * (\boldsymbol{\iota\iota}' - \mathbf{aa}' - \mathbf{bb}') + \mathbf{aa}' * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s jpy$		δ_{spr}	
Const.	0.080***	(3.06)	0.015	(1.23)	-0.012*	(-1.71)	-0.058**	(-2.22)	-0.009	(-0.88)
FWD			-0.020	(-0.77)	-0.088***	(-3.76)	-0.035	(-0.59)	0.005	(0.13)
RM			0.003	(1.30)	-0.002	(-0.83)	0.008	(1.23)	0.012***	(3.75)
$\Delta Default$			0.165***	(3.52)	-0.577***	(-4.07)	0.018	(0.05)	-0.016	(-0.09)
$\Delta Euro\$$			0.073*	(1.85)	0.415***	(4.29)	-0.074	(-0.77)	-0.605***	(-12.21)

Panel B GARCH parameters

	r_w	r_m	$r_s jpy$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	-0.441***	0.035***	-0.109***	0.193***	0.055***	-0.009***	0.017***	0.024***	0.012
	(-18.33	(4.35	(-4.04	(13.63	(6.21	(-3.68	(3.15	(10.05	(1.50
b	-0.815***	-0.671***	-0.963***	0.022	0.951***	0.938***	-0.818***	-0.975***	0.786***
	(-26.64)	(-3.12)	(-45.30)	(0.28)	(59.76)	(76.83)	(-13.41)	(<-99.00)	(5.74)

Panel C Hypothesis testing

Null Hypothesis	χ^2	*df*	*p-value*
World market risk is not priced.	21.14	5	0.000
The price of world market risk is constant.	18.99	4	0.000
Local market risk is not priced.	61.79	5	0.000
The price of local market risk is constant.	56.85	4	0.000
Currency risk is not priced.	8.48	5	0.132
The price of currency risk is constant.	2.85	4	0.584
Size risk is not priced.	>99.00	5	0.000
The price of size risk is constant.	>99.00	4	0.000

Table 27 (continued)

Panel D Diagnostic check

	r_w	r_m	$r_s jpy$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.06	0.08	-0.02	0.11	0.10	0.07	0.08	0.08	0.08
APE	-0.17	0.12	0.03	0.13	0.19	0.17	0.16	0.16	0.15
RMSE	2.66	3.59	1.47	2.81	4.13	4.21	4.04	3.93	3.84
Mean(z)	-0.061*	0.033	0.019	0.043	0.046	0.040	0.040	0.041	0.040
SD(z)	0.936	0.999	0.992	0.978	0.989	0.999	0.999	0.997	1.000
Kurtosis(z)	10.01***	2.69***	1.47***	3.90***	2.05***	2.96***	2.72***	2.20***	3.15***
B-J (z)	>99.00***	>99.00***	86.11***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***
Q12(z)	0.84	0.02	0.29	0.04	0.03	0.01	0.02	0.02	0.04
Q12(z^2)	0.62	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00

Likelihood function value -11762.66

The table reports the QML estimation results for the conditional model assuming time-varying price of risk for weekly returns, over the period from 2001:01–2017:09.All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland market return, r_{st} is the currency risk measured by nominal exchange rate of EUR/CNY, r_{sprt} is size factor. δ_w, δ_m, $\delta_s reer^{-1}$, δ_{spr} are the prices of the four risk factors, in percentages. The four information variables are lagged local market return RM(1), lagged change in euro dollar one month rate (ΔEuro$), lagged change in default premium(ΔDefault), and FWD, lagged return on Chinese yuan 1 month forward contract. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is the average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

Table 28 Quasi-maximum likelihood estimates of the conditional model assuming time-varying price of risk, weekly returns, over the period after the currency reform, using JPY/CNY as currency risk

$r_{it} = const + \delta_{w,t-1}cov_{t-1}(r_{it}, r_{wt}) + \delta_{m,t-1}cov_{t-1}(r_{it}, r_{mt}) + \delta_{s,t-1}cov_{t-1}(r_{it}, r_{st}) + \delta_{spr,t-1}cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$

$\delta_k = const_k + \kappa_{FWD,k}FWD + \kappa_{RM(-1),k}RM(-1) + \kappa_{\Delta Default,k}\Delta Default + \kappa_{\Delta Euro\$}\Delta Euro\$$

