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시간가변적인 중국 주식과 국채시장 간에 동조화

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경영학과

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시간가변적인 중국 주식과 국채시장 간에 동조화

Time-Varying Stock and Government Bond Market Comovement in China

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초록

시간가변적인 중국 주식과 국채시장 간에 동조화

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이 논문은 금융시장 불확실성이 중국 주식과 국채시장 간에 동조화에 미치는 영형에 대해서 연구한다. 시간가변적인 중국 주식과 국채시장 간에 동조화는 2003Q2부터 2016Q4까지에 중국 상하이 선전과 홍콩 세 개 금융시장의 주식과 국채 수입의 실현된 상관관계로 대리한다. OLS 방법을 이용해서 VIX로 대리하는 금융시장 불확실성은 중국 금융시장의 주식과 국채시장 간에 동조화에 부정적인 영향을 미치는 결과를 발견한다.

1. Introduction

Because of the benefits of economic growth via risk sharing, improved asset allocation and reductions in macroeconomic volatility and transaction costs, financial markets integration grasps investors and researcher's attention in international finance. (see Baele et al., 2009, Prasad et al., 2003 among others). Recently, Chinese financial market is rapidly developing and has attracted considerable attention not only for Chinese but also for foreign investors. The effective allocation of financial assets has importance for the efficiency and process of Chinese financial markets' innovation.(see Liu, 2013). Stock and bond markets are important constituent parts of Chinese capital markets. Portfolios consisting of stocks and bonds are most fundamental investment strategy for risk diversification in the financial markets. Hence the comovement between stock and bond markets plays an important role in portfolio strategy and risk management. Furthermore, the relationship between stock and bond returns provides us with indirect evidence that the market uncertainty is priced into different asset types on financial markets. A good understanding of stock-bond markets comovement is also crucial from an academic point of view. (see Lee et al.,2010)

Many of the researchers analyze the integration of Chinese stock and bond markets. Those find numerous factors that affect the integration. For example, Zhou (2014) finds that there exists a correlation between Chinese stock and bond returns. China central banks' interest rate, exchange rate and money supply can explain the correlation of Chinese stock and bond returns. Inflation rate, loan volume, PMI (the purchasing Managers' index) and CEFD (closed-end fund discount) also have an impact on the comovement between Chinese stock and bond markets (see Liu .2013). By contrast, Zou (2013) argues that no variable can explain the correlation but institutional factor. Zheng, Chen (2011) find that stock market uncertainty and expected inflation rate are primary element for the correlation of stock and bond returns. Studies by Connolly et al. (2005), Kim et al. (2006), Hobbes et al. (2007) and Bekaert et al. (2009) argue that economic uncertainty plays a key role in explaining the comovement of stock-bond markets. Sun (2013) argues that stock and bond markets affect each other but the degree of integration

is very small. Overall, Chinese stock and bond markets are in segmentation. In addition, there are so many studies arguing that money liquidity affects the correlation as well. Theoretically, an increase in money liquidity can increase demand of both stock and bond. Baks and Kramer(1999) targeting the sample of G7 countries prove that excessive money liquidity can explain the increase of asset prices.

This paper mainly examines the effect of financial market uncertainty on the comovement of Chinese stock and bond markets. If the "flight to quality" hypothesis is valid for Chinese financial markets, Chinese stock and bond returns would be negatively correlated when any market uncertainty occurs. So, one of main aims of the study is to shed light on analyzing the validity of the flight to safety hypothesis in China through our empirical results. Zheng, Chen (2011) analyze the effect of stock market uncertainty on correlation of Chinese stock and bond returns. They use the Chinese stock volatility to proxy the uncertainty of stock market. Because the implied volatility is unavailable in China, they fit it by the EGARCH-M model. This study uses the implied volatility from equity index options index (e.g. the VIX) of the USA financial markets to proxy this uncertainty. Because of the economic globalization, the uncertainty of the USA financial markets could also has substantial influence on the Chinese financial markets.

This study employs the OLS estimation which uses the quarterly realised correlations between the Chinese stock and government bond returns to proxy the comovement and uses the SSE (Shanghai stock exchange) Composite index, the Shenzhen Component index and the Hang Seng index to proxy the Chinese stock prices. The sample stocks of the SSE Composite index are all A-shares and B-shares in Shanghai stock Exchange. Similarly, the Shenzhen Component index is calculated by the prices of all A-shares and B-shares in Shenzhen stock exchange. The Hang Seng index is similar with these two stock price indices. So these indices can reflect the price changes of Chinese stock markets. Due to unavailability of 10 years long term government bond return data, this study uses the SSE T-bond index which is calculated by the prices of all government bond in Shanghai stock exchange whose maturities are longer than 1 year and weighted by the volume of government issuance. It is the indicator for the price change of Chinese government bond market.

According to the flight to quality hypothesis, investors would substitute safer assets for their risky ones when there is any financial turmoil or regulation change in market. In generally, government bond is regarded as a safer asset when financial markets are in a hard time because of its fixed gain. So when there is any trouble or regulation change in financial markets, investors buy bonds and sell stocks and it could cause the negative correlation of stock and bond prices. (see Chordia et al., 2005, Connolly et al., 2005, Hartmann et al., 2004, and Kim et al., 2006 among others). For instance, studies such as Connolly et al. (2005), Kim et al. (2006), Hobbes et al. (2007) and Bekaert et al. (2009) argue that economic uncertainty plays a key role in explaining the comovement of stock-bond markets. They primarily use implied volatility from equity index options index (e.g. the VIX) to proxy this uncertainty. So, this study also uses the VIX to proxy the financial markets uncertainty.

