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Master Thesis

Measuring Bond Market Liquidity:

An empirical study of the Chinese inter-bank bond market

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Key words: inter-bank bond market, liquidity, principal-components analysis

Purpose: The main purpose of this study is to analyze the liquidity of Chinese inter-bank bond market comprehensively, and to compare the liquidity level of the Chinese inter-bank bond market with that of other countries.

Methodology: Three quantitative methods are used to assess the liquidity: (i) Correlation test; (ii) Component Analysis; (iii) Kruskal-Wallis H test.

Theoretical Perspectives: The theoretical framework mainly involves prior studies in the field of liquidity indicators.

Empirical Foundation: The data during the period from January 2007 to June 2009 is obtained in order to study the Chinese inter-bank bond market.

Conclusions: Comprehensive Score computed by principal-components analysis has robust explanatory power which fits the economic tendency quite well. During the period January 2007 - June 2009, the liquidity has the tendency to increase with years. Meanwhile, there exists a large gap between the liquidity of the inter-bank bond market in China and those in other countries. Therefore, it is urgent for China to improve the liquidity, and some suggestions from the perspectives of term structure and bond categories are provided to optimize the structure of bonds in China.

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1. Introduction

1.1 Background

A mature and effective inter-bank bond market plays an important role in financial Macro-control, and it is also helpful to promote interest rate liberalization, improve financing sources and optimize monetary transmission mechanism (An and Gu, 2008).

The history of the bond market in China dates back to 1981, and with the development for almost 30 years, the bond market gradually transforms from the initial over-the-counter market to the one dominated by the inter-bank bond market after experiencing the exchange-market-driven stage (Li and Yin, 2006).

In 1988, the pilot negotiation of treasury bonds set by the Chinese ministry of finance indicated the official commencement of the transactions of bonds in the Chinese over-the-counter market. Later in 1990, Shanghai Stock Exchange was established, beginning to accept the trust of bearer bonds and carrying out book-entry bond transactions after accounts were opened, which formed the market structure where transactions on exchange and over-the-counter dealings co-existed (*ibid*).

A variety of problems arose along with the rapid development of the bond market. At that time the Chinese ministry of finance did not issue book-entry bonds, which made the treasury bonds traded over the bank counters all bearer bonds; however, the drawbacks of bearer bonds became 'prominent' about this period, namely, difficult safekeeping, great risks, high costs (An and Gu, 2008). Under such circumstances, the custody service carried out by some institutions spontaneously prevailed, making the excessively issuing and short selling treasury bonds in the form of custodial receipt very widespread. This brought in tremendous market risks. Though the Chinese bond market expanded rapidly and achieved brisk trades, the problems hidden in the market structure of that time foreshadowed great future risks, which were mainly due to the lack of an independent bond market in China.

As a majority of bond trades were conducted between banks in China (Li *et al.*, 2008), it was of great urgency to establish an inter-bank bond market. China needed an independent bond market guaranteed by government credit to sustain its economic and financial stability and improve the ability to resist risks; meanwhile, a mature over-the-counter bond market is also a powerful tool for the government to implement monetary policies so as to control macroeconomic situations indirectly (*ibid*). However, the golden opportunity came up in the first half year of 1997. A large amount of bank capital entered into the stock market in the form of bond repurchase from the exchange market, resulting in an overheated stock market. To restrain the overheated market, commercial banks were all forced to quit from the exchange market. In June of 1997, the establishment of the inter-bank bond market was officially approved by the State Council (Feng, 2008).

Ever since its foundation in the early half of 1997, the Chinese inter-bank bond market has played a dominant role in both repurchase transactions and total bond trading volume (Li and Yin, 2006). Albeit with a short development history, the Chinese inter-bank bond market develops so fast that it dominates the entire bond market in China. That is also the reason why this paper focuses on the Chinese inter-bank bond market.

In retrospect, throughout the development process of Chinese inter-bank bond market, the market per se has not fully functioned in terms of supporting market financing, investment and improving macro-adjustment. There may be many reasons behind this phenomenon, and Jia (2009) proposes that the relatively low liquidity of inter-bank bond market is an important one. Therefore, this paper tries to measure the liquidity of the Chinese inter-bond market and to verify the liquidity level of this given market from the global perspective.

1.2 Problem discussion

Over the last decades, there have been many studies on the liquidity problem

from different perspectives. The father of option pricing model Black (1971) points out that in a liquid market there are always small spreads existing between bid and offer price, and execution of large-volume transactions only had little impact on prices. Similarly, the definition of market liquidity given by Bank for International Settlements (BIS[1], 1999) is also from the aspect of price. The market with high liquidity means that participants can rapidly execute large-volume transactions with a small impact on prices.

From the angle of costs, former president of American Finance Association O'Hara (1995) proposes that there is no transaction cost in a complete liquid market. In reality, a market with low transaction costs can be called a liquid market; otherwise it is the one lack of liquidity. Amihud and Mendelson (1986) study how the transaction cost influences on rate of return on investment. They find that there is a close relationship between the cost of transaction and market liquidity.

In terms of time, Grossman and Miller (1988) assert that liquidity is related to the possibility of immediate execution of market transaction. In other words, illiquidity can be considered as a delay cost.

Based on these previous studies, we can make a simple summary of those definitions. A market with good liquidity should have four different characteristics as follows:

First, immediacy, which means that a trade can be executed immediately in the market (Grossman and Miller, 1988). Second, stability, that is to say large transactions will not give rise to big impacts on market prices (Black, 1971). Third, low transaction cost, which is reflected in the bid-ask spread (Engle and Lange, 1997). Fourth, activeness, which implies that there should be many traders in a market with high liquidity, and a lot of trades are implemented simultaneously (O'Hara, 1995).

However, until now there has still been no general consensus about how to define market liquidity. Moreover, the different definitions generate various indicators in practice. In order to further study the liquidity of the Chinese inter-bank bond market, this paper takes the corresponding problems into account. (1) How to rank the importance of the above-mentioned features? Considering that there are four basic

features of liquidity, it is relatively difficult to allocate the appropriate proportion to each category. (2) How to combine them as the comprehensive indicator of liquidity? The composite indicator aims to solve these questions, and we will introduce the comprehensive score in the latter chapter. (3) How to identify the liquidity level of Chinese inter-bank bond market against that in other countries?

Following the above framework, this paper attempts, firstly, to build up a comprehensive liquidity indicator; secondly, to identify the liquidity level of Chinese inter-bank bond market by comparing with that of other countries.

1.3 Purpose

The purpose of this paper is to analyze the liquidity level of the Chinese inter-bank bond market, which is divided into the following two parts.

First, this paper tries to build up a comprehensive indicator to measure the liquidity level of the Chinese inter-bank bond market during the sample period. There exist a number of indicators which measure liquidity from different aspects and it is difficult to find a single indicator that captures all the aspects. We therefore aim to combine a number of indicators in order to construct a measure that captures different aspects of the market liquidity.

Second, this paper attempts to analyze the liquidity level of the Chinese inter-bank bond market by applying a cross-sectional comparison with other countries. This will also provide a general view of the liquidity level of the Chinese inter-bank bond market from a global perspective.

1.4 Contribution and limitation

Most of the previous studies apply different indicators to measure liquidity separately. Instead of merely employing one specific liquidity indicator, this paper makes a comprehensive assessment of bond market liquidity. The main contribution

of this paper is to measure market liquidity comprehensively by using principal-components analysis (PCA), which is illustrated by the empirical result to be a sound approach that combines different liquidity indicators.

However, some limitations are inevitable. The source of data is WIND financial high frequency database in China. The data in WIND database has only been updated to the first half of 2009 when the authors conduct this research, which cannot provide the most recent information of the liquidity of the Chinese inter-bank bond market.

Furthermore, the authors do not use the indicator reflecting stability to interpret liquidity, since there is still no consensus reached among scholars on how to measure market stability. Moreover, there are no data available to represent stability.

The third limitation is that when making the international comparison of market liquidity, this paper only includes the official data of 2005 as the benchmark, which was issued by BIS in 2007; therefore the data is not so updated.

1.5 Thesis outline

Chapter 2 gives an overall introduction to the theoretical framework with the focus on how to measure liquidity comprehensively. Chapter 3 exhibits data collection and processing, methodology and methodological problems. In chapter 4, the empirical results are presented and analyzed. In chapter 5, along with the conclusions of the empirical studies, some suggestions are proposed on how to improve liquidity in the Chinese inter-bank bond market.