$\boldsymbol{H_t} = \boldsymbol{H_0} * (\mathbf{\iota\iota}' - \mathbf{aa}' - \mathbf{bb}') + \mathbf{aa}' * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s jpy$		δ_{spr}	
Const.	0.074**	2.27	0.026	(1.55)	-0.006	(-0.83)	-0.061*	(-1.93)	0.011	(1.01)
FWD			0.001	(0.02)	-0.080***	(-3.28)	-0.060	(-0.75)	0.025	(0.80)
RM			0.002	(0.67)	-0.002	(-0.45)	0.010*	(1.68)	0.014***	(4.67)
$\Delta Default$			0.120	(0.92)	-0.414**	(-2.46)	0.508	(1.28)	0.095	(0.46)
$\Delta Euro\$$			0.033	(0.65)	0.401***	(5.44)	-0.171	(-0.49)	-0.293***	(-3.64)

Panel B GARCH parameters

	r_w	r_m	$r_s jpy$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	0.513***	-0.034**	0.146***	0.075***	-0.069***	-0.014**	-0.007	-0.006*	-0.004
	(2.86)	(-2.18)	(2.93)	(6.28)	(-3.98)	(-2.30)	(-1.18)	(-1.85)	(-1.23)
b	0.754***	0.792***	0.948***	0.962***	-0.935***	0.971***	0.924***	-0.995***	-0.967***
	(3.31)	(4.03)	(21.60)	(86.66)	(-25.30)	(42.47)	(19.47)	(-446.50)	(-44.61)

Panel C Hypothesis testing

Null Hypothesis	χ^2	*df*	*p*-value
World market risk is not priced.	17.94	5	0.003
The price of world market risk is constant.	2.82	4	0.588
Local market risk is not priced.	86.06	5	0.000
The price of local market risk is constant.	85.07	4	0.000
Currency risk is not priced.	10.98	5	0.052
The price of currency risk is constant.	5.88	4	0.209
Size risk is not priced.	34.95	5	0.000
The price of size risk is constant.	33.97	4	0.000

Table 28 (continued)

Panel D Diagnostic check

	r_w	r_m	$r_s jpy$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.08	0.23	-0.03	0.23	0.31	0.28	0.28	0.27	0.25
APE	-0.24	0.09	0.04	0.06	0.13	0.11	0.10	0.10	0.10
RMSE	2.79	3.85	1.48	3.10	4.44	4.54	4.37	4.23	4.16
Mean(z)	-0.076**	0.024	0.026	0.019	0.030	0.024	0.023	0.024	0.024
SD(z)	0.927	0.997	0.984	0.983	0.986	0.997	0.998	0.996	0.997
Kurtosis(z)	11.31***	2.81***	1.08***	3.23***	2.15***	3.11***	2.88***	2.16***	3.29***
B-J (z)	>99.00***	>99.00***	40.13***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***
Q12(z)	0.81	0.05	0.16	0.15	0.19	0.09	0.13	0.19	0.15
Q12(z^2)	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Likelihood function value: -8976.72

The table reports the QML estimation results for the conditional model assuming time-varying price of risk for weekly returns, over the period after the currency reform. All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland market return, r_{st} is the currency risk measured by nominal exchange rate of EUR/CNY, r_{sprt} is size factor. δ_w, δ_m, $\delta_s reer^{-1}$, δ_{spr} are the prices of the four risk factors, in percentages. The four information variables are lagged local market return RM(1), lagged change in euro dollar one month rate (ΔEuro$), lagged change in default premium(ΔDefault), and FWD, lagged return on Chinese yuan 1 month forward contract. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is the average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.

Table 29 Quasi-maximum likelihood estimates of the conditional model assuming time-varying price of risk, weekly returns, over the period after the currency reform, using USD/CNY as currency risk

$r_{it} = const + \delta_{w,t-1}cov_{t-1}(r_{it}, r_{wt}) + \delta_{m,t-1}cov_{t-1}(r_{it}, r_{mt}) + \delta_{s,t-1}cov_{t-1}(r_{it}, r_{st}) + \delta_{spr,t-1}cov_{t-1}(r_{it}, r_{sprt}) + \varepsilon_t, \quad \varepsilon_t|\Omega_{t-1} \sim (0, \boldsymbol{H_t})$

$\delta_k = const_k + \kappa_{FWD,k}FWD + \kappa_{RM(-1),k}RM(-1) + \kappa_{\Delta Default,k}\Delta Default + \kappa_{\Delta Euro\$}\Delta Euro\$$

$\boldsymbol{H_t} = \boldsymbol{H_0} * (\mathbf{\iota\iota' - aa' - bb'}) + \mathbf{aa'} * \boldsymbol{\varepsilon_{t-1}\varepsilon'_{t-1}} + \boldsymbol{bb'H_{t-1}}$

