Emerging China Bond Market

-- Study on Relationship between China and US Government Bond Yields

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Abstract

This paper analyzes possible causal relationships between China and US government bond market (primary market, not include zeros and strips), from year 2002 to 2005 to examine the changes after China's several opening up capital market policies. The investigation is divided into two periods and three different maturity categories (short term, mid term and long term) are examined respectively.

It is inevitably that the cointegration test and the lead lag regression both present a closer integration of China bond market with the US market in the later period. The Granger Causality tests results show there is a unidirectional causality from US to China bond yields. These results indicate successful opening up policies for the Chinese domestic capital market. Though the improvements are limited, they may be considered milestones in the nation's move up to the internationalization of bond market. In addition, overall a higher causality exists in the second period than the first period. However, while short term bond yields have a unidirectional causality in the first period, mid term and long term bonds have a unidirectional causality in the second period. This is probably because longer term bond yields are more affected by other factors like expectations, the RMB's reputation increase etc. It is believed that China capital account has become more open to the international capital market, evidenced by the enhancement in the government bond market.

1. Introduction

In most market economies, government bonds are the foundation for broader domestic debt markets. Therefore, the logical way to start a review of China's emerging domestic debt markets is to look at the market for government bonds.

Compared to more developed market economies, however, China's domestic government bonds market, though rapidly growing, is small relative to the needs of the country's burgeoning institutional investors and managed funds.

1.1 Current Situation of China Bond Market

The pace of financial sector development in China has accelerated as a result of membership in the World Trade Organization (WTO), but capital market reform continues to lag behind developments in the real economy. Within capital markets, debt markets lag behind equity markets.

China's bond markets have become quite large in the past seven years, but they remain highly segmented, dominated by Government bonds (GB[1]) and in other respects underdeveloped. The secondary market for GB is dominated by repurchase contracts (repos); the spot market is relatively small. Because of China's growing fiscal deficits and the requirements of a rapidly growing number of institutional investors in China, both the primary and secondary markets for GB are likely to grow fast in the years ahead and the range of maturities offered is likely to widen. There is also a need to broaden and deepen the market for corporate bonds (CB) and to give

[1] There are two kinds of governme t bonds (or T-bond) in China. One is normal GB. It issues regularity and can be divided into two types, the Voucher Form and the Book-entry GB. The other one is special GB, which includes Specify GB, Special GB, and Specify Project GB.

access to that market to non-state enterprises. Provincial and municipal bonds as yet do not exist - at least not officially - but should be introduced before long to facilitate the financing of local infrastructure. (A detailed history for China government bond market and other related information are attached as ***Appendix I***.)

1.1.1 The QFII and QDII Mechanism

China bond market has quickened its opening up paces a lot since the year 2002. A lot reforms have been done thereafter.

On November 5, 2002 the China Securities Regulatory Commission (CSRC) and the People's Bank of China (PBOC) introduced the QFII (Qualified Foreign Institutional Investor) program as a provision for foreign capital to access China's financial markets. Chinese QFII regulations relax some capital controls and allow foreign institutions to invest in RMB-denominated equity and bond markets. Indeed, QFII is a Chinese brokerage business, which allows qualified foreign institutions to trade Chinese A-shares and treasuries[2] etc. via special accounts opened at designated custodian banks[3], for their clients. To encourage long-term holding and dampen short-term volatility, the regulations require QFII participants to hold their investment for a minimum of 12 months before they can apply for repatriation of capital or capital gains. The QFII mechanism not only further opens China's capital markets – but also gives foreign investors a direct access to the closed China's domestic capital market.

[2] They can invest in Shares listed on China's stock exchanges (excluding B shares); Treasuries listed on China's stock exchanges; Convertible bonds and enterprise bonds listed on China's stock exchanges; Other financial instruments approved by the CSRC.

[3] Currently (till June 2005), there are 27 QFIIs approved by CSRC and SAFE (State Administration of Foreign Exchanges), and 11 banks in China that are qualified for the custodian business.

The QFII mechanism indicates China's tries to integrate itself into the global financial market. While the total inflow of funds under the program is insignificant (estimated to be less than $2 billion till 2005) compared with total FDI (Foreign Direct Investment) inflows, the participants have introduced professional fund management expertise and risk-control technology to China, and provided a new advocate for improving corporate governance, hence, contributing to the development of Chinese capital market.

As we all known, the opening up should be carried out step by step. One year after China opened the door to foreign institutions, the country now seems to be ready to open another door. And QDII is expected to free billions of foreign exchange funds for overseas capital markets. The QDII, a twin scheme to QFII, will allow Chinese citizens to invest in overseas equities markets with designated foreign currencies through qualified institutional investors, such as fund management companies. "The launch of QDII could guide the capital outflow into official channels, which could make it easier for the authorities to better govern the capital outflow and fend off financial risks."[4] Both the systems represent significant initial steps by the Chinese authorities toward capital account liberalization and liberalizing cross-border portfolio investment.

As more foreign capital will rush into the China capital market, there might be less capital inflows to the US financial market, and which might induce the decrease of the redemption yield of US treasury bonds. On another hand, the outflow of forex in

4 Fred Hu. (Spring 2005). Capital Flows, Overheating, and the Nominal Exchange Rate Regime in China. *Cato Journal*, Vol. 25(2), 357-367, Washington. Retrieved Jan 25, 2006, from ProQuest database.

China is still under strict limitation, as the QDII is still pending. There will be limited influence on the US capital market directly.

1.1.2 RMB Bond and Other Policy Initiatives

Although the QFII came into effect in December 1, 2002, the abroad capital began to play actively in the China GB market since 2004, when the MOF set out to absorb the foreign banks to be in the syndication group of the treasury bonds. At the end of 2004, Chinese Government ratified that The International Finance Cooperation, Asia Development Bank and Japan Bank for International Cooperation (JBIC), were entitled to issuing RMB treasury bonds. In May, 2005, through the ratification of the People's Bank of China, Pan-Asia Bond Index Fund，(PAIF) was allowed into inter-bank bonds market, the first foreign institutional investor in this market. All of these measures are significant milestones in the opening up process.

As China's bond market lacks liquidity, many bonds must be held till they are redeemed. Thus, they cannot effectively distribute capital or separate price risks. "Foreign financial institutions' issue of RMB bonds can alleviate the pressure on the central bank by issuing base money, and help improve the structure of China's current bond market and enhance its liquidity." [5] Owing to pressure for the RMB's appreciation, the scale of China's foreign debt, especially the short term foreign debt, has become increasingly large. When foreign currencies enter China, they will be exchanged into RMB, which will increase the money supply. It will deregulate capital outflow, which can ease the pressure of foreign debts and balance the international

[5] Lan Xinzhen. (Jan 27, 2005). Opening up the RMB Bond Market. *Beijing Review,* 32-33.

payments. The cost of raising money in the domestic market will fall and so will the exchange rate risks. However, the domestic banking sector may be hurt.

1.1.3 The Implications of Opening Up and Exchange Rate Reform

Since the opening up, China has played a more and more important role in the World's economy. The macroeconomic factors changes have been paid more attention. However, managing the potential risks of overheating or the capital flows is currently the top priority of the Chinese policy authorities. "It is challenging given China's pegged exchange rate regime, which makes it difficult for the authorities to exercise effective monetary control in the face of substantial external inflows"[6].

Maintaing a pegged currency in the face of a large balance-overpayments surplus has sharply pushed up the official foreign exchange reserves and China's base money accelerated sharply, which induce the People's Bank of China to sterilize its foreign exchange market intervention. On July 21, 2005, the People's Bank of China announced the RMB exchange rate reform scheme and these brought lots of effects to China and World's financial market. In addition, the pressure from the U.S. financial deficits, the inflation and increasing interest rates, induced more issues in the China government bond market.

1.2 Objectives of the Study

Therefore, how effective are these opening up reforms? How close has the China government bond market integrated to the global bond market now? For the global

[6] Fred Hu. (Spring 2005). Capital Flows, Overheating, and the Nominal Exchange Rate Regime in China. *Cato Journal*, Vol. 25(2), 357-367, Washington. Retrieved Jan 25, 2006, from ProQuest database.

market, we pick the typical mature bond market—US Treasury bonds.

This paper is going to investigate the causality of the Chinese government bond market with the US Treasury bond market, in terms of the bond redemption yields, to review these problems to a certain extent. Analysis and discussions will examine the market efficiency caused by the effectiveness of the opening up reforms and the extent of Chinese bond market integrated into the global financial market.

2. Literature Review

2.1 Previous Studies on the Factors Impinging on Yields

The literature on how yields are determined in well run, liquid market is extensive, and should be applicable to the China and US bond market to some degree.

The first of these forces is the combination of risks. Modigliani and Miller have predicted that the default will be positively related to yield. Additional studies by Cohan (1962) and by Ingram et al. (1983) have arrived at similar conclusion. The combination of the risk free rate and the systematic risk (based on volatility of returns) defined in the capital asset pricing model has been discussed by Sharpe and confirmed in the work of Friend, Westerfield and Granito (1978) and Weinstein (1981). These two risk factors are also positively related to yield, although the risk free rate are the same for all government bonds and thus might be omitted.

The second force is the impact of security. Jensen and Meckling, and many other writers on agency theory have commented on the reduction in yield which is associated with the awarding of security rights, and the associated reduction in the agency costs of monitoring the investment.

The third force is inflation. The first view on this was by Fisher to the effect that inflation was positively linked to yields. Additional work by Fama (1975) and y Kane, Rosenthal, and Ljung (1983) confirmed this result.

Fisher was also the first to mention the fifth force, term to maturity, which is the longer, and the higher yield would expect to be. This factor is perhaps most closely related to the liquidation preference theory, which is also the main motivator for the sixth force, which is the frequency of interest payments, negatively related.

Solnik (1974) suggested that country influence and foreign exchange risk are two separable determinants of the prices of equity securities. There does not appear to be any direct evidence that the same tow forces will implying upon bond yields, yet I assume there is negative or positive relationships.

2.2 Previous Studies on the Linkages Between the Global Bond Markets

One of the main spurs to research into financial market linkages was the October 1987 stock market crash. Koutmos and Booth (1995) find evidence to suggest that interdependencies between the world's three major stock markets - London, New York and Tokyo – increased after the 1987 crash. This apparent increase in the linkages between national equity markets could be due to the globalization of finance, and hence to an increase in the presence of ‘international investors’.

Many similar researchers followed to look into the equity market. Finally, some researchers have also considered the relationship between bond and stock markets.