2. Theory

2.1 Definition and measures of Liquidity

The concept of market liquidity stems from the studies on stock market. Hicks (1962) defines liquidity as the possibility to immediately execute a transaction. Demsetz (1968) analyzes how the bid-ask spread is formed by market makers in the process of quoting, which becomes the rudiment of the concept of liquidity.

Later on, many scholars give out their own definitions and explanations of market liquidity from different perspectives. Engle and Lange (1997) propose transaction cost theory, regarding that a market with sound liquidity should be a zero-cost market when executing transactions. In fact, the market with low transaction-cost is regarded as liquid while that with high transaction-cost as illiquid. Grossman and Miller (1988) come up with immediacy, which indicates that liquidity refers to the transactions of any scale that can be immediately executed at the expected market price. Black (1986) characterizes the market with good liquidity as follows: quotes of bid and ask always exist; meanwhile, the bid-ask spread is small enough to allow the immediate execution of small-amount trades; and the market price is slightly influenced; large-amount transactions can be realized at a price close to an average market price within a certain period. Amihud and Mendelson (1986) think that the meaning of liquidity includes two aspects: one is the cost of certain transactions executed within certain periods while the other is the time within which a reasonable price is figured out. For Glosten (1987) market's liquidity is the ability to immediately execute transactions while keeping prices from fluctuating dramatically.

However, Engle (2000) regards liquidity as the influence on price imposed by a potential transaction. O'Hara (1995) proposes that liquidity is the cost of immediacy; in nature, it is always the dealers who intend to delay transactions obtain better knock down prices than those who hope to execute transactions immediately. In the market,

the dealers who are about to submit limit orders can gain a more ideal price through waiting; meanwhile, those dealers who execute transactions at once will have to accept a less ideal price. This proves that the inter-temporal movement of price is the basic measurement of liquidity.

Kyle (1985) divides liquidity indicators into three dimensions: tightness, depth and resiliency, which is the theoretical and commonly adopted support for later studies on liquidity. Subsequently, based on Kyle's research (1985), Harris (1990) added in "immediacy" as a new dimension, which constitutes the corresponding four measures shown as follows:

(1) Immediacy indicates that how soon market participants can execute a trade of a given size at a given cost. Traders always encounter a trade-off of whether to await transactions at favorable prices or to execute immediately at current prices. Therefore, immediacy can be described as "an ability to buy or sell assets quickly", and "it also reflects whether the traders' willingness to trade can be satisfied as soon as possible, which can be measured by the cost of immediate transaction" (Amihud and Mendelson, 1986: 223).

(2) Tightness refers to the extent that transaction price deviates from the true level of an asset. Provided that an investor wants to buy an asset whose prices happen to be the same in different markets, the investor will surely execute a trade without hesitation since there is no need to compare the prices. To some extent, the essence of a liquid market does not merely refer to immediacy but also includes the ability to reduce the difference between the transaction price and the true level. That is to say, sellers can not benefit much; neither do buyers have to pay much for the deviation from the intrinsic price. According to previous empirical studies, bid-ask spread is frequently used as the proxy of tightness.

(3) Depth is defined as the corresponding feasible trade volume that will not affect current market prices or the number of orders on the order-books of market-makers at a given time. It can be construed as the trade volume that

the dealers are willing and able to trade at a given price (Amihud and Mendelson, 1986). In a liquid market, people can execute a large trade volume at a given price without any influence on the market prices. Since there is a positive correlation between trade size and price impact (Easley and O'Hara, 1987), trade volume is commonly used as the indicator to gauge market depth. Meanwhile, as proposed by McInish and Wood (1992), smaller bid-ask spreads (the indicator of market tightness) tend to be followed by larger trade volumes (the indicator of market depth), indicating a close relationship between market depth and market tightness.

(4) Resiliency denotes the speed at which a price reverts to the intrinsic price after large-volume trades. Coppejans *et al.* (2000) use the data which consist of the complete limit order book for Swedish stock index futures contracts with a sample period from July 31st 1995 to February 23rd 1996, during which prices are set in Swedish currency (SEK) and volume is denominated by the number of contracts. And it is found that "volatility shocks reduce liquidity", which "supports arguments for trading halts following sharp market movements. Shocks to liquidity dissipate quickly, indicating a high degree of resiliency" (Coppejans *et al.*, 2000: 3). They regard resiliency as an automatic correction ability, that is to say, the price fluctuations resulting from large volume trades will dissipate immediately in a liquid market due to high resiliency.

In general, from the points mentioned above, it can be concluded that the definition of liquidity includes two aspects: on one hand, from the perspective of individual investors, the securities held by them can be immediately liquidated, and the price will not deviate from the true level too much. On the other hand, from the perspective of market, in a short period there are a large number of transactions around a given price level, and these transactions have small influences on the prices of securities. Even if market prices are changed by large-amount trades, it will immediately revert to its true level.

Up till now, this paper has reviewed the four attributes of liquidity, namely,

immediacy, market tightness, market depth and resiliency. The following part will look back the former empirical studies of liquidity in the fields of stock market and bond market respectively.

There are lots of empirical studies about liquidity of stock market. Amihud and Mendelson (1986) use bid-ask spread as the indicator of market tightness to reflect liquidity; and from the empirical study of the U.S. stock market within the timeframe from 1961 to 1980, they propose that there is a positive relationship between returns of assets and liquidity. They figure out that "a natural measure of illiquidity is the spread between the bid and ask prices". Amihud (2002) uses the average across stocks of the daily ratio of absolute stock return to dollar volume as an illiquidity measure, and verifies that illiquidity affects small firm stocks more strongly. Ding and Lau (2001) focus on Singapore stock market, employing the relative bid-ask spread as liquidity indicators to measure market liquidity on a daily basis from March 11th, 1996 to July 1st, 1996.

However, the relevant empirical studies of bond market are fewer than those of stock market. Gregory (1998) uses monthly data on investment-grade trader-priced corporate bonds, with a sample period from January 1985 to March 1995 to investigate how bid-ask spreads respond to the changes in the Treasury term structure of American security market, which also implies the popularity of bid-ask spread as a liquidity indicator. Fleming (2003) selects high-frequency bond trading data from December 30th 1996 to March 31st 2000 with a focus on U.S. bond market. Fleming (*ibid*) initially defines the original indicator system to measure the liquidity in bond market, which includes trading volume, trading frequency, bid-ask spreads, quote-sizes, trade sizes and price impact coefficients. In addition, Fleming (*ibid*) compares the merits of liquidity indicators and points out that bid-ask spread is an excellent indicator of liquidity: the smaller the bid-ask spread is, the more liquid the market is, which resonates with Amihud and Mendelson's (1986) findings on the stock market; quote size and the yield spread between new bonds and old bonds are simply medium indicators of market liquidity; trade volume and trading frequency are weak proxies of market liquidity, since both of them can be high in a market with

whether high or low liquidity.

2.2 The factors affecting market liquidity

2.2.1 The factors affecting liquidity of stock market

Amihud and Mendelson (1986), through the analysis of transaction cost's influence on rate of return, disclose the direct relationship between liquidity and capital cost and indicate that liquidity can be improved by adjusting the number of market makers in the long run; in the market maker system, market liquidity is motivated by the continuous quote of market makers, which means that market liquidity is affected by the market mechanism.

Bloomfield and O'Hara (1999) examined the influence of trading information disclosure on market efficiency and bid-ask spread. They find that trading information disclosure improves the informational efficiency of trade prices. Meanwhile, information disclosure dampens market makers' incentives to compete for order flow, resulting in the increase of bid-ask spreads. In short, trading information disclosure negatively affects liquidity.

Admati and Pfleiderer (1988) regard that because the opportunity costs vary with transactions within a week, liquidity may be affected by market volatility and within-one-week effects. Chordia *et al.* (2001) also share the same idea. After conducting the empirical research on the entire liquidity of US stock market, they find that long-term and short-term interest rates have significant influences upon market liquidity.

2.2.2 The factors affecting liquidity of bond market

Ho and Stoll (1981) point out that market risk, central monetary policy, constraint on short selling and other factors not only affect the holding positions of market makers and institutional investors, but also exert influences upon the liquidity

of bond market.

Fleming (2003) also points out that market liquidity is poor during recession period which demonstrates that market liquidity is affected by market volatility. In other words, market liquidity can be affected by the time-varying expectations of market participants.