Using the VIX to proxy the markets uncertainty, this work finds that the VIX significantly has a negative effect on the integration of stock and government bond markets in China. Our sample periods include the US subprime crisis and the EU GIPP crisis. So this paper also includes these two crises dummies in the model. The study finds that they absorb the effect of the VIX and have a significant impact on the realised correlations of stock and government bond returns in Chinese financial markets. Moreover, the US subprime crisis has a comparative greater effect on Chinese financial markets than the EU GIPP crisis. The EU GIPP crisis has a bigger effect in Shenzhen market. These results suggest the validity of flight to quality hypothesis in Chinese financial markets.

The remainder of this paper is as follows. Section 2 surveys previous literature examining comovement of stock and bond markets. Section 3 explains the methodologies for this study. Section 4 discusses our data. Section 5 provides the empirical results. Finally, section 6 concludes.

2. Literature review

Many researchers try to discover the drivers of comovement between stock and government bond markets. For example, Engsted et al. (2001) study comovement between stock and bond markets in Denmark. They argue that higher future inflation leads negative correlation of stock and bond returns. Since higher future inflation could incur the increase of expected stock returns. However, bond returns have no comparative change because of its fixed gain. Barsky (1989) aruges that low productivity growth and high market risk explain the negative correlation of asset returns well. Li (2002) finds that economic uncertainty and expected inflation play an important role in explaining the integration between stock and bond markets in G7. Connolly et al. (2005) provide evidence that increased market uncertainty which is proxied by the VIX index explains the negative correlation of US stock and bond returns in the short term well. Bekaert et al. (2009), Chordia et al. (2005), and Hartmann et al. (2004) get similar results. Hobbes et al. (2007) also argue that the correlation of stock and bond returns in Australia is related to economic uncertainty proxied by the VIX. Andersson et al. (2008) provide the evidence that situations of Germany, US, and UK also support the flight to quality hypothesis. They indicate that during the period of high expected inflation, stock and bond prices move in the same direction and during the low expected inflation, stock and bond returns have negative correlation. They also argue that GDP has no impact on the comovement of asset markets in these countries.

Studies targeting the correlation between stock and bond prices in Chinese financial markets are limited to few. Zhang (2005) tries to study the comovement and its drivers (e.g. the inflation rate, business cycle, and monetary policy). The author argues that inflation rate and its uncertainty have a negative effect on correlation between stock and bond returns in China. Liu (2013) indicates that stock and bond returns in Chinese financial markets have a correlation. Moreover, the author argues that inflation rate, credit volume, the purchasing manager's index (PMI) and closed-end fund discount have lagging effect on comovement of Chinese asset markets. Sun (2013) finds that inflation rate has a

negative effect on correlation of stock and bond prices and that supports Liu and Zhang's arguments. Sun (2013) also provides evidence that interest rate, monetary supply and exchange rate could explain the correlation of stock and bond returns in China. Zhou (2014) argues that money supply and interest rate have significant effect on integration of Chinese asset markets than inflation and GDP.

Financial markets uncertainty has effect on correlation between stock and bond prices in theory. When there is any uncertainty in financial markets, stock expected returns rise and it also causes the decline of stock prices. In order to evade the risk of stock market, investors turn their attentions to relatively safe long term government bond market. Then risk premium of bond decline which also causes the decrease of bond prices. That is "flight to quality" hypothesis. If flight to quality hypothesis is effective for Chinese financial markets, then the correlation between stock and bond prices would be negative when there is any financial markets uncertainty in China.

Zheng, Chen (2011) fit stock volatility to proxy the Chinese stock market uncertainty using EGARCH-M model. They provide evidence that correlations of Chinese stock and bond returns are time-varying and stock market uncertainty and inflation are the main drivers of them.

Because financial markets around the world have interaction effect to each other, this paper uses the VIX index to proxy the financial markets uncertainty and examines if the financial markets uncertainty proxied by the VIX has effect on comovement between stock and government bond markets in China.

3. Methodologies

3.1 Measuring realised correlations between Chinese stock and bond returns

The paper defines stock and government bond returns as $r_{i,t,d} = \ln(p_{i,t,d} / p_{i,t,d-1}) \times 100$ $p_{i,t,d}$ means the closing prices of asset i (stock or government bond) in t quarter d day where the number of quarters t is 55 (t=1,.....55) and business days of a quarter are 62(d=1,.....62).

In order to measure the realised correlations between stock and bond returns, this paper calculates the variance like this:

$$\sigma_{t,s}^2 = \sum_{d=1}^{D_t} [r_{s,t,d}]^2$$
$$\sigma_{t,b}^2 = \sum_{d=1}^{D_t} [r_{b,t,d}]^2 \qquad (1)$$

S denotes stock and b denotes government bond. $r_{s,t,d}$ is the stock returns in t quarter d day and $\sigma_{t,s}^2$ means the stock returns variance in t quarter. $r_{b,t,d}$ is the government bond returns in t quarter d day and $\sigma_{t,b}^2$ means the government bond returns variance in t quarter.