Shiller and Beltratti (1992) and Campbell and Ammer (1993) find that the negative relationship observed between real stock prices and long-term interest rates is much stronger than the relationship implied by the simple rational expectations present value model. Edward S. Lim, John G. Gallo and Peggy E. Swanson (2000) investigate the interrelationships between international bond and international stock markets over the period November 1988 through December 1993. Using co-integration and Granger causality methodology, they finds that (1) bidirectional causality exists between stock market returns and bond market returns; and (2) international markets were more inefficient during the first half of the study period.

It seems reasonable to expect bond markets to be more closely integrated than equity markets, largely because differences between bonds in different countries are small. Nevertheless there are reasons to believe that they might not be fully integrated. Home bias, for example, may influence bond investors, as the information requirements associated with local monetary and fiscal policies, expected inflation, and the behavior of local investors may lead overseas investors to stay home. Besides, the biggest players in the market, the issuers themselves, only rarely issue debt in foreign currency.

However, far fewer researchers have investigated the relationships between international bond markets. Moreover, it appears that they have not provided consistent results. The sizes and signs of correlation coefficients varied depending on the markets chosen, the sample time period chosen, the frequency of observations, etc. Andrew Clare and Ilias Lekkos (2000) decompose the relationship between the government bond markets of Germany, the United Kingdom and the United States. They found that the yield curves for each of these markets are influenced by international factors. Furthermore the impact of these factors increases significantly during times of financial stress. They also found that while the total covariation between these markets is relatively stable, components of the covariance can vary substantially over time.

Delroy M. Hunter (2004) uses a bivariate GARCH framework to examine the lead-lag relations and the conditional correlations between 10-year US government bond returns and their counterparts from the UK, Germany, and Japan. The results indicate that the correlations between the US and other major bond market returns are time varying and are driven by changing macroeconomic and market conditions.

As we know, currently only a few researchers have looked into the emerging China bond market. The purpose of this paper then is to add to the literature on financial market linkages by considering the links between China and U.S government bond markets.

3. Data and Methodology

3.1 Data

The data in this paper will be both the daily and weekly observations of the two government bonds: China government bonds and U.S. Treasury bonds. The following indexes are picked and used in this paper, as the short-term, mid-term and long-term government bond redemption yields respectively, in these two countries, as ***Figure 1*** shown below.

Figure 1. The Government Bond Indexes in US and China Markets

	US Bond Index	**China Bond Index**
Short	LEHMAN US TREASURY 1-3 YR	CHINA GOVT 1-3 YR
Mid	US TREAS.BENCHMARK BOND 7 YR	CHINA GOVT 7 YR
Long	LEHMAN TREASURY 7-20 YR	CHINA GOVT OVER 10 YR

The US part data are collected from the DataStream International and the China part data are from the "China Bond website[7]". They both cover the period from 2002 Jan 1 to 2005 Dec 30, and include 1044 observations. The casual relationships of these two countries bonds' redemption yields (adjusted) will be examined in the three categories (short-term, mid-term and long-term), respectively. This investigation focuses during the two sub samples:

- Year 2002 to 2003
- Year 2004 to 2005

3.2 Methodology

This investigation will examine the time-variance of the redemption yields for bonds with different maturities and their lead-lag causal relationships between US and China market. Some statistical tests are performed on the two sub-samples as well as the full sample. Daily data will be tested for summary statistics and unit roots, while weekly

[7] China Bond Website: http://www.chinabond.com.cn

data will be used in the cointegration and causality tests since daily data may contain too many noises.

3.2.1 Augmented Dickey-Fuller (ADF) Test for Unit Roots

Testing for stationary is essential prior to running any regression as lack of stationary makes traditional inference invalid by giving rise to misleading values of R^2 and t-statistics. In addition, the bilateral causality test we used in the following sections assumes that the variables in the system are stationary. So before estimating the relationship among different markets, a unit root test is performed for the two markets using the augmented Dickey-Fuller (ADF) test, to test for the presence of unit roots and stationary.

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t$$

where ε_t is a pure white noise error term, and where $\Delta Y_{t-1}=(Y_{t-1}-Y_{t-2})$, or $\Delta Y_{t-2}=Y_{t-2}-Y_{t-3}$, etc. We test whether $\delta=0$. If it is zero, we conclude that Yt is nonstationary and has a unit root in it. But if it is negative, we conclude that Yt is stationary and do not have a unit root.

The following hypothesis is set up for testing each bond market's yields.

H_0: $\delta=0$, Yt is nonstationary

H_1: $\delta<0$, Yt is stationary

Statistically insignificant ($\delta=0$) imply acceptance of the null hypothesis, Yt is nonstationary, and if the results indicate that one should reject the null hypothesis, then Yt is said to be stationary.

3.2.2 Engle-Granger (EG) Test for Cointegration

Failure to acknowledge cointegration when it exists can lead to spurious regression results and possible incorrect inferences. If two time series are cointegrated, then some linear combinations between the variables may exist. Some linear combinations may be stationary even though the variables may not be (the individual variables can move away from each other). The linear combination cancels out the stochastic trends in the two series. On the other hand, if variables display a lack of cointegration, then no longer-term and equilibrium link seems to exist and "they can wander arbitrarily far away from each other" according to Dickey, Jansen, and Thornton (1991).

A popular test for cointegration between two variables was developed by Engle and Granger (1987). The first step in the procedure is to determine the order of integration of the variables. A time series is integrated of order d if it achieves stationary after being differenced d times. If the time series does contain a unit root, then first-differencing is necessary for stationary. The variable is then said to be first-order integrated, I(1). A variable stationary in level form is I(0). If the two variables are integrated of different orders, then no cointegration exists. However, if the two variables are integrated of the same order, d, and if the residual from regressing one variable on the other is integrated of an order less than d, then the variables are cointegrated. Thus, cointegration exists if two variables, X and Y, are I(1) and the residuals from the regression of Y on X is I(0).

3.2.3 Granger-Causality Test

Bilateral Granger-Causality Tests are employed in this paper to analyze the possible short-term relationship between the US and China government bonds redemption yields from year 2002 to year 2005, in three categories respectively. A time series, X, is said to Granger-cause another time series, Y, if using past values of X improves the prediction of current values of Y. In other words, if changes in X precede changes in Y, X is said to "Granger cause" changes in Y. This can be tested by running a regression of Y on past values of Y and X. The F-test of the joint significance of the X terms offers insights into the short-run relationship.

However, if the two series are cointegrated, then a linear combination between the two variables exists and it is then necessary to estimate an Error-Correction Model (ECM). This is necessary in part to distinguish short-run from long-run effects. The ECM takes into account the linkage between two cointegrated time series by incorporating the lagged residual from the cointegrating equation into the Granger-causality model as shown in equation.

Let Yt and Xt be the bond yield series for the two markets. First, estimate a restricted equation of order n,

$$Y_t = \delta + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \varepsilon_t$$

where Yt represents the bond yield in market Y at time t. The lag-lengths here are all determined using the Akaike information criterion (AIC).

Next, estimate an unrestricted equation which includes the past data of the Xt series, which is,

$$Y_t = \delta + \sum_{i=1}^{p} \alpha_i X_{t-i} + \sum_{j=1}^{p} \beta_j Y_{t-j} + Ke_{t-1} + \varepsilon_t$$

where Y_t is the dependent variable, X_t is the independent variable and e_{t-1} is the lagged residual from the cointegrating equation. (Note: in the absence of cointegration, the lagged residual is excluded from the equation.) The change in Y (ΔY) and change in X (ΔX) are used instead, if both variables are stationary in first differences.

Then run the restricted regression and unrestricted regression respectively to obtain the restricted residual sum of squares, RSS_R and unrestricted residual sum of squares, RSS_{UR}.

The F-statistic below

$$F = \frac{(RSS_R - RSS_{UR})/p}{RSS_{UR}/(n-k)}$$

Where n is the sample size, k is the number of parameters, estimated in the unrestricted regression.

H_0: $\sum \alpha_i = 0$, X_t doesn't granger cause Y_t

H_1: At least one α_i is not equal to zero, X_t does granger cause Y_t

If the computed F value exceeds the critical F value at the chosen level of significance, we concluded that there is a causality relationship from market X to market Y.

In this paper, considering the following pair of regressions:

$$Y_t = \delta + \sum_{i=1}^{p} \alpha_i X_{t-i} + \sum_{j=1}^{p} \beta_j Y_{t-j} + Ke_{t-1} + \varepsilon_t \quad \text{(I)}$$

$$X_t = c + \sum_{i=1}^{p} \lambda_i Y_{t-i} + \sum_{j=1}^{p} \gamma_j X_{t-j} + Ke_{t-1} + \mu_t \quad \text{(II)}$$

A unidirectional causality from X to Y is indicated if the estimated coefficients on the lagged X in Equation (I) are statistically different from zero, (i.e., $\Sigma\alpha_i \neq 0$) and the set of estimated coefficients on the lagged Y in Equation (II) is not statistically different from zero (i.e., $\Sigma \lambda_i = 0$).

Conversely, a unidirectional causality from Y to X exists if the lagged X coefficients in Equation (I) is not statistically different from zero (i.e., $\Sigma\alpha_i = 0$) and the set of lagged Y coefficients in Equation (II) is statistically different from zero (i.e., $\Sigma\lambda_i \neq 0$). Feedback causality exists when the sets of X and Y coefficients are statistically different from zero in both regressions. ($\Sigma\alpha_i \neq 0$ & $\Sigma\lambda_i \neq 0$) Finally, independence is suggested when the sets of X and Y coefficients are not statistically significant in both regressions. ($\Sigma\alpha_i = 0$ & $\Sigma\lambda_i = 0$)

4. Analysis and Finding

4.1 Summary Statistics

The plots for the two markets are shown in ***Appendix II***. As the graphs illustrate, both the two market yields with three different maturities fluctuate from year 2002 to 2005. For the short term yields plot, there is a longer period (almost two years) that China bonds have a higher yield than US bonds, while there is a relative short time (around year 2004) that China yields curve is above the US curve. The last three plots present the differences between the two market yields (US minus China yields). For both the mid term and long term yields, the China yields and the US yields are pretty close around year 2004, and the current difference is lower than in the year 2002. This initial result implies a closer integration of the two markets. However, the short term yields indicate a larger difference than in the year 2002. This might be caused by the appreciation of the RMB in the later period of year 2005.