The report of the Bank for International Settlements (BIS[2], 1999) demonstrates that the product design is also a key factor influencing market liquidity. The liquidity of securities may be different in terms of issue sizes, maturity periods, and interest rates, which thus calls for a better product structure to improve liquidity. This view is also supported by Harrison (2001), who asserts that bond size is a liquidity factor, at least for some corporate bonds.

And some researchers select bond categories as study object, observing different elements affecting the liquidity of bonds. One of the examples is the empirical study carried out by Chakravarty and Sarkar (1999), whose research objects are government bonds, financial bonds and corporate bonds in US within the timeframe from 1995 to 1997. They select realized bid-ask spread as the indicator of liquidity and discover that trading volume has positive effects upon the liquidity of the three kinds of bonds; meanwhile there are also other different factors influencing each of the three kinds of bonds.

2.3 Critical review

Among the studies carried out by western scholars on the liquidity in securities market, various indicators are utilized, such as bid-ask spread (Schultz, 2001), trade size or trade volume (Kamara, 1994; Alexander, Edwards and Ferri, 2000), yield or return spreads (Sarig and Warga, 1989; Blume, Keim and Patel, 1991; Warga, 1992; Crabbe and Tumer, 1995). Besides, some other scholars adopt trading frequency, quote size, and price impact coefficients (a measurement to test the price change resulted from the change of trade amount, which is also called the Kyle lambda) (Kyle,

1985).

Most indicators merely measure one single aspect of the characteristics of liquidity, as Amihud (2002) mentions, it is impossible to capture all the liquidity aspects by applying a single indicator. Therefore, how to utilize a composite indicator to measure bond market liquidity becomes a focus question in the academic field.

However, there are few previous literatures with regard to the solution of this question, and Fleming (2003) can be regarded as the pioneer in this area. His main contribution is to apply principal-components analysis on the combination of several liquidity indicators (including trading volume, trading frequency, bid-ask spreads, quote-sizes, trade sizes and price impact coefficients), which solves the problem of indicator being unitary.

When reviewing the literature, the authors find that the definition of market liquidity and application of liquidity measures is not limited to a specific market, whether stock market, bond market or any other derivative markets. That is to say, there exists commonality in liquidity across different securities, which is also confirmed by Fleming (2003). Therefore, the liquidity indicators can be commonly used across different securities markets, which will not constitute a potential problem in this paper.

3. Methodology

3.1 Introduction of research approach

Most of previous research applied different indicators to measure liquidity separately. Fleming (2003) focused on the U.S bond market, selected some popular liquidity proxies (bid-ask spread, trade volume, quote size, yield spread, etc.) to measure liquidity. The main contribution of this paper is the comparison of the merits of liquidity indicators by using correlation analysis and principal-components analysis. This also gives us an inspiration that principal-components analysis can be a good approach to combine different liquidity indictors.

As discussed in theory part, different liquidity measures contain different information (reflecting liquidity from different aspects: Immediacy, Tightness, Depth, Resiliency), this paper is aimed to make a comprehensive assessment of bond market liquidity instead of employing one specific liquidity indicator.

To achieve this target, firstly we will use high-frequency data of traded bond, and select some liquidity indicators to evaluate liquidity in the market respectively. Then based on the results of correlation tests as Fleming (2003) did in his study, we will apply factor analysis to extract components which combine information from different indices.

Furthermore, we will choose some liquidity measures to make a comparative analysis to evaluate the performance of liquidity in the Chinese inter-bank bond market. To suggest on how to improve market liquidity, we have to examine whether maturity structure or bond structure has an influence on market liquidity, and thus firstly we have to test whether the liquidity is statistically significantly different between bonds with different maturities and categories. Our studies will provide empirical evidence to support some suggestions on the improvement of market liquidity.

3.2 Data collection and processing

In order to calculate different liquidity proxies, this paper uses daily high frequency data of historical bond quotation and transaction record. The source of data is WIND financial high frequency database in China. Due to the large amount of data, we make data aggregation and selection with the help of SPSS software.

3.2.1 Data and sample period

The sample period is from January 1st, 2007 to June 30th, 2009, which covers the period of overheating economy in 2007, high inflation and global financial crisis in 2008 and the new economic threshold of 2009. This sample period provides us adequate evidences to verify how our liquidity measure fits economy situations in practice. In addition, as an emerging market, market-maker mechanism was just introduced in 2004, but the development is incredibly fast: there were only 9328 quotation records for 2007, however, the records rocketed to 26495 in 2008 and there were 17259 records for the first half year of 2009. Hence, the data of the two and a half years is capable to capture the features of the Chinese inter-bank bond market under different development stages, and thus we don't need to include the data earlier than 2007.

To apply principal-components analysis to measure liquidity, this paper mainly focuses on a sub-sample of government bonds for simplicity. According to official annual report of bond market, the government bonds always dominate approximately half of market share (Annual report of the Chinese inter-bank market[1]), which makes it suitable as a representation for the whole market. More than 100,000 historical daily government bond quotations and transaction records are collected and processed to calculate liquidity indicators, such as bid-ask spread, trading frequency and so on. All of these records will be processed as predefined liquidity measures on a monthly basis

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[1] See http://www.pbc.gov.cn

(30 months in total).

In order to test whether liquidity is affected by maturity, this paper takes a subset of sample from January 2008 to June 2009, and divides the data into three groups by the length of maturity. This paper also introduces high frequency quotation data of financial debt and corporate bond in the same period as the comparison group to test the influence of bond categories on the liquidity. The reason why this paper selects January 2008 to June 2009 as the sample period in this part is that the data of other two categories of bonds is not available before 2008.

3.2.2 Defining chosen liquidity measures

Based on previous studies of liquidity and the convenience of the access to the data, this paper selects bid-ask spread, quote size, turnover ratio, trade size and trading frequency as the indicators, reflecting market liquidity from the dimensions of market tightness, market depth and immediacy respectively. It's worth noting that we put market resilience aside because it's difficult to obtain the corresponding data.

(1) Bid-ask spread

As the indicator of market tightness, bid-ask spread reflects the extent that transaction price deviates from true level. Compared with an illiquid market, the difference between bid and offer price (bid-ask spread) is relatively smaller in a liquid market due to low transaction costs, implying that the lower the spread is, the more liquid the market is (Fleming, 2003). It is convenient to calculate bid-ask spread, which is one of the most commonly used liquidity indicators. In terms of the definition of bid-ask spread, there are mainly two types of spreads, one is absolute bid-ask spread and the other one is relative bid-ask spread. There may be many times of bilateral quotations by different market makers for the same bond within one trading day, and in this paper we define absolute bid-ask spread as the difference between best ask price (the lowest ask price) and best bid price (the highest bid price)

of one bond in one day as Fleming (2003) did. And the relative bid-ask spread is calculated by following formula (Ding and Lau, 2001):

Absolute bid-ask spread = best ask price (lowest) – best bid price (highest)   (1)

$$\text{Relative bid-ask spread} = \frac{\text{absolute bid} - \text{ask spread}}{(\text{best bid price} + \text{best ask price}) / 2} \qquad (2)$$

From the above formula, we can see that the relative bid-ask spread is absolute bid-ask spread being divided by the average of the best bid price and ask price. Compared with absolute bid-ask spread, relative bid-ask spread, as a percentage, is immune from the effects of price level, which takes both immediate transaction cost and the extent of price change into consideration. Therefore, it is more reasonable to use relative bid-ask spread to measure market liquidity, which is used by Ding and Lau (2001: 156) in their research as well. However, as Fleming (2003) mentions, the drawback of bid-ask spread is its constraint on the quantity and selection of time length.

In this paper, we use average weighted bid-ask spread of all bonds in the market on a monthly basis.

(2) Quote size

Traders are willing to take large positions since they can easily deal with the positions in a liquid market; but when the market turns to be less liquid, traders will charge a higher bid-ask spread (Alexander, Edwards and Ferri, 2000). And thus trade volume can be seen as a complement of bid-ask spread. Quote size refers to trade volume that is corresponding to the price the market makers quote, measuring liquidity from the dimension of market depth. Fleming (2003) points out that quote size cannot reflect the full quantities of trade in respect that "a quote is for a fixed and usually small quantity" (Kamara, 1994: 404) and hence underestimates the true depth of market, which is one main drawback of quote size being the indicator of market depth.