The covariances between stock and government bond are measured as:

$$\sigma_{sb,t} = \sum_{d=1}^{D_t} [r_{s,t,d} \times r_{b,t,d}] \qquad (2)$$

$\sigma_{sb,t}$ means the covariances of stock and government bond returns in t quarter. So, the correlations between stock and government bond returns are obtained as:

$$\rho_{sb,t} = \frac{\sigma_{sb,t}}{\sqrt{\sigma_{s,t}^2 \times \sigma_{b,t}^2}} \qquad (3)$$

Finally, this paper use a Fisher-Z transformation of $\rho_{sb,t}$ that Li (2002), Andersson et al. (2008) and Beine et al. (2009) employ:

$$\overline{\rho_{sb,t}} = \ln\left(\frac{1+\rho_{sb,t}}{1-\rho_{sb,t}}\right) \qquad (4)$$

The measurement of realised correlations is on the basis of prior literature, e.g. Bekaert et al. (2009), Cappiello et al. (2006), Kim et al. (2006), and Connolly et al. (2005).

3.2 The OLS Estimation Results

In order to examine the effect of the VIX index on the integration between stock and government bond markets, this paper uses three OLS models. Model 1 uses the VIX index only as the independent variable. Model 2 includes some variables that have effect on the realised correlations of stock and bond returns according to the prior literature as the control variables. Because of the great influence of the 2008-2009 US subprime crisis and the 2010-2011 EU GIPP crisis on China, Model 3 adds two dummies to take these two crises effects into account. Since the VIX index and control variables have lagged effects on dependent variables, this paper uses t-1 as these variables' subscript. D_1 denotes the dummy of US subprime crisis and D_2 denotes the EU GIPP crisis. This paper uses CPI (the consumer price index), GDP, and US 3-month T-bill interest rate as the control variables.

$$Y_{it} = \alpha_i + \beta_{1i} VIX_{t-1} + \varepsilon_{it} \quad (5)$$

$$Y_{it} = \alpha_i + \beta_{1i} VIX_{t-1} + \beta_{2i} C_{t-1} + \varepsilon_{it} \quad (6)$$

$$Y_{it} = \alpha_i + \beta_{1i} VIX_{t-1} + \beta_{2i} C_{t-1} + \beta_{3i} D_{1t} + \beta_{4i} D_{2t} + \varepsilon_{it} \quad (7)$$

4. Data Issues

4.1 Stock and bond returns

This paper uses the data of three Chinese stock markets to examine our problem. They are Shanghai, Shenzhen and Hong Kong stock markets. The paper uses the Shanghai Securities Composite index, the SZSE Component index and the Hang Seng index to proxy the stock prices, respectively. Because of the unavailability of Chinese 10 year long term government bond price data, This paper uses the SSE T-bond index to proxy the government bond price. To measure the realised correlations of stock and government bond returns, the study uses the daily prices of stock and government bond from 1st April 2003 to 31th December 2016. Using the daily prices of stock and government bond, this paper could calculate the returns like:

$$r_{i,t,d} = \ln(p_{i,t,d} / p_{i,t,d-1}) \times 100 \qquad (8)$$

Then the paper uses the returns to measure the realised correlations between stock and government bond returns. Because the sample includes Chinese three stock markets, this paper has three pairs fisher-Z correlations as dependent variables in models. Finally, stock and bond prices data are obtained from the Wangyi finance.

4.2 Explanatory variables

The paper mainly examines the effect of market uncertainty on integration between stock and government bond markets. Many papers indicate that market uncertainty affects the integration between stock and government bond markets. Li (2002) finds that economic uncertainty and expected inflation play an important role in explaining the comovement between stock and bond markets in G7. Connolly et al. (2005) provide evidence that increased market uncertainty which is proxied by the VIX index explains the negative

correlation of US stock and bond returns in the short term well. Bekaert et al. (2009), Chordia et al. (2005), and Hartmann et al. (2004) indicate that US correlation of stock and bond returns is negative when financial markets are highly uncertain. Hobbes et al. (2007) also argue that the correlation of stock and bond returns in Australia is related to economic uncertainty proxied by the VIX. Zheng (2011) provides evidence that correlations of Chinese stock and bond returns are time-varying and stock market uncertainty and inflation are the main drivers of them.

The realised correlations of stock and government bond returns transformed by fisher-Z are used in this paper as dependent variable. To proxy the financial markets uncertainty, the paper uses the VIX (the volatility index) as main independent variable. Because its lagged effect, this paper uses the quarterly VIX data from 1st January 2003 to 30th September 2016.

Meanwhile, inflation rate is also considered as one of the main driver of correlation of stock and bond returns by some researchers.

Engsted et al. (2001) study the correlation between stock and bond returns in Denmark. They argue that higher future inflation leads negative correlation of stock and bond returns. Li (2002) finds that economic uncertainty and expected inflation play an important role in explaining the comovement between stock and bond markets in G7. Andersson et al. (2008) indicate that during the period of high expected inflation, stock and bond prices move in the same direction and during the low expected inflation, stock and bond returns have negative correlation. Zhang (2005) argues that inflation rate and its uncertainty affect correlation between stock and bond returns in China. Liu (2013) indicates that stock and bond returns in Chinese financial markets have a correlation. Furthermore, the author finds that inflation rate has lagging effect on comovement of Chinese asset markets. Sun (2013) indicates that inflation rate has a negative effect on correlation of stock and bond returns and that also supports Liu and Zhang's arguments.

This paper uses the increasing rate of CPI (the consumer price index) to proxy Chinese inflation. Since its lagged effect which is the same as the VIX, the study chooses its quarterly data from 1st January 2003 to 30th September 2016 as sample.