The statistics summary of the daily bond yields and yield differences are displayed in ***Appendix III.*** The summary shows both the sub periods and the whole period results of the three different maturities. The means increase from the first period to the second period, except the US long term yield. In addition, the China yields have a larger rise than the US yields. This also indicates that the China government bond market has been integrated more to the US market.

4.2 Augmented Dickey-Fuller (ADF) Test for Unit Roots

Before the causality tests, daily data are tested for stationary by ADF test. The unit root test result is summarized in ***Figure 2*** below. This paper uses "CNS" as short term government bonds in China, "CNM" as mid term, and "CNL" as long term. While similarly, "USS" stands for US short term government bonds, "USM" stands for mid term and "USL" stands for long term. The "D" stands for first difference.

Figure 2. Unit Root Tests for the Bonds Yields

Level	**Level Form**		**First Difference**	
Index	ADF Statistic	H_0: Nonstationary	ADF Statistic	H_0: Nonstationary
CNS	-2.14231	Accept	-13.55569	Reject
USS	-1.529017	Accept	-24.57796	Reject
CNM	-1.04803	Accept	-5.375077	Reject
USM	-2.336134	Accept	-32.18445	Reject
CNL	-1.029864	Accept	-7.551285	Reject
USL	-2.600937	Accept	-23.77802	Reject

Notes: The critical values for t are: -3.13 at 10%, -3.41 at 5 %, and -3.97 at 1% in the level form; and -2.57 at 10%, -2.86 at 5 %, and -3.44 at 1% in first difference form.

After testing the level form of the daily data, I found none of the t-stats is significant to reject the null hypothesis, thus difference-stationary process is used, while the details for the 1st difference data are shown in ***Appendix IV***. As all the t-stats are more negative than the critical value for the first differenced yields, the null hypotheses are all rejected. The first differenced data are stationary.

4.3 Engle-Granger (EG) Test for Cointegration

The t-stats of EG Test for the cointegration between the pairs of two market's bond yields in different maturities are summarized in ***Figure 3*** below. The "N", "D" and "I" stands for not much change, improvement and no improvement respectively.

Figure 3. Engle-Granger Tests for the Bonds Yields

Y	X	Period 1	Period 2	Period 1&2	Improvement
USS	**CNS**	-1.56192	-1.54203	-1.573005	**N**
CNS	**USS**	-1.89343	-1.64834	-2.076535	**D**
USM	**CNM**	-1.56289	-3.03828	-2.648156	**I**
CNM	**USM**	-2.28235	-1.7874	-0.962279	**D**
USL	**CNL**	-2.03301	-2.96001	-2.927437	**I**
CNL	**USL**	-2.20838	-2.32959	-1.119027	**I**

Notes: The critical values are: -3.15 at 10%, -3.45 at 5 %, and -4.05 at 1%.

As the above summary illustrates, none of the t statistics (test for the residuals) is significant enough. The residual from regressing one variable on the other is not stationary in the level form, and the two variables (pairs of bonds yields for the two markets) are not cointegrated. These results imply that models for testing linkage or causality in the return series do not require the inclusion of an error correction term.

However, if the two time periods are tested respectively and compared, I found the t statistics for long term government bonds of the two markets are improved. And the same situation happens in regression of US mid term yields on China mid term yields. For the rest, there isn't too much change.

4.4 Granger-Causality Test

First, before the granger test, summary of the lead lag regressions covering both the sub samples and full sample are presented in ***Figure 4*** below, respectively. Regressions of the first differenced China bond yields are run on lag, contemporaneous, and lead US bond yields.

$$CN_t = \delta + \sum_{k=-5}^{5} \beta_k US_{t+k} + \varepsilon_t$$

The three different maturities are shown respectively.

Figure 4. Summary for the Lead lag Regression (Continued to the next page)

Short Term	**DCNS1 Period 1**		**DCNS2 Period 2**		**DCNS Period 1&2**	
Variables	Coefficient	T Values	Coefficient	T Values	Coefficient	T Values
DUSS(5)	-0.357666	-1.0047	-0.0615	-0.491954	-0.464851	**-2.251665***
DUSS(4)	0.33994	0.927956	0.310147	**2.404947***	0.436763	1.995134
DUSS(3)	0.00796	0.021857	-0.193907	-1.506959	-0.025745	-0.117835
DUSS(2)	-0.122893	-0.33764	0.127246	0.996992	-0.141124	-0.645607
DUSS(1)	0.018154	0.050178	0.139306	1.096176	0.074388	0.342952
DUSS	0.254039	0.70027	-0.180514	-1.425313	0.210622	0.979197
DUSS(-1)	-0.717012	-1.96994	0.165106	1.294982	-0.455244	-2.101761*
DUSS(-2)	0.161402	0.438432	0.094647	0.742868	0.056995	0.260989
DUSS(-3)	0.456638	1.255627	0.058621	0.460991	0.29573	1.363773
DUSS(-4)	0.085232	0.235992	-0.069554	-0.56831	0.007379	0.034442
DUSS(-5)	-0.211165	-0.62076	-0.037232	-0.329488	-0.040817	-0.204889
C	-0.001604	-0.04516	-0.009567	-0.925596	-0.001752	-0.098057
R-squared	0.124656		0.113333		0.08956	
F-statistic	1.061589		0.952837		1.663344	

Mid Term	DCNM1 Period 1		DCNM2 Period 2		DCNM Period 1&2	
DUSM(5)	0.016997	0.399115	-0.0615	-0.491954	-0.043486	-0.837369
DUSM(4)	0.029481	0.663115	0.310147	1.404947	0.107229	1.951255
DUSM(3)	-0.061023	-1.37973	-0.193907	-1.506959	-0.086182	-1.555968
DUSM(2)	-0.005354	-0.11951	0.127246	0.996992	0.052186	0.936362
DUSM(1)	-0.005179	-0.11688	0.139306	1.096176	0.002254	0.041045
DUSM	0.016223	0.368772	-0.180514	-1.425313	-0.041445	-0.756266
DUSM(-1)	-0.009965	-0.22519	0.165106	**2.294982***	0.076866	1.405773
DUSM(-2)	-0.052982	-1.17117	0.094647	0.742868	-0.017494	-0.315819
DUSM(-3)	-0.025798	-0.57672	0.058621	0.460991	-0.012971	-0.23659
DUSM(-4)	0.064402	1.42212	-0.069554	-0.56831	-0.003068	-0.056705
DUSM(-5)	-0.107807	**-2.524847***	-0.037232	-0.329488	-0.078637	-1.548581
C	0.001988	0.373562	-0.009567	-0.925596	-0.000183	-0.033358
R-squared	0.136693		0.144683		0.056805	
F-statistic	1.180328		1.260991		1.018365	
Long Term	**DCNL1 Period 1**		**DCNL2 Period 2**		**DCNL Period 1&2**	
DUSL(5)	0.061609	0.528187	0.174643	0.906263	0.108611	1.091249
DUSL(4)	-0.212008	-1.74371	-0.160999	-0.811148	-0.176467	-1.682035
DUSL(3)	0.06775	0.559182	0.195663	0.981324	0.122882	1.161331
DUSL(2)	0.112173	0.908861	0.147872	0.743478	0.124759	1.166592
DUSL(1)	-0.115945	-0.9512	-0.119549	-0.603159	-0.1363	-1.288892
DUSL	0.007456	0.061367	0.077005	0.3903	0.039986	0.378345
DUSL(-1)	0.077624	0.637722	-0.100997	-0.509774	-0.007817	-0.074161
DUSL(-2)	-0.148819	-1.20087	0.433951	**2.192955***	0.069768	0.656055
DUSL(-3)	0.079885	0.655597	-0.049832	-0.252592	0.038751	0.369677
DUSL(-4)	0.021117	0.172385	0.055372	0.291293	0.026334	0.254883
DUSL(-5)	-0.059552	-0.51684	0.108702	0.61144	0.020356	0.209566
C	0.002388	0.191627	-0.005942	-0.4004	0.001234	0.132613
R-squared	0.106919		0.103641		0.04858	
F-statistic	0.89245		0.861931		0.863389	
Observations	94		94		198	

Note: DCNS is the first difference of short term yields in China, and DUSS is the first difference of short term yields in the US. The rest are similar. Numbers in right side of coefficients are t values. The "*" indicates statistical significance at 5% level.

The lead-lag regression shows the coefficients and t values over time. Some of the t values are significant at 5% level, as bolded in the table, though none of the F values is significant. In addition, more values are significant while regressing China market yields over US market yields, which implies that the US market are more likely to cause the China market in government bonds yields, especially for the mid term and long term bonds. For the whole testing period, the short term yields show more significant t values, while in mid term and long term yields have a better relationship in period 2. After comparing with the two sub testing periods, more significant t values appear in the later period, which suggests an improvement between the linkages of the two markets. However, one interesting thing is that lead relationship happens for the short term yields in the second period and the whole time period testing, which possibly implies China leads the US market in short term government bond yields in later time period.

After the regression, the main results of the bilateral Granger Causality Test for both the sub samples and whole period are presented in ***Figure 5*** below, while the detailed test results are shown in ***Appendix V***.

Figure 5. Bilateral Granger Causality Test

Y	X	Period 1			Period 2			Period 1 & 2			Improvement
USS	**CNS**	0.01660	N		0.31973	N		0.05708	N		I
CNS	**USS**	**6.21792**	**Y**	*	0.14572	N		**5.42137**	**Y**	*	D
USM	**CNM**	0.18029	N		1.04724	N		0.55752	N		I
CNM	**USM**	1.48760	N		**3.10448**	**Y**	*	0.46377	N		I
USL	**CNL**	1.93459	N		0.84891	N		1.12238	N		D
CNL	**USL**	0.56639	N		**3.02054**	**Y**	*	0.22337	N		I

Note: The "Y" and "N" next to the F values stand for the existence of Granger Causality, and no existence, respectively. The significant level is 5%.

All the significant values appear in the regression of China yields over US yields. On the other hand, none of the F statistics are significant in the opposite direction. These results account for a unidirectional granger causality in the US and China government bond redemption yields. US bond yields Granger Cause China bond yields, which are in accordance with the previous tests results.

Comparisons between the two time periods are also conducted in both the cointegration test and the Granger Causality Test:

Both the cointegration test and Granger Causality Test indicate not too much improvement for the causality from China to US in terms of short term yields, though the Granger Causality Test here shows a little increase in the absolute F value. On the other direction, both the two tests show no improvement;

For the mid term bond yields, the Granger Causality Test shows a improvement in the feed back causality, while the cointegration test shows no improvement for the causality from US to China market;

For the long term bond yields, the cointegration test suggests an improvement in both the two directions. However, Granger Causality Test implies a little decrease in the absolute F value, which means weaker causality from China market to US market.