"Traders with large quantities cannot determine in advance the actual price for the entire quantity they wish to trade" (*ibid*) due to the performance of liquidity, and

hence if market makers in a market usually quote larger volume than that in other markets, that market has a higher liquidity in terms of market depth by reason that market makers in this market are more willing to execute larger trades.

Quote size in this paper is calculated by taking average of quote size of all bonds in the market on a monthly basis.

The definition of quote size is given as below (Fleming, 2003: 90):

$$\text{Quote size} = \text{best bid price} \times \text{quote volume}_{bid} + \text{best ask price} \times \text{quote volume}_{ask} \quad (3)$$

(3) Trade size

Trade size is another liquidity proxy of market depth. It is the quantity of trade executed per unit time, and the larger trade size always represents the better liquidity. Similar to quote size, it also underestimates market depth (Fleming, 2003). He proposes that "trade size also underestimates market depth as the quantity traded is often less than the quantity that could have been traded at a given price" (*ibid*).

There are usually two ways to reflect trade volume, one is in currency, the sum of the product of quantities and corresponding prices of transactions, e.g., quote size, and the other one is in shares, the sum of the quantities of transactions. In respect that the former one has been applied in the above-mentioned indicator, quote size, this paper employs the latter way to denominate trade size, by simply quoting the quantity of transactions, to reveal market depth in a thorough way.

This paper uses daily average trade size on a monthly basis, which is monthly total trade size being divided by the number of actual trading days per month.

$$\text{Trade size} = \frac{\text{monthly total trade size}}{\text{actual trading days per month}} \quad (4)$$

(4) Turnover ratio

Kamara (1994: 404) is the first one who suggests that trade volume can be an indicator of liquidity and calculates turnover ratio as the ratio of the average daily volume of transactions over the absolute value of daily net positions.

As a popular indicator of depth, in this paper turnover ratio is defined by current

trade volume being divided by the absolute value of monthly net positions, where the denominator is expressed as the average amount of beginning and ending inventory of the corresponding month, which is analogous to the definition of inventory turnover (Weygandt *et al.*, 1996: 802).

BIS[1] (1999) argues that "average turnover figures for a given time period (such as daily or weekly) can sometimes act as proxies for depth, because they show the order flow a market tends to accommodate in 'normal' times", and that study also uses turnover ratio as the indicator of market depth to measure liquidity across different courtiers.

In respect that the statistical data of bond inventory is commonly disclosed annually, it is difficult to obtain turnover ratio on a daily basis. This paper introduces this indicator in order to measure market depth in a long run (on a monthly basis), which can also be used to make a comparison amongst countries.

$$\text{Turnover ratio} = \frac{\text{current trade volume}}{(\text{beginning inventory} + \text{ending inventory})/2} \qquad (5)$$

(5) Trading frequency

When assessing immediacy, trading frequency is times of transactions executed per unit time, i.e., number of transactions completed per unit time, and thus it can reveal liquidity from the dimension of immediacy (the time needed to complete one transaction). Compared with the time length of completing one transaction, it is easier to obtain trading frequency, so this paper adopts trading frequency to reflect immediacy. With higher frequency, the market is regards as more active and liquid. However, it has been verified empirically by Jones *et al.* (1994) that frequency is also positively related to volatility, which makes it a weak proxy of liquidity.

Trading frequency in this paper is daily average times of completed transactions.

$$\text{Trading frequency} = \frac{\text{monthly total times of trades}}{\text{actual trading days per month}} \qquad (6)$$

3.2.3 Characteristic of sample data

3.2.3.1. Statistical description

In this paper five different liquidity indicators are selected and well-defined.

Considering requirements of the following tests in Table 3.1, this paper makes a brief summary of statistical descriptions of chosen liquidity indicators. Turnover ratio is excluded because it's only used to make comparisons in the later chapter instead of input for any test.

Table 3.1 Statistical description of chosen indicators

Input indicators	Bid-ask spread	Quote size	Trade size	Trading frequency
Description	Continuous	Continuous	Continuous	Discrete

Bid-ask spread, quote size and trade size are continuous variables while trading frequency is the discrete variable by reason that it's calculated by the number of transactions in a certain month being divided by the sum of actual trading days of that month, where the numerator and denominator are both integers and discrete.

3.2.3.2. Normality

Many statistical tests are based on the assumption that data is normally distributed, and hence this paper makes a normality test of input variables respectively to decide which kind of statistical tests we should use.

In SPSS, one-sample Kolmogorov-Smirnov test is used to test whether a sample comes from a normal distribution or not, and the null hypothesis is that the data follow a normal distribution.

Table 3.2 One-Sample Kolmogorov-Smirnov Test

		Bid-ask Spread	Quote size	Trade size	Trading frequency
Number of Obs.		30	30	30	30
Normal Parameters	**Mean**	.006	3856.915	11517.126	54.097
	Std. Deviation	.002	976.900	4947.891	22.162
Most Extreme Differences	**Absolute**	.100	.092	.138	.234
	Positive	.100	.090	.138	.234
	Negative	-.064	-.092	-.096	-.153
Kolmogorov-Smirnov Z		.548	.503	.753	1.282
Asymp. Sig. (2-tailed)		.925	.962	.622	.075

Table 3.2 presents the result of normality tests of processed liquidity indicators on a monthly basis in the sample period. All input variables are normally distributed in 5% level of significance with P-value exceeding 0.05 that the null hypothesis cannot be rejected.

In addition, in order to test the influence of products design, this paper selects bid-ask spread as a liquidity indicator to test whether liquidity differs with maturity and bond categories or not. To satisfy the requirement of Kolmogorov-Smirnov test, a normality test of bid-ask spread needs to be employed. The processed monthly bid-ask spread with 30 observations, which may lead to a biased result due to a small sample in the following comparison tests, this paper employs the full original sample of bid-ask spread instead, i.e., on a daily basis. There are 108948 observations in total, and it is evident that daily bid-ask spread does not follow a normal distribution, as the two-tailed significance of test statistics is quite small (less than 0.01%), which means we can even reject the null hypothesis at 1% level of significance (See Table 3.3). Therefore, we cannot employ Kolmogorov-Smirnov test due to the restriction of the normal distribution, and Kruskal-Wallis H test is applied to solve this problem.

Table 3.3 One-sample K-S Test for Bid-ask spread

		Bid-ask spread
Number of Obs.		108948
Normal Parameters	**Mean**	.008
	Std. Deviation	.011
Most Extreme Differences	**Absolute**	.231
	Positive	.220
	Negative	-.231
Kolmogorov-Smirnov Z		76.141
Asymp. Sig. (2-tailed)		.000

3.3 Statistical method of research

3.3.1 Correlation test

Generally, Pearson's correlation coefficient is the most well-known measure of testing the correlation between two variables. However, Pearson's correlation coefficient is employed to test the linear relationship, and requires that both variables should be continuous and normally distributed. Due to the strong restrictions of Pearson's correlation test, this paper employs Spearman's rank correlation coefficient instead.

Spearman's rank correlation test is a nonparametric measurement of linear relationship between two groups of ranked data. One of the key steps to calculate Spearman's rank correlation coefficient is to convert the original data to ranked data. Each observation is given a corresponding rank by sorting the raw values of data in an ascending or descending order. For instance, we give the lowest value rank 1, the second lowest rank 2 and so on. Special case for ranking is that same values of observations, which should be given averaged ranks.

Spearman's rank correlation test measures a monotonic relationship using the ranks instead of the values of observations. Similar to Pearson's coefficient, the value of Spearman's rank correlation coefficients is between -1 and +1. A positive

correlation means the ranks of both variables increase or decrease together while a negative correlation is the one in which the ranks of one variable decrease as the ranks of the other variables increase. There is no linear relationship between the ranks if correlation coefficient equals zero. When the Spearman's coefficient takes value of -1 or +1, there exists a perfect rank correlation between two variables. However, it is seldom to get the perfect Pearson's correlation coefficient by using actual value of data more strictly.

Based on the empirical study of American government bond market by Fleming (2003), a negative correlation is expected to exist between quote sizes and bid-ask spreads, and quote size is supposed to be the measure which is most closely-related to other liquidity measures.