Andersson et al. (2008) suggest that there is no systemic linkage between an economic growth expectations (GDP) and correlation of stock and bond returns within Germany, UK, and USA. To examine if GDP has explanation for the comovement between stock and government bond markets in Chinese financial markets, the paper also includes GDP in our model. The data period is the same as the VIX and the CPI.

The full sample period is from 2003 to 2016 which includes the 2008-2009 US subprime crisis and the 2010-2011 EU GIPP crisis. So this paper makes two dummies that are included in model to absorb the effects of these two crises to Chinese financial markets. In addition, the paper also includes the US 3-month bill interest rate in model as control variable because of its importance.

The paper does the unit root test for all variables. Results of test are like Table 1 presents. To make the conclusion more reliable, the paper uses difference method on GDP and US 3-month bill interest rate.

[insert Table 1 here]

Finally, the study gets the VIX data from *the datastream*. The CPI data source is *the OECD MEI data*. The GDP data is from *the national bureau of statistic of China*. The US 3-month bill interest rate data is from the *Federal Reserve Bank of St. Louis*.

5. Empirical results

This section is the exhibition of our results. Table 2 presents descriptive statistics for variables. Z correlation is the Fisher-Z transformation of realised correlation between stock and government bond price indices. SH, SZ and HK denote Shanghai, Shenzhen and Hong Kong, respectively. As the Table 2 presents, mean value of the Shanghai's realised correlations is 0.0281. Standard error is 0.3542. They are similar to Shenzhen's 0.026 of mean and 0.3473 of standard error. On the contrary, mean value of the Hong Kong's realised correlations is -0.0577. Standard error is 0.2960. That is because the similar investing environment of Shanghai and Shenzhen as the Chinese mainland financial markets. Hong Kong is a little different to them. The mean value of the VIX is 19.394 and standard error is 8.0443. This large standard error is likely to be caused by the US subprime crisis and the EU GIPP crisis. The VIX which is called 'fear' index affected by these two crises significantly fluctuates during the periods of 2003 to 2016.

[insert Table 2 here]

Table 3 presents the correlation matrix across the independent variables. The correlation of the US subprime crisis dummy and the VIX is 0.5165. It indicates that the US subprime crisis has an effect on the VIX. The value of correlation between the EU GIPP crisis dummy and the VIX which is 0.1197 indicates that the EU GIPP crisis has no sufficient effect on the VIX compared with the US subprime crisis.

[insert Table 3 here]

Figure 1, 2 and 3 present the time varying (Z-fisher transform) realised correlations of Shanghai, Shenzhen and Hong Kong, respectively. According with the results of Table 1, trends of the realised correlations are similar in Shanghai and Shenzhen. Hong Kong is different from them.

[insert Figure 1 2 3 here]

As the figure 1 and 2 present, there are approximately 5 times of a sharp decline from 2003 to 2016. The first time is beginning of the 2004 when the Chinese mainland financial markets get into great crisis of confidence. In this crisis, investors sell the stocks and buy long term government bonds to avoid risk, which caused a negative correlation of stock and government bond returns. The second time is a starting period of the 2005 Chinese reform of non-tradable shares[1]. After the reform, the confidence of investors goes up and the trend of stock and government bond correlations presents a upward trend. The third time is US subprime crisis which affects global financial markets. Due to the crisis, the negative realised correlations of Chinese stock and government bond returns last nearly 2 years from second quarter of 2008 to second quarter of 2010. The fourth and fifth are caused by the steep fall of Chinese stock returns.

5.1. Results of the OLS regressions for Shanghai, Shenzhen and Hong Kong markets

At the first, the paper regresses 3 models including Shanghai, Shenzhen, and Hong Kong markets. Regression 1 only uses the VIX variable as the independent variable. As Table 4 presents, the coefficient of the VIX is -0.0149. Its standard error is 0.0031. It is significant at 1% level.

According to “flight to quality” hypothesis, investors would have preference for safer assets when financial markets are on uncertain period. This action could cause a negative correlation of stock and government bond prices. Higher VIX index means higher degree of investors “fear” (higher uncertainty of market). So if the flight to quality hypothesis is

1) Stock shares of Chinese listed company were divided into tradable shares and non-tradable shares. Reform of non-tradable shares was carrying on in 2005 and it aimed at breaking the boundary of the dual structure of tradable and non-tradable shares, so as to optimize the ownership structure and to achieve the circulation of all shares.

valid on Chinese financial markets, the VIX would has a negative effect on the realised correlations of Chinese stock and government bond returns. In Regression 1, the coefficient of VIX is -0.0149 which supports the flight to quality hypothesis. Adjusted R square is 0.1223. Result of Regression 2 which includes CPI, GDP and US 3-month treasury bill interest rate as control variables also supports flight to quality hypothesis. Coefficient of the VIX is -0.0157. Standard error is 0.0031. It is significant at 1% level. CPI has no significant effect on dependent variables which is different from Zhang (2005), Liu (2013) and Sun (2013). Adjusted R square of Regression 2 is 0.1222. Because sample period of this paper from 2003 to 2016 includes the well-known two financial crises, Model 3 adds the US subprime crisis dummy and the EU GIPP crisis dummy to examine our problem. As Table 4 presents, the US subprime dummy and the EU GIPP dummy absorb some effect of the VIX which is significant at 5% level. The significance level of the US subprime dummy is 1% that is more significant than EU GIPP dummy's 10%. Supporting flight to quality hypothesis, their coefficients are all negative values which are -0.264 and -0.133, respectively. The absolute values of these two crises dummies' coefficients are bigger than the VIX which reminds us the great influence of these two crises especially the US subprime crisis. Adjusted R square of Regression 3 is 0.1602.