Overall, the second period shows a higher causality than the first period. However, short term bond yields have a unidirectional causality (from US to China) in the first period, while mid term and long term bonds have a unidirectional causality in the second period. Moreover, the causality from US to China bond yields is much stronger than the other direction.

The improvement from the first period to the second period accounts for a better integration of the China financial market, especially the government bond market with the global market. The unidirectional causality suggests that the US market have a larger influence on China market, as China bond market, or financial market is mostly regarded as an emerging market. It has limited influence on the center of the global economy and global financial market.

The later period indicates a higher long efficient relationship with the US government bond yields, especially for the mid and long term, as they are influenced more by macroeconomic factors like expectation (e.g. the expectation of the future by investors). In addition, the outflow induced by RMB bonds issued by foreign institutions alleviates the pressure of short term foreign debts, especially those US treasury bonds. The diversification of the foreign debts caused by the RMB exchange rate scheme reform also might be the reason for the ease of the causality of short term government bond yields.

5. Limitations

There are several main limitations in this paper.

1. The data covers the time period from Jan 1, 2002 to Dec 30, 2005, which is divided equally into two periods, each is two year. It may not be sufficient enough to observe the real situation. And there may be already some effects due to the QFII mechanism

announced in the first period. Thus the two periods may not be that much significant for comparison. However, the available data is limited to these four years, as China has only opened the capital market for a few years. In order to have a comparative time length for comparison, such time period was chosen for this paper.

2. When using the Akaike information criterion (AIC) to find out a suitable lag length for the Granger causality tests, a maximum 10 lagged terms was used for the trial and error in each case. Though the causality relationship might be reflected in more than 10 days, it was reasonable to do so as in most of the cases, information could be transferred and reflected within 10 lagged terms.

3. According to Granger representation theorem, if two variables, say X and Y, are cointegrated of order 1, then either X must Granger-cause Y, or Y must Granger-cause X. In our case, the US and China government bond yields are individually I(1), but there is weak evidence that they are cointegrated. Thus the causality test may become moot.

4. Since this paper only checks pairs of variables of US and China government bond yields, bilateral causality is test instead of vector autoregression (VAR). In addition, this paper assumes that the error terms entering the causality test are uncorrelated. The Runs Test or other test may be carried out first.

5. As the China market is considered as an emerging market, and much factors rather than the market factor affects the bond yields, more complex model or tests might be considered (e.g. Non random walk, potential value etc.).

6. Conclusion and Recommendation

This paper analyzes possible causal relationships between China and US government bond market, from year 2002 to 2005 to examine the change brought by the several opening up capital market policies. Lead-lag relationships between the two market's redemption yields of bond indexes in three maturity categories (short term, mid term and long term) are investigated.

Granger Causality tests results show a higher causality in the second period than the first period. There is a unidirectional causality from US to China bond yields. This indicates successful opening up policies for the Chinese domestic capital market have facilitated the internationalization of China's bond market. Though the improvement is limited, they may be considered milestones in the nation's move up.

However, while short term bond yields have a unidirectional causality in the first period, mid term and long term bonds have a unidirectional causality in the second period. This is probably because longer term bond yields are more affected by macroeconomic factors like expectations of the future by investors. China's credit standing and influence in the international capital market have been raised as the confidence in China's economic development has been enhanced. On the other hand, the RMB's reputation increases, the pressure of short term foreign debts eases, and the central banks base money will decrease as the public hold dollars instead of the central bank. These might be the reason for the alleviation of causality for short term yields in the second period.

In general, China's gaining benefits from the capital account liberalization. The capital account has become more open to the international capital market, evidenced by the enhancement in the government bond market. However, downside risks associated with unrestricted cross border capital flows. “China is still well advised not to lift capital controls prematurely before putting in place the necessary institutional framework and a sound financial infrastructure. Although currently the opening up process for the capital market has been driven by significant trade reforms unleashed, to a large extent, by China’s membership in the WTO”[8], in the long run, both the deregulation of capital inflows and outflows will be further carefully looked into.

[8] Fred Hu. (Spring 2005). Capital Flows, Overheating, and the Nominal Exchange Rate Regime in China. *Cato Journal,* Vol. 25(2), 357-367, Washington. Retrieved Jan 25, 2006, from ProQuest database.

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Appendix I

The Development of China's Government Bond Market

1949-1981: Sporadic domestic borrowing and small amounts involved.

The 1980s: Issues were small and in essence a form of taxation (part of the national credit plan). State banks were not allowed to trade, but individuals and non-bank agencies spontaneously began to trade government paper in unofficial curb markets. Largely unregulated secondary bond markets started in China in the 1980s.

Late 1980s: Maturities were reduced and coupon rates increased to make bonds competitive with bank deposits. The secondary bond market developed faster after the opening of stock exchanges (which could list bonds) in Shanghai and Shenzhen.

1994: The Government started financing all budget deficits through borrowing in capital markets. Domestic GB issues jumped from RMB 31.5 billion yuan in 1993 to RMB 102.9 billion yuan in 1994 and rose steeply every year thereafter.

August 1997: the GB market was split between the inter-bank and the stock market. Central bank decided to ban commercial banks trading on the stock exchanges and lending to securities firms (usually on the basis of repos) in an effort to curb speculative stock trading. Short selling[9] was officially prohibited in June 1997.

February 2002: A fourth market[10] for GB was created when the People's Bank of China allowed the trading of certificate bonds (also called savings bonds or savings certificates, and issued from that time onward) held by individuals and institutions.

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[9] Short selling by securities firms has been a recurrent problem in China. In February 1995, the futures market for GB essentially collapsed because of the "Incident No. 327" The incident happens as Shanghai Wanguo, a leading securities firm, sold short RMB 211 billion yuan of GB without collateral.

[10] The other three markets are stock market (for bond trading), the inter-bank market and the OTC market.

Other Information of China Government Bond Market

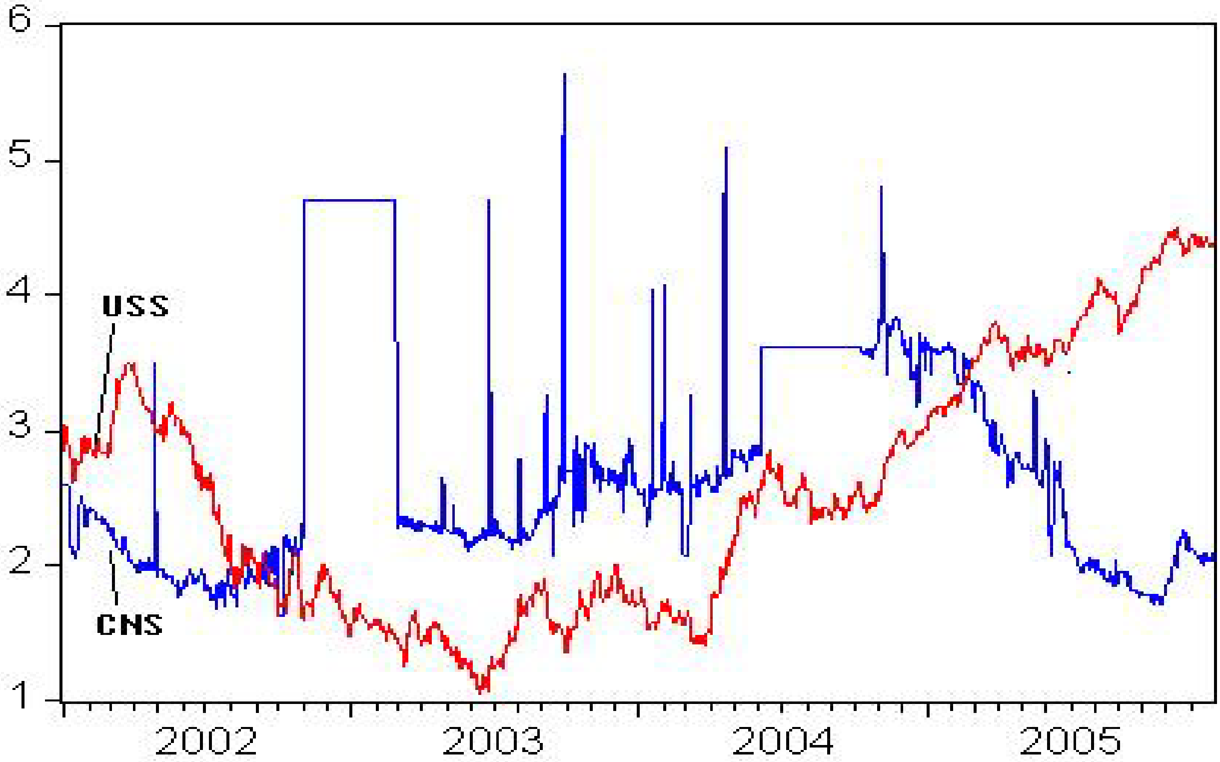
There are three kinds of GB: (a) book-entry bonds (usually held by financial institutions and traded in the inter-bank market as well as the stock market), (b) certificate bonds (usually held by individual investors and, since February 2002, tradable in the stock market), and (c) bearer bonds (usually held by individual investors and enterprises, and tradable in the OTC market).