3.3.2 Principal-components analysis

It is worthy of being mentioned that this paper applies principal-components analysis rather than regression analysis. The reason is that a certain indicator, for example, the bid-ask spread has to be the dependent variable in a regression equation, and the implied assumption is that the bid-ask spread is the only indicator of liquidity. However, it conflicts with the purpose of the paper that focuses on finding a composite way to express liquidity from various angles.

As the most important part of research approach in this paper, principal-components analysis (Fleming, 2003: 97) is applied to achieve a comprehensive assessment of market liquidity. Principal-components analysis can combine the information from possibly correlated variables by extracting principal components from raw data.

Before making component analysis, we should make sure that all input variables estimating liquidity by the same criterion, e.g. the higher the better. In this respect, bid-ask spread should be preprocessed, since smaller bid-ask spread indicates higher liquidity. A simple way to deal with this problem is to take the opposite number of original data.

The outputs of the analysis with SPSS start with communalities, which show the proportion of each input variable's variances explained by principal-components analysis. There is no thumb of rule on the definition of an appropriate communality, but many previous literatures give out some suggestions about suitable range of communality in empirical studies. MacCallum *et al.* (1999) point out that it is better to have all communities above 0.6 for a relatively small sample size (less than 100).

Next, principle components will be extracted with eigenvalues over 1, and the sum of corresponding ratio of variance explained should not be too small which would affect the efficiency of principal-components analysis. If K input variables (X_1, X_2, … ,X_k) are reduced into N components(C_1, C_2, …. , C_n), the relationship between original variables and components should be stratified these equations as following:

$$C_i = \alpha_{i1}X_1 + \alpha_{i2}X_2 + ... + \alpha_{ik}X_k \quad (i = 1, 2, ..., n) \tag{7}$$

These equations can be rewritten in a matrix form, and from component matrix, we can analyze what information is mainly concerned in each component by taking the coefficients of loaded variables. If it is hard to interpret it from the original extraction, the varimax rotation solution can be employed to obtain the rotated component matrix. Varimax rotation is an orthogonal rotation of the factor axes to maximize the sum of the variances of the squared loadings without changing the sum of eigenvalues. Since varimax rotation does not change the total variance explained by components, only changes factor loadings, we can compare and inspect both solutions and choose the one that is easier to explain the variances.

SPSS will compute component scores for each case, and with these results, one can calculate the comprehensive score for the whole sample by the following formula, in which FACTi_1 represents the score vector of factor i, and λ_i is corresponding component variance loading:

$$\text{Component Score} = \frac{\lambda_1}{\sum_{i=1}^{n}\lambda_i}\text{FACT1} - 1 + \frac{\lambda_2}{\sum_{i=1}^{n}\lambda_i}\text{FACT2} - 1 + ... + \frac{\lambda_n}{\sum_{i=1}^{n}\lambda_i}\text{FACTn} - 1. \tag{8}$$

On the basis of scores combining information from different liquidity measures,

we can have an overview of market liquidity during the sample period.

3.3.3 Kruskal-Wallis H test

Some prior studies, e.g., Chakravarty and Sarkar (1999), mention that product design is a factor influencing market liquidity, which provides a theoretical support to conduct the following studies. This paper aims to analyze the factors (product design) that influence liquidity after the liquidity of the Chinese inter-bank bond market is identified, and it is necessary to compare liquidity among different groups.

In statistics, Analysis of variance (ANOVA) is commonly used to test whether the means of independent variables are different or not, but here we use Kruskal-Wallis H test instead of ANOVA due to the violation of assumption of normal distribution.

Kruskal-Wallis H test is a non-parametric test used to compare more than two independent groups of data without the restrictions of distributions. Just like Spearman's correlation coefficient mentioned above, Kruskal-Wallis H test is performed on ranked data rather than the original values. The main idea of this test is that if the data comes from the identical population, the means of ranks should not differ too much.

The procedure is that to rank the whole sample at first, and then to get sum of the ranks for each group, and finally to calculate the test statistics H, where H is the variance of the ranks among groups which is approximately chi-square distributed. When comparing test statistic H with the corresponding critical value, if H is greater than the critical value, the null hypothesis of identical populations is rejected.

4. Empirical results and analysis

4.1 Comprehensive assessment of liquidity

In this section, we will use high-frequency data of traded bond, and select some liquidity indicators to evaluate liquidity in the market. As discussed in theory part, different liquidity measures contain different information (reflecting liquidity from different aspects: Immediacy, Tightness, Depth and Resiliency). Based on the study of Fleming (2003), we will apply factor analysis (correlation analysis and principal-components analysis) to extract components which combine information from different indices. Instead of employing one specific liquidity indicator, this paper makes a comprehensive assessment of bond market liquidity.

4.1.1 Correlation analysis

Table 4.1 demonstrates the relationship between selected liquidity indicators given by Spearman's correlation coefficients. There are many coefficients flagged by small stars implying that their correlation is statistically significant, where one star represents the significance at the 0.05 level (2-tailed) and two stars stands for the significance at the 0.01 level (2-tailed) as shown in Table 4.1

Table 4.1 Correlation

	Bid-ask spread	Quote size	Trade size
Quote size	-0.441*		
Significance	0.015		
Trade size	-0.054	-0.406*	
Significance	0.778	0.026	
Trading frequency	0.132	-0.767**	0.478**
Significance	0.487	0.000	0.008

The empirical result indicates that bid-ask spread is negatively correlated to quote size, which is consistent with the definition of bid-ask spread and quote size in the pervious section, that is to say, both smaller bid-ask spread and larger quote size represent higher liquidity. Quote size is the most closely-related to all other chosen liquidity indicators with a negative correlation to trade size and trading frequency, which is consistent with the finding of Fleming (2003). Moreover, quote size and trading frequency are most correlated with a correlation coefficient of -0.767 at 1% level of significance, and quote size and trade size are negatively correlated with a correlation coefficient of -0.406 at 5% level of significance, which is different from Fleming's study (2003). According to the definitions of each liquidity indicator in the previous chapter, trade size is a daily average, while quote size is on the basis of per quotation. With the development of inter-bank bond market, quote size will decrease due to the improving mechanism and trade size will increase monotonously as well as trading frequency, and it has also explained the reason why trade size is positively correlated with trading frequency, which is consistent with the correlation coefficient of 0.478 at the 1% level.

4.1.2 Principal-components analysis of liquidity

Since there is no specific single indicator that can thoroughly measure liquidity, and the results may be different by employing different liquidity indicators. Plus, correlation test demonstrates that these liquidity indicators are closely related, and thus principal-components analysis becomes a possible solution to measure liquidity comprehensively by merging chosen liquidity indicators.

Executed by SPSS, communalities of input variables are all greater than 0.7, greater than the critical value, 0.6, proposed by MacCallum *et al.* (1999), indicating all selected liquidity indicators can be well interpreted by the factors extracted by principal-components analysis (See Table 4.2).

Table 4.2 Communalities

Communalities	Initial	Extraction
Bid-ask spread	1.000	0.821
Quote size	1.000	0.909
Trade size	1.000	0.747
Trade frequency	1.000	0.775

Extraction Method: Principal-components analysis

Two components are drawn with eigenvalue exceeding 1, which explain 81.278% of variance of all input variables in total. Table 4.3 shows the total explained variation both of initial extraction and varimax rotation, and it is evident that rotation changes factor loadings rather than total variance explained. However, the question is which solution should be selected.

Table 4.3 Total variance explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.172	54.306	54.306	1.697	42.421	42.421
2	1.079	26.972	81.278	1.554	38.857	81.278
3	0.606	15.147	96.426			
4	0.143	3.574	100.000			

Extraction Method: Principal-components analysis

Component matrices of these two solutions are presented below. The left one is unrotated component matrix. As almost all the absolute value of coefficients are more than 0.5, it is difficult to explain what information the first component is mainly concerned. In contrast to the initial extraction, rotated component matrix is easier to interpret. The first component mainly focuses on trade size and trading frequency whereas the second component places an emphasis on bid-ask spread and quote size.

These two components consist of liquidity information during the procedure of quotation and trading respectively, and thus the first component can be referred to as quotation factor and the second one as trading factor.