[insert Table 4 here]

5.2. Robustness analyses

Because there are some differences in these three markets of China, this paper regresses each of them as a robustness check. Table 5 presents the result of Shanghai market. Regression 1 indicates that the VIX has a negative effect on the realised correlations of stock and government bond returns which listed in Shanghai stock exchange. The coefficient of the VIX is -0.0203 that is significant at 1% level. Adjusted R square is 0.1967. Regression 2 which includes some control variables presents the same results from

Regression 1. Adjusted R square of Regression 2 is 0.1580. Two crises dummies included in Regression 3. The same as the results above, the US subprime dummy absorbs the effect of the VIX on dependent variable. But Regression 3 also presents that EU GIPP crisis has no significant effect on the realised correlations of stock and government bond returns in Shanghai stock exchange. Supporting the flight to quality hypothesis, coefficients of the VIX and the US subprime crisis dummy are negative. Adjusted R square of Regression 3 is 0.1993.

[insert Table 5 here]

Table 6 presents us the results of OLS regressions for the Shenzhen market. Similarly to the results for the Shanghai market, the VIX has a significant negative effect on the dependent variable. Adjusted R square of Regression 1 is 0.1370. Control variables do not significantly explain the dependent variable well except the two crises dummies. Unlike the Shanghai's result, the EU GIPP crisis dummy has a significant negative effect on the realised correlations of stock and bond returns. The study concludes that the EU GIPP crisis has bigger impact on Shenzhen financial market than Shanghai one. Moreover, the two crises dummies absorb the effect of the VIX so that they result in insignificant effect of the VIX. Adjusted R square of Regression 3 is 0.1645.

[insert Table 6 here]

Table 7 presents the results of Hong Kong market. In Regression 1, coefficient of the VIX is -0.0076 and standard error is 0.0049 which is marginally significant. Regression 2 includes three control variables. As the table represents, VIX, CPI and US 3-month treasury interest rate have significantly effect on the realised correlations of stock and government bond returns. But in Regression 3 which adds two crises dummies, they all lose their significant validity. The results suggest that the US subprime crisis dummy and the EU GIPP crisis dummy absorb the effect of the VIX. In Regression 3, all variables have no statistical significance except the US 3-month treasury interest rate which is

significant at 5% level. R square of Regression 1 is 0.0429 and Regression 2's one is 0.1891, which suggests that the VIX and control variables except GDP have a jointly effect on dependent variable. From Regressions 2 and 3, the study concludes the robust impact of US 3-month treasury interest rate on the realised correlations of stock and government bond returns in Hong Kong market.

[insert Table 7 here]

6. Summary and Concluding Remarks

This paper mainly examines the validity of "flight to quality" hypothesis in Chinese financial markets. If flight to quality hypothesis is valid for Chinese financial markets, market uncertainty would has a negative effect on comovement between stock and government bond markets in China. The paper uses the VIX to proxy the market uncertainty and conducts our research on three Chinese stock markets. They are Shanghai, Shenzhen and Hong Kong markets. Our work gets conclusion that the VIX has a significantly negative effect on the realised correlations of stock and long term government bond prices in China. This paper also tests the US subprime crisis and the EU GIPP crisis whether have impact on the realised correlations. Our conclusion is that they all have effect on the realised correlations and absorb the effect of the VIX. The US subprime crisis has comparative greater effect on Chinese financial markets than the EU GIPP crisis. The EU GIPP crisis has bigger effect on Shenzhen market than other two markets. All of these results support the flight to quality hypothesis and prove the validity of this hypothesis in Chinese financial markets. On the other hand, the paper also examines the effect of CPI, GDP and US 3-month treasury bill interest rate. However, the study does not get the apparent evidence that could fully prove their effectiveness on integration of stock and long term government bond markets.

These conclusions are helpful to investors. According to theory of risk diversification, if stock and bond returns are not negative correlated when market uncertainty occurs, the returns of portfolio which consists of stock and long term government bond would be low and the portfolio could not offer the function of risk diversification. So managers have to take the time-varying comovement between stock and long term government bond markets into account when they aim to construct the portfolios which have minimum variance and maximum returns.

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Appendix 1

Table 1. Augmented Dickey-Fuller test for unit root. (Lag=1)

Level variable		
Variables	Z(t)	p-value
Z correlation -SH	-2.639*	0.0853
Z correlation -SZ	-3.075**	0.0285
Z correlation -HK	-5.291***	0.0000
VIX_{t-1}	-2.949**	0.0399
CPI_{t-1}	-4.269***	0.0005
LN_GDP_{t-1}	-1.473	0.5468
$US\text{-}Tbill_{t-1}$	-1.234	0.6590
Difference variable		
Variables	Z(t)	p-value
Z correlation -SH	-2.639*	0.0853
Z correlation -SZ	-3.075**	0.0285
Z correlation -HK	-5.291***	0.0000
VIX_{t-1}	-2.949**	0.0399
CPI_{t-1}	-4.269***	0.0005
ΔLN_GDP_{t-1}	-8.306***	0.0000
$\Delta US\text{-}Tbill_{t-1}$	-6.353***	0.0000

Notes: Z correlation is the Fisher-Z transformation of realised correlation between stock and government bond price index. SH, SZ and HK are mean Shanghai, Shenzhen and Hong Kong, respectively. ***,**, and * denote significance at 1%, 5% and 10% levels, respectively. Figures in parentheses indicate standard errors.