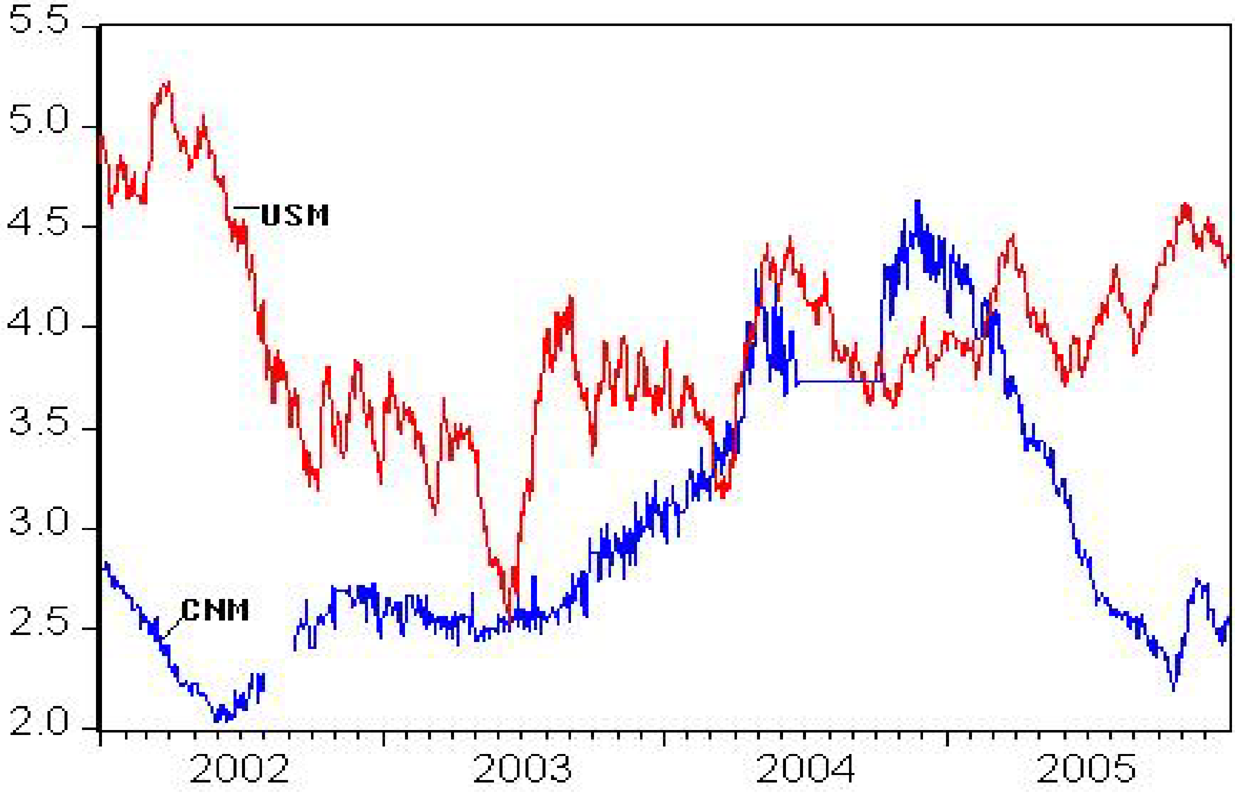
Clearing and settlement processes for stock exchange trading remain relatively inefficient, which reduces liquidity. As market participation by institutional investors for whom liquidity is especially important is rapidly growing, a further streamlining of relevant procedures is desirable.

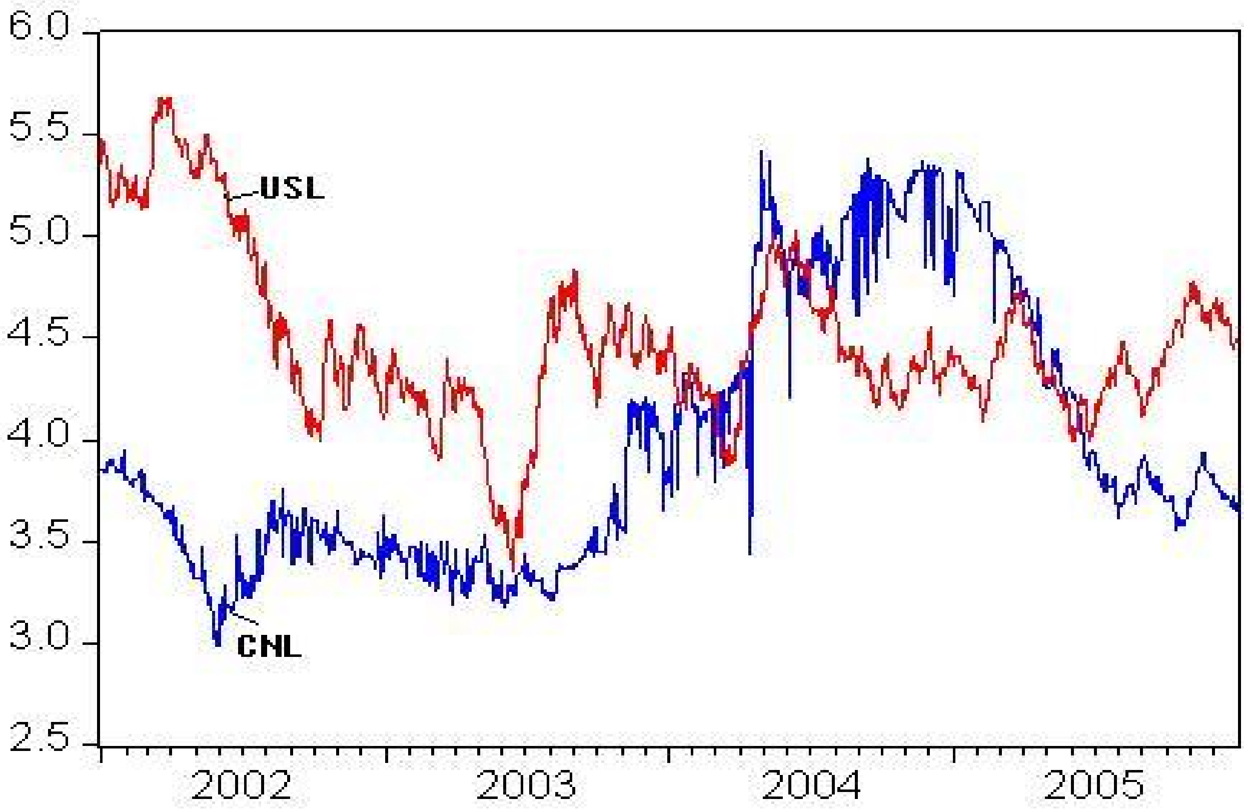
China's legal and regulatory frameworks for government debt issues and secondary market trading are very limited. There is as yet no government debt law. The Treasuries Regulation issued by the State Council in 1992 governs new GB issues. Secondary market trading is regulated by the People's Bank of China for the inter-bank market and by the China Securities Regulatory Commission (CSRC) for the two stock exchanges. Regulation and supervision of the GB market is at present divided between three agencies: the Ministry of Finance (MOF) for new issues, the People's Bank of China for trading in the inter-bank market, and the CSRC for trading in the stock markets. A harmonization of policies and standards would contribute to market integration and transparency.

Appendix II

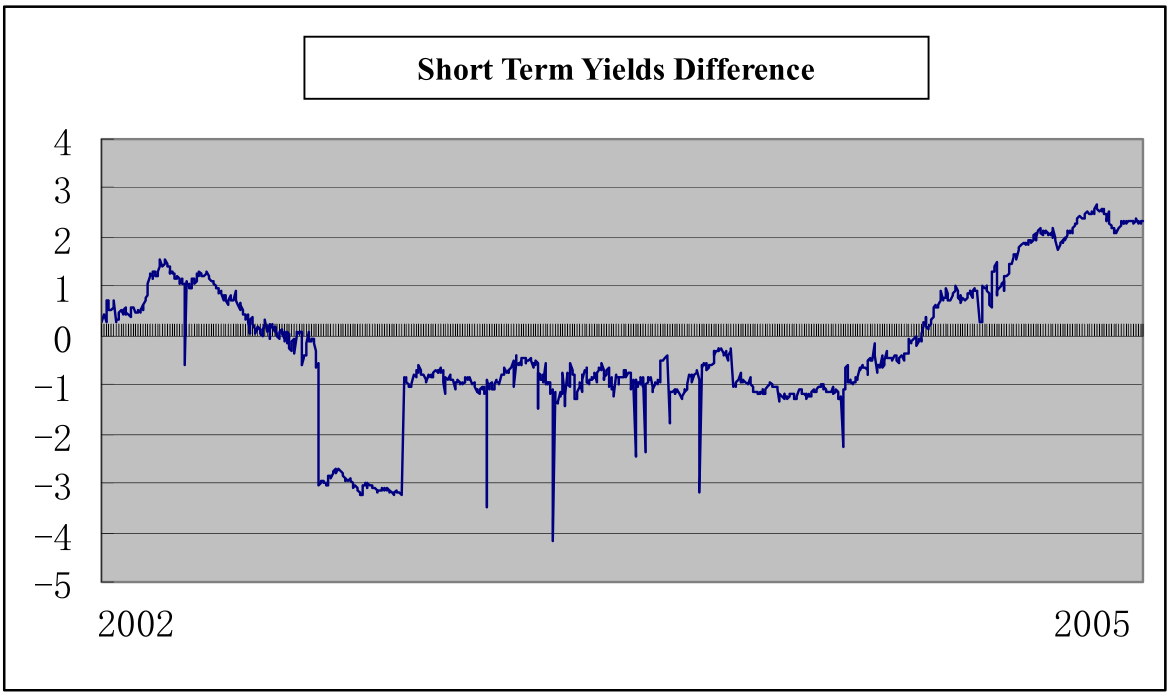
Plots of Government Bonds Redemption Yield of China and US Markets