Panel A Estimates of pricing coefficients

	Const.		δ_w		δ_m		$\delta_s usd$		δ_{spr}	
Const.	-0.045***	(-2.92)	0.063***	(4.59)	0.003	(0.29)	0.033	(0.15)	0.032**	(2.46)
FWD			-0.027	(-0.99)	-0.059***	(-2.62)	0.571*	(1.93)	0.011	(0.36)
RM			0.002	(1.27)	-0.002	(-0.69)	-0.001	(-0.02)	0.015***	(4.30)
$\Delta Default$			0.020	(0.20)	-0.409**	(-2.06)	-2.109	(-0.86)	-0.006	(-0.02)
$\Delta Euro\$$			0.097***	(2.75)	0.406***	(7.61)	0.651	(0.97)	-0.335***	(-6.36)

Panel B GARCH parameters

	r_w	r_m	$r_s usd$	r_{spr}	r_1	r_2	r_3	r_4	r_5
a	-0.495***	0.048***	0.167***	-0.050**	0.100***	0.047***	0.039***	0.050***	0.030***
	(-5.15)	(2.70)	(3.08)	(-2.29)	(7.68)	(4.60)	(3.66)	(3.74)	(2.85)
b	0.764***	-0.952***	0.980***	-0.970***	0.747***	-0.937***	-0.942***	-0.733***	-0.962***
	(6.84)	(-23.29)	(87.37)	(-29.38)	(9.35)	(-44.28)	(-44.37)	(-10.72)	(-25.98)

Panel C Hypothesis testing

Null Hypothesis	χ^2	*df*	*p*-value
World market risk is not priced.	47.24	5	0.000
The price of world market risk is constant.	8.24	4	0.083
Local market risk is not priced.	97.33	5	0.000
The price of local market risk is constant.	92.91	4	0.000
Currency risk is not priced.	5.60	5	0.347
The price of currency risk is constant.	5.53	4	0.237
Size risk is not priced.	82.82	5	0.000
The price of size risk is constant.	76.65	4	0.000

Table 29 (continued)

Panel D Diagnostic check

	r_w	r_m	$r_s usd$	r_{spr}	r_1	r_2	r_3	r_4	r_5
Mean	0.08	0.23	-0.03	0.23	0.31	0.28	0.28	0.27	0.25
APE	-0.28	-0.02	0.01	-0.03	-0.09	-0.12	-0.12	-0.10	-0.08
RMSE	2.81	3.86	0.29	3.10	4.45	4.54	4.37	4.23	4.16
Mean(z)	-0.088**	-0.006	0.030	-0.012	-0.021	-0.028	-0.027	-0.024	-0.019
SD(z)	0.923	0.994	1.027	0.992	0.992	0.994	0.996	0.999	0.997
Kurtosis(z)	12.50***	2.73***	31.25***	3.33***	2.13***	2.99***	2.79***	2.10***	3.21***
B-J (z)	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***	>99.00***
Q12(z)	0.76	0.06	0.00	0.15	0.19	0.10	0.14	0.19	0.16
Q12(z^2)	0.71	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00

Likelihood function value: -7962.50

The table reports the QML estimation results for the conditional model assuming time-varying price of risk for weekly returns, over the period after the currency reform. All the reported return figures are in percentages. r_{wt} is the world market portfolio return, r_{mt} is the Chinese mainland market return, r_{st} is the currency risk measured by nominal exchange rate of EUR/CNY, r_{sprt} is size factor. δ_w, δ_m, $\delta_s reer^{-1}$, δ_{spr} are the prices of the four risk factors, in percentages. The four information variables are lagged local market return RM(1), lagged change in euro dollar one month rate (ΔEuro$), lagged change in default premium(ΔDefault), and FWD, lagged return on Chinese yuan 1 month forward contract. The conditional covariance matrix $\boldsymbol{H_t}$ is estimated using the parsimonious GARCH(1,1) model described in Section 3.3. $\boldsymbol{a}$ and $\boldsymbol{b}$ are 9×1 vectors of parameters and $\boldsymbol{\iota}$ is an 9×1 unit vector. The t-statistics reported in parenthesis are robust to heteroscedasticity and autocorrelation. Mean is the sample mean of the residual series. APE is the average pricing error. RMSE is the root mean squared error. Z is the standardized residuals. Kurtosis(z) shows the excess kurtosis for z and equals to zero for normal distribution. B-J(z) is the Bera-Jarque test statistic for the null hypothesis of normality. Q12(z) and Q12(z^2) show p-values for Ljung-Box statistic up to 12 lags. ***, **, * denote significance level of reported value at 1%, 5% and 10% respectively.