Table 2. Descriptive statistics for all the variables.

Variables	Obs.	Mean	S.D.	Min.	Max.
Dependent variables					
Z correlation -SH	55	0.0281	0.3542	-0.8259	0.6835
Z correlation -SZ	55	0.0260	0.3473	-0.7460	0.6597
Z correlation -HK	55	-0.0577	0.2960	-0.8250	0.7969
Independent variables					
VIX_{t-1}	55	19.3940	8.0443	11.1500	45.4500
CPI_{t-1}	55	2.7097	2.0168	-1.5333	8.0333
LN_GDP_{t-1}	55	11.3840	0.5525	10.3031	12.1697
$US\text{-}Tbill_{t-1}$	55	1.1962	1.6380	0.0100	4.9400
$D_{US\text{-}SUB}$	55	0.1455	0.3559	0	1
$D_{EU\text{-}GIPPS}$	55	0.1455	0.3558	0	1

Notes: Z correlation is the Fisher-Z transformation of realised correlation between stock and government bond price index. SH, SZ and HK mean Shanghai, Shenzhen and Hong Kong, respectively. $D_{US\text{-}sub}$ denotes the 2008-2009 US subprime crisis dummy. $D_{EU\text{-}GIPPS}$ denotes the 2010-2011 EU GIPPS crisis dummy.

Table 3. Correlation matrix across the exogenous independent variables

	VIX_{t-1}	CPI_{t-1}	ΔLN_GDP_{t-1}	$\Delta US\text{-}Tbill_{t-1}$
VIX_{t-1}	1			
CPI_{t-1}	-0.1273	1		
ΔLN_GDP_{t-1}	-0.0629	0.0724	1	
$\Delta US\text{-}Tbill_{t-1}$	-0.0597	-0.1649	-0.2309	1

Table 4. Results of the Pooled OLS regressions for Shanghai, Shenzhen and Hong Kong markets.

This table presents the Pooled OLS regressions results in three Chinese financial markets:

$$Y_{it} = \alpha_i + \beta_{1i} VIX_{t-1} + \beta_{2i} C_{t-1} + \beta_{3i} D_{1t} + \beta_{4i} D_{2t} + \varepsilon_{it}$$

Where dependent variable Y_{it} is the realised correlations between Chinese stock and government bond returns. The VIX is the main independent variable which proxy the market uncertainty, and C_{t-1} represents a vector of control variables. D_1 denotes the dummy of US subprime crisis and D_2 denotes the EU GIPP crisis.

Variables	Reg.1	Reg.2	Reg.3
Constant	0.2882*** (0.0641)	0.3484*** (0.0774)	0.2309*** (0.0850)
VIX_{t-1}	-0.0149*** (0.0031)	-0.0157*** (0.0031)	-0.0087** (0.0038)
CPI_{t-1}		-0.0132 (0.0125)	-0.0008 (0.0132)
ΔLN_GDP_{t-1}		-0.3014 (0.2279)	-0.3003 (0.2230)
$\Delta US\text{-}Tbill_{t-1}$		-0.0212 (0.0306)	-0.0422 (0.0307)
$D_{US\text{-}SUB}$			-0.2640*** (0.0889)
$D_{EU\text{-}GIPPS}$			-0.1330* (0.0765)
Number of observations	165	165	165
Adj R-squared	0.1223	0.1222	0.1602
F-value	23.85***	6.71***	6.22***

Notes: ***,**, and * denote significance at 1%, 5% and 10% levels, respectively. Figures in parentheses indicate standard errors.

Table 5. Results of the simple OLS regressions for the Shanghai market.
This table presents the simple OLS regressions results in Shanghai markets:

$$Y_{it} = \alpha_i + \beta_{1i} VIX_{t-1} + \beta_{2i} C_{t-1} + \beta_{3i} D_{1t} + \beta_{4i} D_{2t} + \varepsilon_{it}$$

Where dependent variable Y_{it} is the realised correlations between Chinese stock and government bond returns. The VIX is the main independent variable which proxy the market uncertainty, and C_{t-1} represents a vector of control variables. D_1 denotes the dummy of US subprime crisis and D_2 denotes the EU GIPP crisis.

Variables	Reg.1	Reg.2	Reg.3
Constant	0.4210*** (0.1126)	0.4615*** (0.1393)	0.3152** (0.1525)
VIX_{t-1}	-0.0203*** (0.0054)	-0.0207*** (0.0056)	-0.0119* (0.0068)
CPI_{t-1}		-0.0094 (0.0225)	0.0091 (0.0237)
ΔLN_GDP_{t-1}		-0.2075 (0.4101)	-0.2042 (0.4000)
$\Delta US\text{-}Tbill_{t-1}$		0.0079 (0.0550)	-0.0189 (0.0551)
$D_{US\text{-}SUB}$			-0.3205* (0.1596)
$D_{EU\text{-}GIPPS}$			-0.1981 (0.1373)
Number of observations	55	55	55
Adj R-squared	0.1967	0.1580	0.1993
F-value	14.23***	3.53**	3.24***

Notes: ***,**, and * denote significance at 1%, 5% and 10% levels, respectively. Figures in parentheses indicate standard errors.