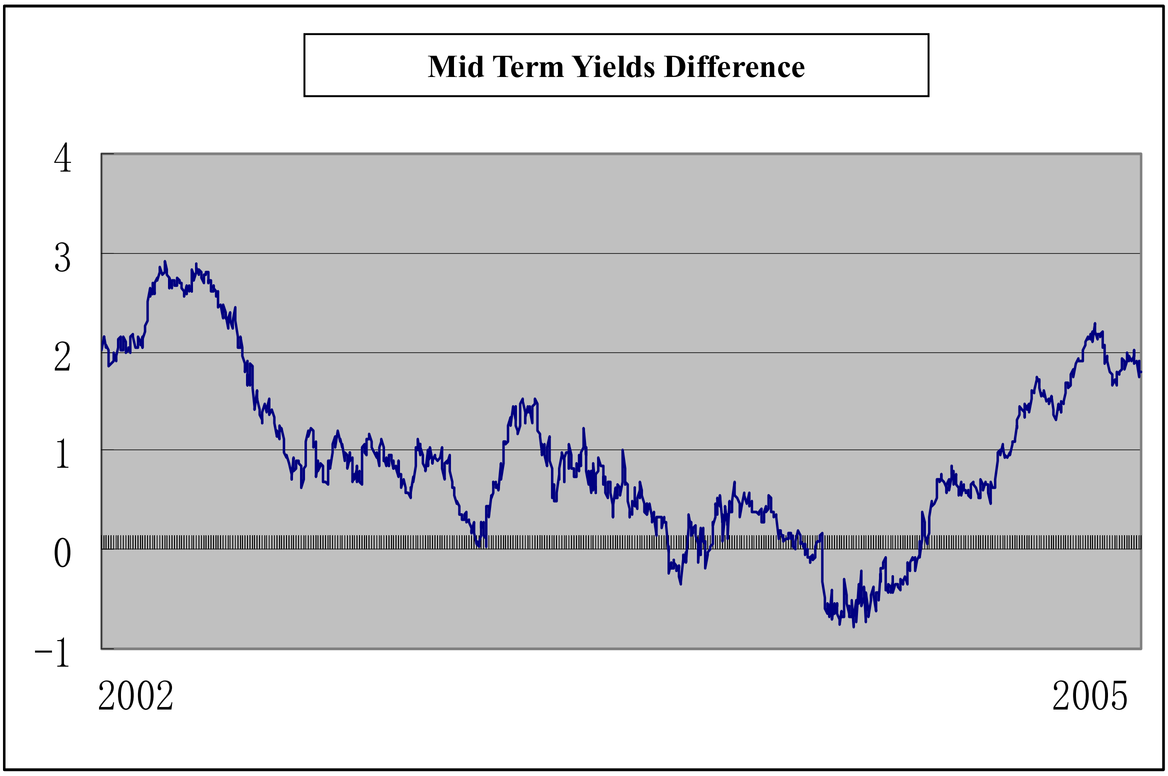


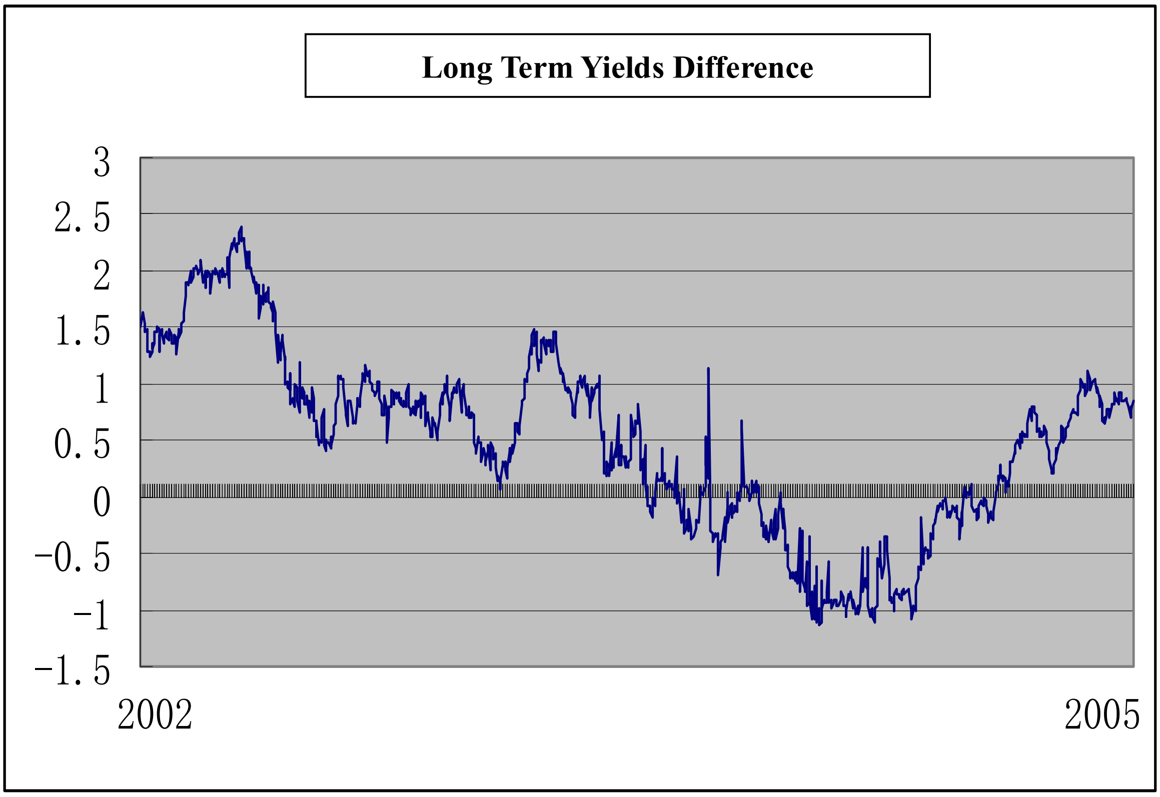




Plots of Differences of Redemption Yields (US minus China)







Notes: CNS stands for the short term government bonds in China, and USS stands for the short term government bonds in China, CNM stands for mid term government bonds, and CNL stands for long term etc. All cover from Jan 1, 2002 to Dec 30, 2005.

Appendix III

Summary Statistics for Bond Yields and Yield Differences of the Two Markets

Period	Period 1		Period 2		Period 1 & 2		
Short Term	**USS**	**CNS**	**USS**	**CNS**	**USS**	**CNS**	**Difference**
Mean	2.014808	2.637299	3.054234	2.857318	2.534521	2.747308	-0.212787
Standard Error	0.028149	0.042125	0.038556	0.030130	0.028777	0.026107	0.043151
Median	1.78	2.27	3.03	2.78	2.45	2.53	-0.53
Standard Deviation	0.643120	0.962448	0.880890	0.688396	0.929825	0.843528	1.394252
Kurtosis	-0.605729	0.771673	-1.058474	-1.188790	-1.007575	0.094153	-0.169085
Skewness	0.817727	1.517895	-0.155505	-0.012778	0.420706	0.996106	-0.007026
Minimum	1.05	1.64	1.41	1.71	1.05	1.64	-4.17
Maximum	3.57	5.65	4.5	5.1	4.5	5.65	2.66
Count	522	522	522	522	1044	1044	1044
Mid Term	**USM**	**CNM**	**USM**	**CNM**	**USM**	**CNM**	**Difference**
Mean	3.871765	2.549981	3.992632	3.434272	3.932199	2.992126	0.940072
Standard Error	0.027951	0.010473	0.013322	0.028162	0.015587	0.020320	0.026666
Median	3.6965	2.56	3.97005	3.525	3.8753	2.69	0.8329
Standard Deviation	0.638597	0.239286	0.304381	0.643419	0.503629	0.656565	0.861593
Kurtosis	-0.662384	0.066979	-0.101007	-1.114116	0.057629	-0.663029	-0.467900
Skewness	0.454073	0.052515	-0.261351	-0.198006	0.208893	0.745081	0.371470
Minimum	2.5242	2.03	3.1445	2.19	2.5242	2.03	-0.7773
Maximum	5.2231	3.24	4.6293	4.64	5.2231	4.64	2.9031
Count	522	522	522	522	1044	1044	1044
Long Term	**USL**	**CNL**	**USL**	**CNL**	**USL**	**CNL**	**Difference**
Mean	4.564943	3.497874	4.407739	4.494100	4.486341	3.995987	0.490354
Standard Error	0.023296	0.010447	0.010190	0.025409	0.012938	0.020649	0.025042
Median	4.45	3.45	4.37	4.535	4.4	3.765	0.565
Standard Deviation	0.532243	0.238693	0.232824	0.580532	0.418052	0.667204	0.809140
Kurtosis	-0.609287	0.849171	-0.161718	-1.496388	0.686189	-0.874642	-0.533542
Skewness	0.299503	0.989217	0.361699	-0.063434	0.709320	0.706902	-0.002071
Minimum	3.35	2.98	3.87	3.43	3.35	2.98	-1.13
Maximum	5.68	4.21	5.03	5.42	5.68	5.42	2.38
Count	522	522	522	522	1044	1044	1044

Notes: The Difference summary is for the redemption yield differences (US minus China) in the whole period.

Appendix IV

1. Unit Root Test for Short Term Yields in China Market (1^{st} Difference)

Null Hypothesis: D(CNS) has a unit root
Exogenous: Constant
Lag Length: 8 (Automatic based on AIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.55569	0.0000
Test critical values:	1% level	-3.436456	
	5% level	-2.864124	
	10% level	-2.568198	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CNS,2)
Method: Least Squares
Date: 04/03/06 Time: 11:18
Sample (adjusted): 1/15/2002 12/30/2005
Included observations: 1034 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CNS(-1))	-2.272666	0.167654	-13.55569	0.0000
D(CNS(-1),2)	0.773909	0.158192	4.892217	0.0000
D(CNS(-2),2)	0.518136	0.145145	3.569770	0.0004
D(CNS(-3),2)	0.390385	0.130506	2.991319	0.0028
D(CNS(-4),2)	0.299004	0.114592	2.609301	0.0092
D(CNS(-5),2)	0.229306	0.097234	2.358296	0.0185
D(CNS(-6),2)	0.170723	0.077988	2.189095	0.0288
D(CNS(-7),2)	0.113718	0.055958	2.032212	0.0424
D(CNS(-8),2)	0.086530	0.031070	2.784974	0.0055
C	-0.000234	0.007901	-0.029557	0.9764

R-squared	0.716923	Mean dependent var	3.87E-05
Adjusted R-squared	0.714435	S.D. dependent var	0.475405
S.E. of regression	0.254048	Akaike info criterion	0.107040
Sum squared resid	66.08954	Schwarz criterion	0.154827
Log likelihood	-45.33963	F-statistic	288.1548
Durbin-Watson stat	1.995568	Prob(F-statistic)	0.000000

2. Unit Root Test for Short Term Yields in US Market (1st Difference)

Null Hypothesis: D(USS) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on AIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-24.57796	0.0000
Test critical values:	1% level	-3.436413	
	5% level	-2.864106	
	10% level	-2.568188	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(USS,2)
Method: Least Squares
Date: 04/03/06 Time: 11:17
Sample (adjusted): 1/04/2002 12/30/2005
Included observations: 1041 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(USS(-1))	-1.089789	0.044340	-24.57796	0.0000
D(USS(-1),2)	0.060331	0.030813	1.957999	0.0505
C	0.001471	0.001750	0.840576	0.4008

R-squared	0.515714	Mean dependent var	5.76E-05
Adjusted R-squared	0.514781	S.D. dependent var	0.081001
S.E. of regression	0.056423	Akaike info criterion	-2.908989
Sum squared resid	3.304574	Schwarz criterion	-2.894730
Log likelihood	1517.129	F-statistic	552.6802
Durbin-Watson stat	2.000807	Prob(F-statistic)	0.000000