Table 4.4 Component matrix

Component Matrix			**Rotated Component Matrix**		
	Component			Component	
	1	2		1	2
Bid-ask spread	0.534	0.731	Bid-ask spread	0.081	**0.902**
Quote size	0.947	0.112	Quote size	-0.638	**0.708**
Trade size	-0.494	0.709	Trade size	**0.839**	0.207
Trade frequency	-0.864	0.170	Trade frequency	**0.761**	-0.442

Extraction Method: Principal-components analysis
Rotation Method: Varimax with Kaiser Normalizations

Based on the analysis above, the rotated solution is employed and the corresponding formulas are calculated by using equation (7):

$$F_1 = 0.081X_{bid-ask\ spread} - 0.638X_{quote\ size} + 0.839X_{trade\ size} + 0.761X_{frequency}$$

$$F_2 = 0.902X_{bid-ask\ spread} + 0.708X_{quote\ size} + 0.207X_{trade\ size} - 0.442X_{frequency}$$

SPSS computes the scores of these two factors for all 30 months, and the score vectors are saved as FACT1_1 and FACT2_1 in Appendix ii. In the case of rotation, the two components' contributions to total variance are 42.421% and 38.857% respectively. Comprehensive score of liquidity is computed as follows (based on equation (8)):

$$\text{Score} = \frac{\lambda_1}{\lambda_1 + \lambda_2} \text{FACT1\_1} + \frac{\lambda_2}{\lambda_1 + \lambda_2} \text{FACT2\_1}$$

$$\lambda_1 = 42.421\%, \quad \lambda_2 = 38.857\%$$

Exhibit 4.1 is the corresponding graph of score of market liquidity from January 2007 to June 2009. For the purpose of assessing the efficiency of these scores, this paper makes a comparison with the performance of economy in the real world.

Exhibit 4.1 Comprehensive Score
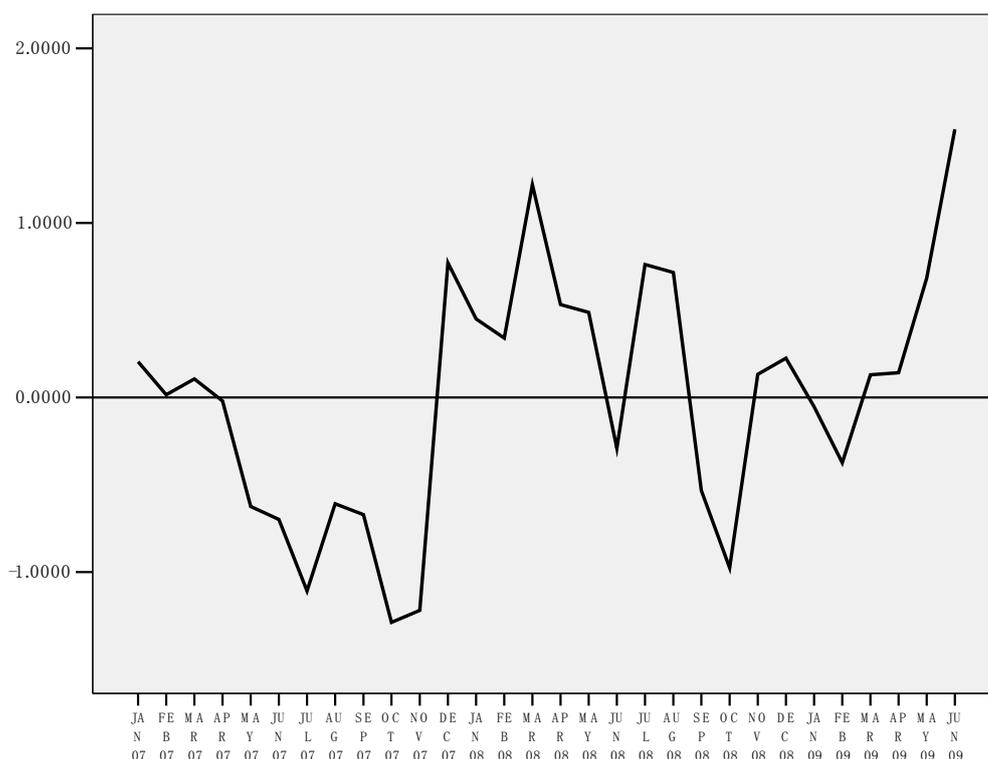
In 2007, in order to control excess liquidity of banks, curb excessive investment and prevent the economy from overheating, the central bank of China had raised the deposit-reserve ratio for 10 times from 9.5% in January to 14.5% in December. The implement of restrictive monetary policy controlled capital flows of banks efficiently. Since Banks are the main participants in the inter-bank bond market, this policy obviously had a great impact on market liquidity. It is clearly shown in the graph that the market liquidity is decreasing in that period.

The liquidity of inter-bank bond market in 2008 had been improved compared with that of 2007. However, the liquidity followed a pattern of great volatility which is consistent of the complicated economic situations. In the first half year, the Olympic effect and increasing international oil prices led to high economic growth and high inflation and the overheated economy was cooled by the threat of global financial crisis in second half year.

From the last season of 2008, financial policy and monetary policy were loosed to smooth the deflation. It is apparent in Exhibit 4.2 that after hitting bottom in the first

half of 2009, both CPI and PPI started to increase, which is a signal of economic recovery from the recession. The liquidity score in this paper captures the features that the economy turned better and peaked in the June of 2009, verifying that the score graph fits economic tendency quite well.

Exhibit 4.2 CPI/PPI
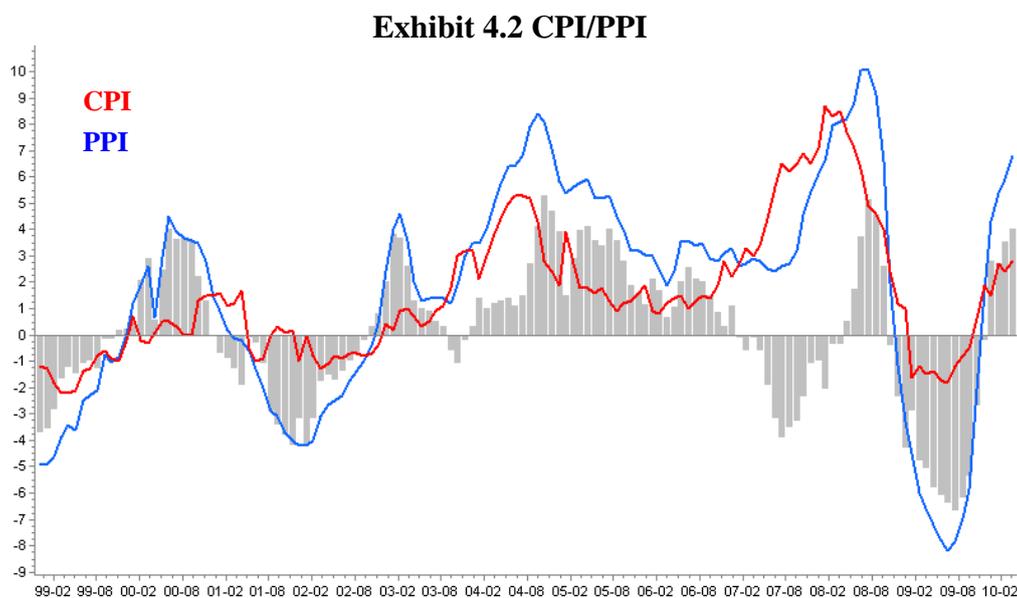
Source: WIND database

4.2 A cross-sectional comparison of liquidity

As shown in the previous section, principal-components analysis (PCA) provides a composite way to measure the liquidity of a market over a specified period but cannot be employed to the comparisons among different countries due to the complication in the data process. In response to the fact that principal-components analysis fails to provide a consistent comparison among different markets, single indicators are selected in this section in order to get a general picture of the liquidity level of the Chinese inter-bank bond market from an international perspective.

With regard to international comparisons of liquidity situations, Lesmond (2005: 445) measures firm-level liquidity by analyzing 31 emerging markets (including the Chinese market) and finds that "liquidity costs range from 1% for the Taiwanese

market to over 47% for the Russian market" by using the bid-ask spread as a basis, confirming that low liquidity cost is charged in a market with a high liquidity and thus liquidity plays an important role in the efficiency of a market. In order to identify the level of liquidity of the Chinese inter-bank bond market on an international basis, this paper takes the liquidity of developed markets into consideration as well as those of emerging markets.

With the purpose of further studying on the liquidity of the Chinese inter-bank bond market, several composite indicators are employed to measure the liquidity in the previous section; and this section aims to identify the liquidity level of Chinese inter-bank bond market through the comparison with the liquidity of inter-bank bond market in other countries (including developed countries and developing countries).