Table 6. Results of the simple OLS regressions for the Shenzhen market.
This table presents the simple OLS regressions results in Shenzhen markets:

$$Y_{it} = \alpha_i + \beta_{1i} VIX_{t-1} + \beta_{2i} C_{t-1} + \beta_{3i} D_{1t} + \beta_{4i} D_{2t} + \varepsilon_{it}$$

Where dependent variable Y_{it} is the realised correlations between Chinese stock and government bond returns. The VIX is the main independent variable which proxy the market uncertainty, and C_{t-1} represents a vector of control variables. D_1 denotes the dummy of US subprime crisis and D_2 denotes the EU GIPP crisis.

Variables	Reg.1	Reg.2	Reg.3
Constant	0.3535***	0.3422**	0.1931
	(0.1145)	(0.1405)	(0.1528)
VIX_{t-1}	-0.0169***	-0.0166***	-0.0076
	(0.0055)	(0.0056)	(0.0069)
CPI_{t-1}		0.0057	0.0267
		(0.0227)	(0.0237)
ΔLN_GDP_{t-1}		-0.2532	-0.2465
		(0.4138)	(0.4007)
$\Delta US\text{-}Tbill_{t-1}$		0.0447	0.0160
		(0.0555)	(0.0552)
$D_{US\text{-}SUB}$			-0.3125*
			(0.1599)
$D_{EU\text{-}GIPPS}$			-0.2583*
			(0.1375)
Number of observations	55	55	55
Adj R-squared	0.1370	0.1088	0.1645
F-value	9.57***	2.65**	2.77**

Notes: ***,**, and * denote significance at 1%, 5% and 10% levels, respectively. Figures in parentheses indicate standard errors.

Table 7. Results of the simple OLS regressions for the Hong Kong market.
This table presents the simple OLS regressions results in Hong Kong markets:

$$Y_{it} = \alpha_i + \beta_{1i} VIX_{t-1} + \beta_{2i} C_{t-1} + \beta_{3i} D_{1t} + \beta_{4i} D_{2t} + \varepsilon_{it}$$

Where dependent variable Y_{it} is the realised correlations between Chinese stock and government bond returns. The VIX is the main independent variable which proxy the market uncertainty, and C_{t-1} represents a vector of control variables. D_1 denotes the dummy of US subprime crisis and D_2 denotes the EU GIPP crisis.

Variables	Reg.1	Reg.2	Reg.3
Constant	0.0900 (0.1037)	0.2415** (0.1187)	0.1844 (0.1329)
VIX_{t-1}	-0.0076 (0.0049)	-0.0099** (0.0048)	-0.0065 (0.0060)
$CPIt_{-1}$		-0.0358* (0.0191)	-0.0333 (0.0207)
ΔLN_GDP_{t-1}		-0.4434 (0.3496)	-0.4502 (0.3486)
$\Delta US\text{-}Tbill_{t-1}$		-0.1161** (0.0469)	-0.1236** (0.0480)
$D_{US\text{-}SUB}$			-0.1592 (0.1391)
$D_{EU\text{-}GIPPS}$			0.0575 (0.1196)
Number of observations	55	55	55
Adj R-squared	0.0248	0.1242	0.1292
F-value	2.37	2.91**	2.33**

Notes: ***,**, and * denote significance at 1%, 5% and 10% levels, respectively. Figures in parentheses indicate standard errors.

Appendix 2

Figure 1. Time varying (Z-Fisher transform) realised correlations of the Shanghai market.