3. Unit Root Test for Mid Term Yields in China Market (1st Difference)

Null Hypothesis: D(CNM) has a unit root
Exogenous: Constant
Lag Length: 18 (Automatic based on AIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.375077	0.0000
Test critical values:	1% level	-3.436517	
	5% level	-2.864151	
	10% level	-2.568212	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CNM,2)
Method: Least Squares
Date: 04/03/06 Time: 11:18
Sample (adjusted): 1/29/2002 12/30/2005
Included observations: 1024 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CNM(-1))	-1.231603	0.229132	-5.375077	0.0000
D(CNM(-1),2)	-0.253375	0.225487	-1.123682	0.2614
D(CNM(-2),2)	-0.483076	0.221293	-2.182975	0.0293
D(CNM(-3),2)	-0.547940	0.216842	-2.526907	0.0117
D(CNM(-4),2)	-0.655988	0.211646	-3.099455	0.0020
D(CNM(-5),2)	-0.676188	0.205577	-3.289217	0.0010
D(CNM(-6),2)	-0.752439	0.198605	-3.788625	0.0002
D(CNM(-7),2)	-0.808671	0.191262	-4.228081	0.0000
D(CNM(-8),2)	-0.858371	0.183261	-4.683877	0.0000
D(CNM(-9),2)	-0.859597	0.174114	-4.936982	0.0000
D(CNM(-10),2)	-0.776631	0.163406	-4.752771	0.0000
D(CNM(-11),2)	-0.689222	0.151518	-4.548763	0.0000
D(CNM(-12),2)	-0.634380	0.138821	-4.569770	0.0000
D(CNM(-13),2)	-0.591493	0.125400	-4.716845	0.0000
D(CNM(-14),2)	-0.507477	0.111428	-4.554316	0.0000
D(CNM(-15),2)	-0.377636	0.095375	-3.959482	0.0001
D(CNM(-16),2)	-0.256982	0.077848	-3.301068	0.0010
D(CNM(-17),2)	-0.172433	0.056414	-3.056591	0.0023
D(CNM(-18),2)	-0.082528	0.031637	-2.608576	0.0092
C	-0.000189	0.002200	-0.085708	0.9317

R-squared	0.718691	Mean dependent var	9.77E-06
Adjusted R-squared	0.713368	S.D. dependent var	0.131466
S.E. of regression	0.070384	Akaike info criterion	-2.450361
Sum squared resid	4.973735	Schwarz criterion	-2.354043
Log likelihood	1274.585	F-statistic	135.0017
Durbin-Watson stat	1.992135	Prob(F-statistic)	0.000000

4. Unit Root Test for Mid Term Yields in US Market (1st Difference)

Null Hypothesis: D(USM) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on AIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-32.18445	0.0000
Test critical values:	1% level	-3.436407	
	5% level	-2.864103	
	10% level	-2.568186	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(USM,2)
Method: Least Squares
Date: 04/03/06 Time: 11:18
Sample (adjusted): 1/03/2002 12/30/2005
Included observations: 1042 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(USM(-1))	-0.995833	0.030941	-32.18445	0.0000
C	-0.000572	0.001995	-0.286550	0.7745

R-squared	0.498998	Mean dependent var	-0.000109
Adjusted R-squared	0.498516	S.D. dependent var	0.090937
S.E. of regression	0.064398	Akaike info criterion	-2.645563
Sum squared resid	4.312932	Schwarz criterion	-2.636065
Log likelihood	1380.339	F-statistic	1035.839
Durbin-Watson stat	1.997392	Prob(F-statistic)	0.000000

5. Unit Root Test for Long Term Yields in China Market (1st Difference)

Null Hypothesis: D(CNL) has a unit root
Exogenous: Constant
Lag Length: 19 (Automatic based on AIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.551285	0.0000
Test critical values:	1% level	-3.436523	
	5% level	-2.864154	
	10% level	-2.568214	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CNL,2)
Method: Least Squares
Date: 04/03/06 Time: 11:19
Sample (adjusted): 1/30/2002 12/30/2005
Included observations: 1023 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CNL(-1))	-2.131849	0.282316	-7.551285	0.0000
D(CNL(-1),2)	0.687682	0.275707	2.494250	0.0128
D(CNL(-2),2)	0.409004	0.267676	1.527980	0.1268
D(CNL(-3),2)	0.349430	0.258984	1.349232	0.1776
D(CNL(-4),2)	0.218811	0.249945	0.875438	0.3815
D(CNL(-5),2)	0.134415	0.239884	0.560332	0.5754
D(CNL(-6),2)	0.074260	0.229471	0.323616	0.7463
D(CNL(-7),2)	0.054751	0.218421	0.250666	0.8021
D(CNL(-8),2)	0.128268	0.206991	0.619677	0.5356
D(CNL(-9),2)	0.079279	0.195323	0.405888	0.6849
D(CNL(-10),2)	-0.012410	0.183187	-0.067744	0.9460
D(CNL(-11),2)	-0.038475	0.171297	-0.224612	0.8223
D(CNL(-12),2)	-0.073949	0.159156	-0.464628	0.6423
D(CNL(-13),2)	-0.094056	0.145003	-0.648651	0.5167
D(CNL(-14),2)	-0.083369	0.129639	-0.643088	0.5203
D(CNL(-15),2)	-0.099930	0.113274	-0.882202	0.3779
D(CNL(-16),2)	-0.042738	0.095856	-0.445854	0.6558
D(CNL(-17),2)	-0.047514	0.077595	-0.612334	0.5405
D(CNL(-18),2)	-0.069063	0.055339	-1.248018	0.2123
D(CNL(-19),2)	-0.098541	0.031430	-3.135222	0.0018
C	-0.000486	0.003275	-0.148471	0.8820

R-squared	0.716326	Mean dependent var	-0.000137
Adjusted R-squared	0.710664	S.D. dependent var	0.194697
S.E. of regression	0.104728	Akaike info criterion	-1.654594
Sum squared resid	10.98981	Schwarz criterion	-1.553381
Log likelihood	867.3247	F-statistic	126.5112
Durbin-Watson stat	1.999086	Prob(F-statistic)	0.000000

6. Unit Root Test for Long Term Yields in US Market (1st Difference)

Null Hypothesis: D(USL) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on AIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-23.77802	0.0000
Test critical values:	1% level	-3.436413	
	5% level	-2.864106	
	10% level	-2.568188	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(USL,2)
Method: Least Squares
Date: 04/03/06 Time: 11:19
Sample (adjusted): 1/04/2002 12/30/2005
Included observations: 1041 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(USL(-1))	-1.039310	0.043709	-23.77802	0.0000
D(USL(-1),2)	0.044899	0.030936	1.451338	0.1470
C	-0.000946	0.001781	-0.530814	0.5957

R-squared	0.498393	Mean dependent var	5.76E-05
Adjusted R-squared	0.497426	S.D. dependent var	0.081051
S.E. of regression	0.057459	Akaike info criterion	-2.872617
Sum squared resid	3.426978	Schwarz criterion	-2.858358
Log likelihood	1498.197	F-statistic	515.6742
Durbin-Watson stat	1.999009	Prob(F-statistic)	0.000000

Appendix V

Bilateral Granger-Causality Test

1. Short Term for Period 1&2

VAR Lag Order Selection Criteria
Endogenous variables: DUSS DCNS
Exogenous variables: C
Date: 04/06/06 Time: 21:10
Sample: 1/01/2002 12/27/2005
Included observations: 198

Lag	LogL	LR	FPE	AIC	SC	HQ
0	184.3243	NA	0.000544	-1.841660	-1.808445	-1.828216
1	197.8704	26.68155*	0.000494*	**-1.938084***	-1.838440*	-1.897752*
2	199.8516	3.862384	0.000504	-1.917693	-1.751619	-1.850471
3	201.3379	2.867467	0.000517	-1.892302	-1.659798	-1.798192
4	203.3477	3.836935	0.000527	-1.872199	-1.573265	-1.751201
5	207.4405	7.730853	0.000527	-1.873136	-1.507773	-1.725249
6	208.1739	1.370466	0.000545	-1.840140	-1.408347	-1.665365
7	210.3186	3.964464	0.000555	-1.821400	-1.323178	-1.619736
8	210.8575	0.985368	0.000575	-1.786440	-1.221788	-1.557887
9	212.6814	3.297741	0.000588	-1.764459	-1.133377	-1.509018
10	215.0330	4.204303	0.000598	-1.747808	-1.050297	-1.465479

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Pairwise Granger Causality Tests
Date: 04/06/06 Time: 21:10
Sample: 1/01/2002 1/02/2006
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Probability
DCNS does not Granger Cause DUSS	207	0.05708	0.81141
DUSS does not Granger Cause DCNS		5.42137	0.02087

2. Mid Term for Period 1&2

VAR Lag Order Selection Criteria
Endogenous variables: DUSM DCNM
Exogenous variables: C
Date: 04/06/06 Time: 21:11
Sample: 1/01/2002 12/27/2005
Included observations: 198

Lag	LogL	LR	FPE	AIC	SC	HQ
0	372.8791	NA	8.09e-05	-3.746254	-3.713039	-3.732809
1	384.5089	22.90724	7.49e-05	-3.823323	-3.723678*	-3.782990*
2	388.4032	7.591848	7.50e-05	-3.822255	-3.656181	-3.755033
3	395.7092	14.09535*	7.25e-05*	**-3.855648***	-3.623145	-3.761539
4	398.3358	5.014499	7.36e-05	-3.841776	-3.542843	-3.720778
5	400.7879	4.631667	7.47e-05	-3.826140	-3.460777	-3.678253
6	403.9041	5.823266	7.54e-05	-3.817213	-3.385421	-3.642438
7	407.7258	7.064411	7.56e-05	-3.815413	-3.317190	-3.613749
8	408.1900	0.848612	7.83e-05	-3.779697	-3.215045	-3.551145
9	409.3098	2.024683	8.07e-05	-3.750604	-3.119523	-3.495163
10	413.5596	7.598130	8.05e-05	-3.753127	-3.055616	-3.470798

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Pairwise Granger Causality Tests
Date: 04/06/06 Time: 21:11
Sample: 1/01/2002 1/02/2006
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Probability
DUSM does not Granger Cause DCNM	205	0.46377	0.70790
DCNM does not Granger Cause DUSM		0.55752	0.64368

3. Long Term for Period 1&2

VAR Lag Order Selection Criteria
Endogenous variables: DUSL DCNL
Exogenous variables: C
Date: 04/06/06 Time: 21:12
Sample: 1/01/2002 12/27/2005
Included observations: 198