Given that there is no corresponding data of trading frequency (the indicator measures liquidity from the dimension of immediacy) in other countries, this paper makes the comparisons from the perspective of market tightness and depth.

4.2.1 Tightness

When determining the liquidity of the inter-bank bond market, this paper selects the bid-ask spread as an indicator of market tightness, which is consistent with what Lesmond (2005) has done in his study. Based on the report that BIS issued in 2007, the graph is displayed in Exhibit 4.3.

The average bid-ask spread of the sample of government bond transactions in the inter-bank bond market in China was 61 bp (basis point, or 0.01%) in 2005, compared with the highest one (60 bp) in the graph above and the average level of the countries, there is great room for development in this market of China. After the quotation system reform and the introduction of market maker system, the bid-ask spread in the Chinese inter-bank bond market has improved significantly, compared with that in the initial stage of the establishment of this market. However, the bid-ask spread average in the first half of 2009 was 55 bp, even if compared with other countries in 2005, this

spread is still too big. This resonates with Guo's (2008) findings on the bid-ask spread of government bonds with different maturities in 1997, and she points out that the government bond in the American market had the smallest bid-ask spread with 1.6 bp, and the French market had the greatest bid-ask spread with 24 bp when comparing market tightness among developed countries. However, the bid-ask spread of government bond in the Chinese market was around 30 bp, still much higher than that in France, implying that the liquidity of the Chinese bond market remained at a comparatively low level from the perspective of market tightness when compared with that in developed countries till 1997.

Exhibit 4.3 International Comparison of bid-ask spread

US	the United States
IN	India
SG	Singapore
KR	Korea
GB	the United Kingdom
BR	Brazil
CL	Chile
DE	Germany
MY	Malaysia
PL	Poland
ES	Spain
MX	Mexico
TH	Thailand
SA	Saudi Arabia
PE	Peru
RU	Russia
CZ	the Czech Republic
PH	the Philippines
ID	Indonesia
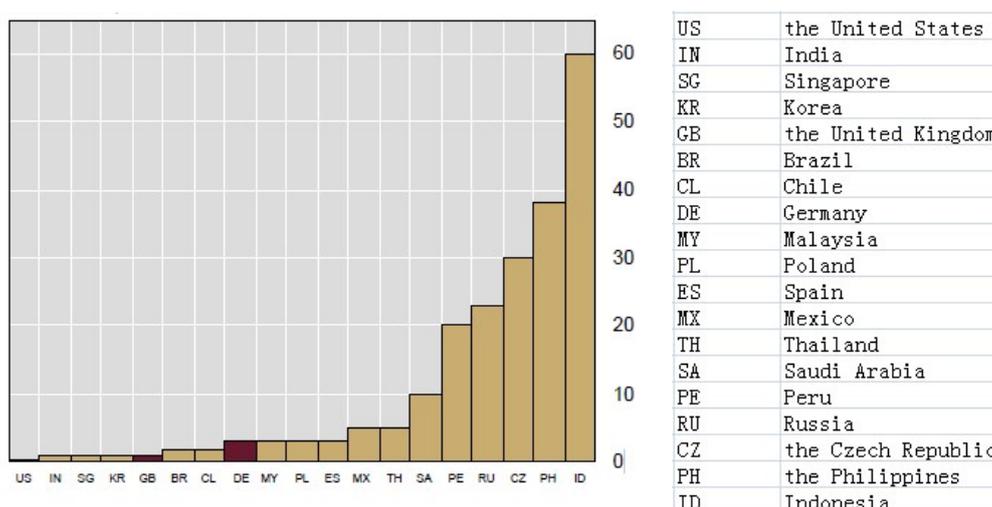
(Source: Financial stability and local currency bond markets, BIS, June 2007)

In retrospect, the liquidity of government bond in the Chinese inter-bank bond market has not been improved significantly in terms of market tightness and still requires to be improved further

4.2.2 Depth

Turnover ratio is the indicator, other than quote size, reflecting the depth of market in this section. This paper employs turnover ratio to measure the annual

market depth in the Chinese inter-bank bond market, and downloads data of the bond transaction size and annual custody volume from WIND database, to calculate the turnover ratio from 2001 to 2009. The results are as follows:

**Table 4.5 annual turnover ratio in the inter-bank bond market in China**

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Turnover Ratio (%)	4.2	24.54	88.22	63.55	102.08	118.71	134.79	337.70	326.74

(Source: Wind Database)

There is apparently an increasing trend of the turnover ratio year by year in the Chinese inter-bank bond market, especially the turnover ratio of 2008 was more than twice of that of 2007, since the bond transaction in the inter-bank bond market in 2008 valued 37.1 trillion RMB, and that in 2007 valued only 15.6 trillion RMB, indicating that the active trades have increased the turnover ratio.

Furthermore, this paper makes an international comparison in terms of turnover ratio, and obtains the graph from the report that BIS issued in 2007 as follows:

Exhibit 4.4 International Comparison of Turnover ratio

SA	Saudi Arabia	IN	India
PE	Peru	PH	the Philippines
SG	Singapore	BR	Brazil
CN	China	HK	Hong Kong SAR
RU	Russia	ES	Spain
DE	Germany	KR	Korea
TH	Thailand	MX	Mexico
AR	Argentina	GB	the United Kingdom
ID	Indonesia	ZA	South Africa
IL	Israel	CA	Canada
CZ	the Czech Republic	CL	Chile
MY	Malaysia	US	the United States
TR	Turkey	PL	Poland
BE	Belgium	TW	Taiwan (China)
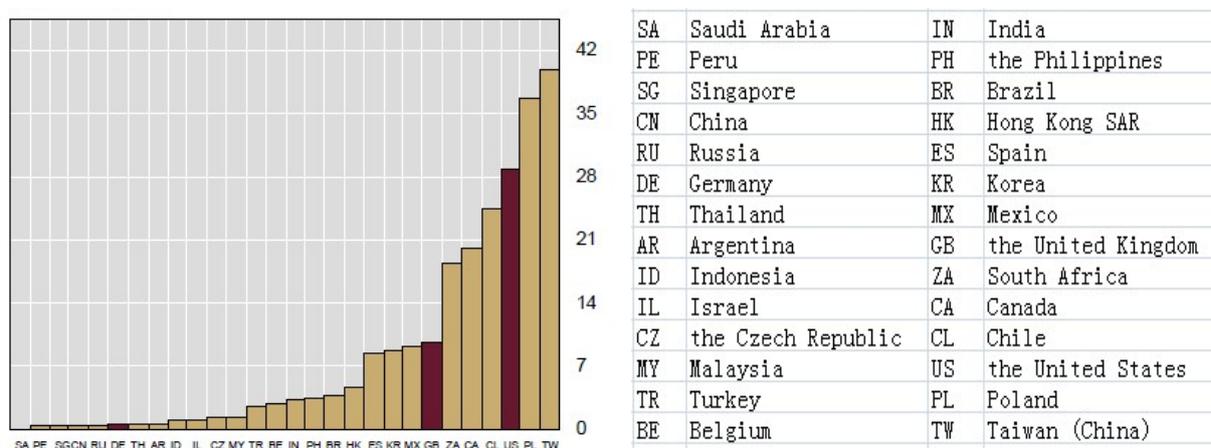
(Source: Financial stability and local currency bond markets, BIS, June 2007)

Exhibit 4.4 shows that the turnover ratio in the inter-bank bond market of China was extremely low when compared with other countries, at least, far behind the level of developed countries. This result is consistent with what Lin and Zhou (2006) find in their study, which shows that, despite of rapid growth, the turnover ratio of the inter-bank bond market of China was left behind by other developed countries: the turnover ratio of the inter-bank bond market of China in 2005 was only 1/7 of that of Japan, 1/22 of that of the USA in 1999, implying that it is impossible for the Chinese market cannot catch up with the Japanese or the American market in terms of market depth in a few years due to the huge gap between them. Their findings also confirm that the bond market in developed countries, for example, the USA, has been extremely advanced and liquid since 1999, while the liquidity of the Chinese bond market remains at a relatively low level when compared with that of other emerging markets, not to mention developed markets.

Therefore, there is a pressing need for China to increase the turnover ratio in the inter-bank bond market.