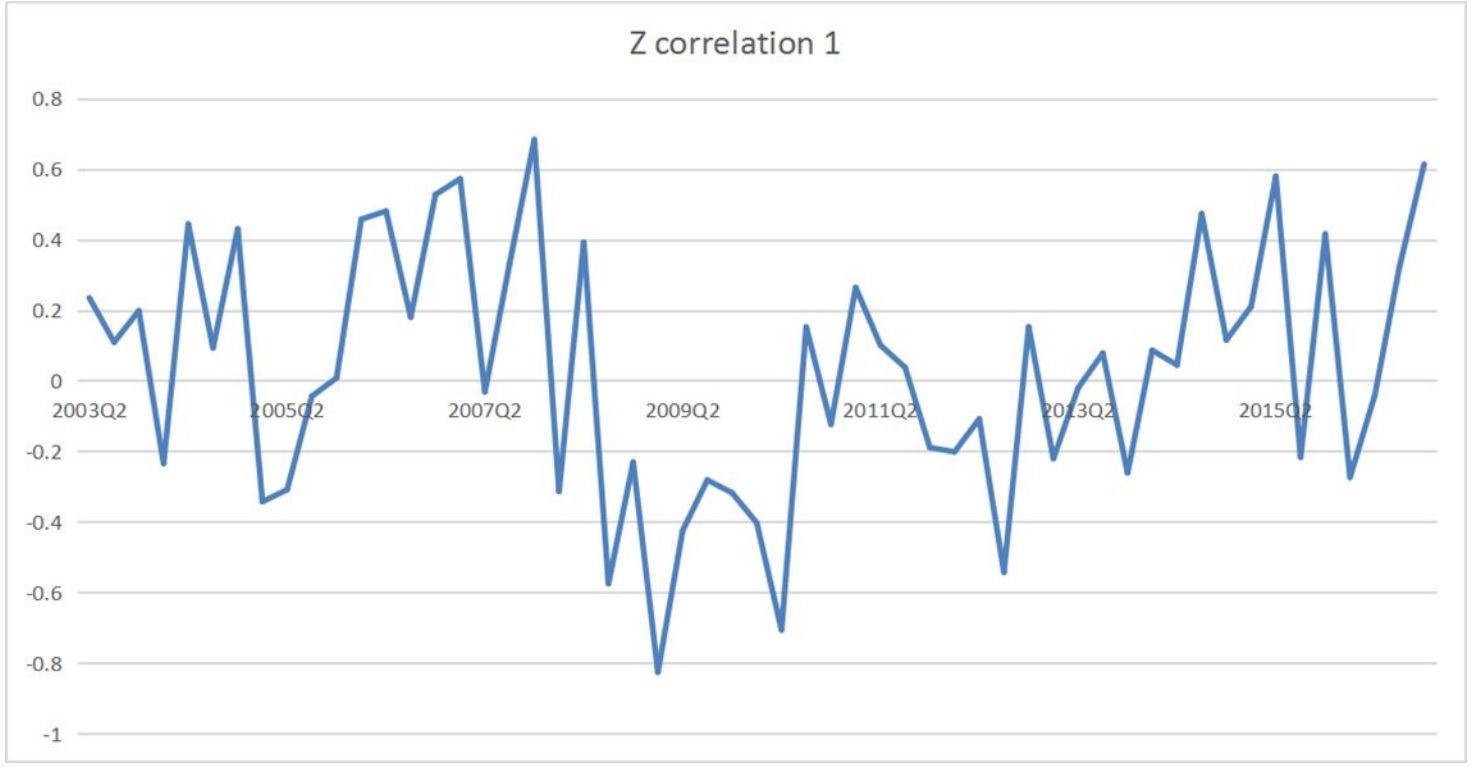

Figure 2. Time varying (Z-Fisher transform) realised correlations of the Shenzhen market.

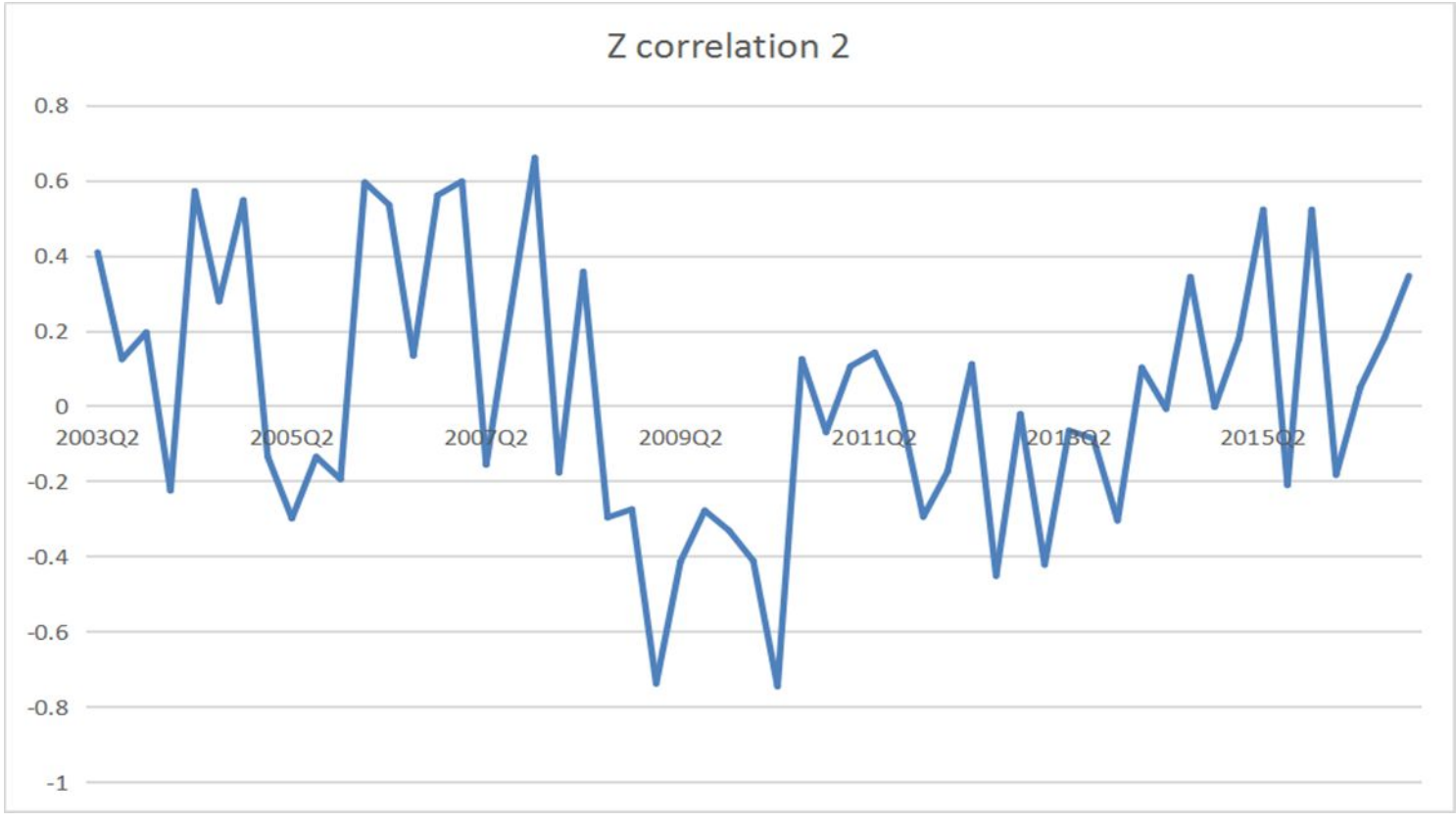

Figure 3. Time varying (Z-Fisher transform) realised correlations of the Hong Kong market.