Lag	LogL	LR	FPE	AIC	SC	HQ
0	295.9388	NA	0.000176	-2.969079	-2.935864	-2.955634
1	308.3939	24.53277	0.000162*	**-3.054484***	-2.954839*	-3.014151*
2	312.3910	7.792422	0.000162	-3.054455	-2.888381	-2.987234
3	315.1982	5.415739	0.000164	-3.042406	-2.809902	-2.948296
4	316.5108	2.506052	0.000168	-3.015261	-2.716328	-2.894263
5	317.0814	1.077657	0.000174	-2.980620	-2.615257	-2.832733
6	320.0279	5.506133	0.000176	-2.969979	-2.538186	-2.795203
7	323.7683	6.914064	0.000176	-2.967356	-2.469134	-2.765693
8	326.0103	4.099083	0.000180	-2.949599	-2.384947	-2.721047
9	331.4612	9.855699*	0.000177	-2.964255	-2.333173	-2.708814
10	333.6077	3.837672	0.000181	-2.945533	-2.248022	-2.663203

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Pairwise Granger Causality Tests
Date: 04/06/06 Time: 21:12
Sample: 1/01/2002 1/02/2006
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Probability
DCNL does not Granger Cause DUSL	207	1.12238	0.29066
DUSL does not Granger Cause DCNL		0.22337	0.63699

4. Short Term for Period 1

VAR Lag Order Selection Criteria
Endogenous variables: DUSS1 DCNS1
Exogenous variables: C
Date: 04/06/06 Time: 20:21
Sample: 1/01/2002 12/30/2003
Included observations: 94

Lag	LogL	LR	FPE	AIC	SC	HQ
0	55.01553	NA	0.001110	-1.127990	-1.073877*	-1.106133*
1	60.91461	11.42162*	0.001066*	**-1.168396***	-1.006058	-1.102823
2	63.18586	4.300877	0.001106	-1.131614	-0.861051	-1.022326
3	64.42517	2.294043	0.001173	-1.072876	-0.694087	-0.919873
4	65.50178	1.947056	0.001249	-1.010676	-0.523662	-0.813958
5	68.12328	4.629448	0.001288	-0.981346	-0.386107	-0.740913
6	68.46780	0.593758	0.001394	-0.903570	-0.200106	-0.619422
7	70.36106	3.182291	0.001460	-0.858746	-0.047056	-0.530883
8	70.78615	0.696412	0.001580	-0.782684	0.137231	-0.411106
9	73.45416	4.257472	0.001631	-0.754344	0.273797	-0.339050
10	76.14574	4.180537	0.001683	-0.726505	0.409861	-0.267497

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Pairwise Granger Causality Tests
Date: 04/06/06 Time: 20:23
Sample: 1/01/2002 1/05/2004
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Probability
DUSS1 does not Granger Cause DCNS1	103	6.21792	0.01429
DCNS1 does not Granger Cause DUSS1		0.01660	0.89774

5. Mid Term for Period 1

VAR Lag Order Selection Criteria
Endogenous variables: DUSM1 DCNM1
Exogenous variables: C
Date: 04/06/06 Time: 20:28
Sample: 1/01/2002 12/30/2003
Included observations: 94

Lag	LogL	LR	FPE	AIC	SC	HQ
0	206.3486	NA	4.43e-05	-4.347842	-4.293730*	-4.325985*
1	211.8531	10.65759*	4.29e-05	-4.379852	-4.217514	-4.314280
2	216.0005	7.853716	4.28e-05*	**-4.382990***	-4.112427	-4.273702
3	219.5156	6.506596	4.33e-05	-4.372672	-3.993883	-4.219669
4	222.2342	4.916683	4.45e-05	-4.345409	-3.858395	-4.148691
5	225.1259	5.106577	4.56e-05	-4.321827	-3.726588	-4.081394
6	228.7110	6.178653	4.61e-05	-4.313001	-3.609536	-4.028853
7	231.8244	5.233082	4.70e-05	-4.294136	-3.482446	-3.966273
8	232.4324	0.996097	5.07e-05	-4.221966	-3.302051	-3.850387
9	236.0423	5.760495	5.13e-05	-4.213666	-3.185526	-3.798373
10	242.1134	9.429548	4.93e-05	-4.257732	-3.121366	-3.798723

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Pairwise Granger Causality Tests
Date: 04/06/06 Time: 20:30
Sample: 1/01/2002 1/05/2004
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
DUSM1 does not Granger Cause DCNM1	102	1.48760	0.23102
DCNM1 does not Granger Cause DUSM1		0.18029	0.83531

6. Long Term for Period 1

VAR Lag Order Selection Criteria
Endogenous variables: DCNL1 DUSL1
Exogenous variables: C
Date: 04/06/06 Time: 20:33
Sample: 1/01/2002 12/30/2003
Included observations: 94

Lag	LogL	LR	FPE	AIC	SC	HQ
0	137.8907	NA	0.000190	-2.891292	-2.837180*	-2.869435
1	146.4448	16.56215*	0.000173*	**-2.988188***	-2.825850	-2.922615*
2	149.1686	5.157732	0.000177	-2.961033	-2.690470	-2.851745
3	150.9153	3.233269	0.000186	-2.913091	-2.534302	-2.760088
4	152.8189	3.442671	0.000195	-2.868486	-2.381473	-2.671768
5	152.8508	0.056371	0.000212	-2.784059	-2.188820	-2.543626
6	154.2995	2.496650	0.000224	-2.729776	-2.026311	-2.445627
7	156.4288	3.579032	0.000234	-2.689973	-1.878284	-2.362110
8	159.3125	4.724467	0.000240	-2.666224	-1.746309	-2.294645
9	161.6838	3.784007	0.000250	-2.631571	-1.603430	-2.216277
10	162.2448	0.871328	0.000270	-2.558400	-1.422035	-2.099392

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Pairwise Granger Causality Tests
Date: 04/06/06 Time: 20:34
Sample: 1/01/2002 1/05/2004
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Probability
DUSL1 does not Granger Cause DCNL1	103	0.56639	0.45346
DCNL1 does not Granger Cause DUSL1		1.93459	0.16734

7. Short Term for Period 2

VAR Lag Order Selection Criteria
Endogenous variables: DUSS2 DCNS2
Exogenous variables: C
Date: 04/06/06 Time: 20:52
Sample: 1/01/2004 12/29/2005
Included observations: 94

Lag	LogL	LR	FPE	AIC	SC	HQ
0	158.7164	NA	0.000122	-3.334392	-3.280280	-3.312535
1	169.0117	19.93344	0.000107*	**-3.468335***	-3.305997*	-3.402762*
2	170.4965	2.811489	0.000113	-3.414818	-3.144255	-3.305530
3	171.0767	1.074130	0.000121	-3.342058	-2.963270	-3.189055
4	171.3552	0.503634	0.000131	-3.262877	-2.775863	-3.066159
5	174.6356	5.792982	0.000134	-3.247565	-2.652326	-3.007132
6	174.9471	0.536948	0.000145	-3.169088	-2.465624	-2.884940
7	186.4022	19.25419*	0.000124	-3.327706	-2.516016	-2.999842
8	189.7424	5.472298	0.000126	-3.313668	-2.393753	-2.942090
9	190.8964	1.841466	0.000134	-3.253115	-2.224974	-2.837821
10	193.7962	4.503932	0.000138	-3.229706	-2.093340	-2.770697

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Pairwise Granger Causality Tests
Date: 04/06/06 Time: 20:53
Sample: 1/01/2004 1/04/2006
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Probability
DCNS2 does not Granger Cause DUSS2	103	0.31973	0.57303
DUSS2 does not Granger Cause DCNS2		0.14572	0.70347

8. Mid Term for Period 2

VAR Lag Order Selection Criteria
Endogenous variables: DUSM2 DCNM2
Exogenous variables: C
Date: 04/06/06 Time: 20:54
Sample: 1/01/2004 12/29/2005
Included observations: 94

Lag	LogL	LR	FPE	AIC	SC	HQ
0	179.3950	NA	7.87e-05	-3.774361	-3.720249	-3.752504
1	192.3519	25.08676*	6.50e-05*	**-3.964934***	-3.802596*	-3.899361*
2	194.2553	3.604403	6.80e-05	-3.920326	-3.649763	-3.811039
3	197.2440	5.532135	6.95e-05	-3.898808	-3.520019	-3.745805
4	201.8818	8.387624	6.86e-05	-3.912379	-3.425365	-3.715661
5	203.4182	2.713240	7.24e-05	-3.859962	-3.264723	-3.619529
6	206.3443	5.042749	7.42e-05	-3.837112	-3.133648	-3.552964
7	207.3605	1.708141	7.92e-05	-3.773628	-2.961938	-3.445765
8	207.9590	0.980573	8.53e-05	-3.701256	-2.781341	-3.329678
9	209.1727	1.936686	9.08e-05	-3.641972	-2.613832	-3.226679
10	214.0489	7.573603	8.95e-05	-3.660614	-2.524248	-3.201605

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Pairwise Granger Causality Tests
Date: 04/06/06 Time: 20:54
Sample: 1/01/2004 1/04/2006
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Probability
DCNM2 does not Granger Cause DUSM2	103	1.04724	0.30861
DUSM2 does not Granger Cause DCNM2		3.10448	0.08113

9. Long Term for Period 2

VAR Lag Order Selection Criteria
Endogenous variables: DCNL2 DUSL2
Exogenous variables: C
Date: 04/06/06 Time: 20:55
Sample: 1/01/2004 12/29/2005
Included observations: 94

Lag	LogL	LR	FPE	AIC	SC	HQ
0	150.1838	NA	0.000146	-3.152846	-3.098733*	-3.130989
1	157.2603	13.70133	0.000137	-3.218304	-3.055966	-3.152731*
2	161.9132	8.810921	0.000135*	**-3.232197***	-2.961633	-3.122909
3	162.7480	1.545232	0.000145	-3.164851	-2.786063	-3.011849
4	163.4191	1.213719	0.000156	-3.094024	-2.607010	-2.897306
5	164.0206	1.062172	0.000167	-3.021715	-2.426476	-2.781282
6	171.9079	13.59297*	0.000154	-3.104423	-2.400958	-2.820275
7	175.2844	5.675420	0.000157	-3.091157	-2.279468	-2.763294
8	175.8894	0.991161	0.000169	-3.018923	-2.099008	-2.647345
9	178.7578	4.577243	0.000174	-2.994847	-1.966706	-2.579553
10	181.0530	3.564871	0.000181	-2.958574	-1.822208	-2.499566

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Pairwise Granger Causality Tests
Date: 04/06/06 Time: 20:56
Sample: 1/01/2004 1/04/2006
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
DUSL2 does not Granger Cause DCNL2	102	3.02054	0.05339
DCNL2 does not Granger Cause DUSL2		0.84891	0.43103