4.3 Factors affecting liquidity

In the previous section, the low liquidity of Chinese inter-bank bond market has been verified by the international comparison. In order to improve the liquidity level, this section tries to exploit the factors that affect liquidity. Various factors have been proposed by previous studies, such as the market mechanism (Amihud and Mendelson, 1986), trading information disclosure (Bloomfield and O'Hara, 1999), market volatility (Fleming, 2003), product design (BIS[2], 1999) and so on. Considering that the data availability and feasibility in terms of empirical analysis, this section attempts to verify the influence of product design on liquidity empirically.

The report of BIS[2] (1999) points out product design is a key factor affecting liquidity, and product design in this paper indicates maturity and category of bond. If market share is mainly occupied by less liquid bond, the market liquidity is surely

influenced, and thus optimizing the structure of bond becomes a critical issue. In this section we choose bid-ask spread as the liquidity proxy to test the differences of bonds with different maturities and categories, and this will provide an evidence for bond structure optimization.

4.3.1 Maturity

Short-term bond refers to a bond with a maturity less than one year while long-term bond matures more than 10 years, and thus this paper divides the government bonds into three groups (short-term bond, medium-term bond and long-term bond), and employs non-parametric Kruskal-Wallis H test to test whether the maturity of bond plays a role in market liquidity or not.

Table 4.6 Kruskal-Wallis H test on maturity

| Bid-ask speard	Number of Obs.	Mean Rank
Short	3580	5080.54
Medium	51607	31584.25
Long	14995	54327.12
Test statistics	**Bid-ask spread**	
Chi-square	22918.983	
df	2	
Asymp.sig	0.000	

It is obvious that the mean ranks are different among these three groups with extremely small probability of Chi-square value (test statistics H) that is far less than the critical value (Table 4.6), and the null hypothesis is rejected that there is no difference of bid-ask spread among these three groups.

In addition, the average bid-ask spread is calculated during the period from January 2008 to June 2009. Short-term bonds have the highest liquidity (11 bp), followed by medium bond with the bid-ask spread of 63 bp, and the liquidity of long-term bond is the lowest with the bid-ask spread of approximately 176 bp. Exhibit

4.5 shows the bid-ask spread of the three types of bonds during the sample period, long-term bond is most lack of liquidity with wild fluctuation for the whole period when comparing with short-term and medium-term bond. The results are consistent with the findings of Bao *et al.* (2009), who also use bid-ask spread as the liquidity indicator, and find that the level of illiquidity is closely related to bond characteristics. Specifically, they mention that illiquidity increases with the maturity of bond, well supporting the conclusion in this part.

In sum, the importance of maturity on the liquidity is verified.

Exhibit 4.5 bid-ask spread grouped by maturity
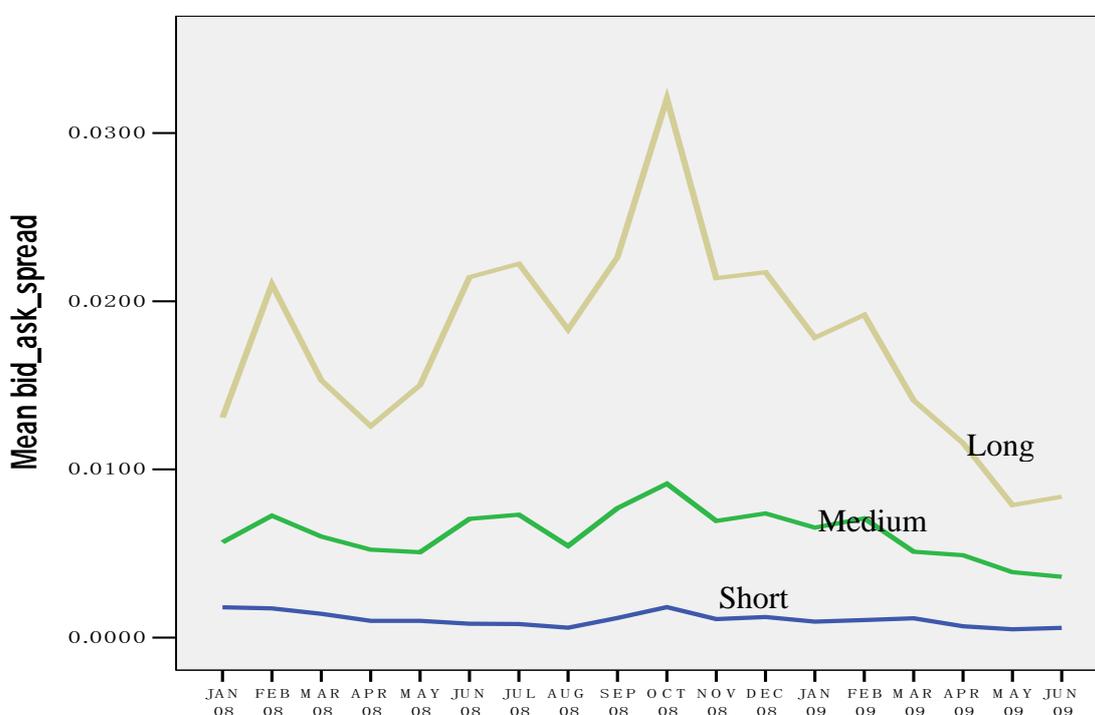
4.3.2 Bond categories

To test whether the liquidity changes with bond categories, Kruskal-Wallis H test is also employed to capture the difference of bid-ask spread. Three kinds of bonds are introduced by Chakravarty and Sarkar (1999), which are government bonds, financial bonds and corporate bonds respectively.

The p-value of rejecting null hypothesis is less than 0.0001, and hence the differences of the bid-ask spreads among these three kinds of bonds are statistically significant. In other words, liquidity varies with categories of bonds (Table 4.7).

Table 4.7 Kruskal-Wallis H test on category

Bid-ask speard	Number of Obs.	Mean Rank
Government	43754	57971.17
Financial	53794	48832.18
Corporate	11400	67678.89
Test statistics	**Category**	
Chi-square	4281.663	
df	2	
Asymp.sig	0.000	

Table 4.8 provides a simple comparison of bid-ask spread among these three kinds of bonds. With lowest bid-ask spread (66 bps) and the most frequent quotations, financial bond is ranked the first in terms of liquidity, followed by government bonds with average bid-ask spread of 83 bp whereas corporate bond is the most illiquid with bid-ask spread of 159 bp and the highest volatility at the same time.

Table 4.8 Comparison of different bonds

Category	Number of Obs.	Mean	Std.Deviation
Government	43754	0.0082	0.0087
Financial	53794	0.0066	0.0085
Corporate	11400	0.0159	0.0219
Total	108948	0.0082	0.0111

The results can be explained from the aspects of risk and transparency. According to the findings of Edwards *et al.* (2007), transaction costs are lowered with bond price transparency, and the bid-ask spread is a good proxy for transaction costs. The price of financial bond has the smallest probability to be information asymmetric, followed by government bond, and corporate bond does not necessarily disclose true information and may mislead uninformed investors, and thus the more transparent, the less risk

and smaller bid-ask spread.

Basically, the importance of bond category on the liquidity is confirmed in this part as well as maturity.

4.4 Existing Problems

The liquidity of the Chinese inter-bank bond market is far behind those of other countries. To explain why the liquidity still remains at a relatively lower level, we should trace back to the short history of inter-bank bond market development. [2] Established in 1997, the market experiences continuous reforms of market mechanism. The introduction of market marker mechanism in 2004 has improved the liquidity efficiently which can be proved by the annual turnover ratio shown in Table 4.5. However, there are still a lot of problems existing due to the immature market marker mechanism. Market makers are responsible for active quotations, but the strict restrictions of regulations and lack of incentive mechanism may hamper the enthusiasm of market makers. According to the official annual report of inter-bank bond market, there are only 19 market makers at the end of 2008. Insufficient market markers may also be the reason of low liquidity. On the other hand, the market participants also play an important role in influencing market liquidity. Although the number of market participants has increased form 17 in 1997 to more than 8200 at the end of 2008 (Annual report of the Chinese inter-bank market [3]), it finds that commercial banks dominate the transactions in the market. Lin and Zhou (2006) point out that the Chinese commercial banks just hold the bonds to realize the purpose of asset restructuring and capital transfer, but they lack awareness about asset management through market transactions. The passive operation attitude of commercial bank also impairs market liquidity.

In addition, this paper examines whether the product design is a factor influencing liquidity mentioned by the report of the Bank for International Settlements

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[2] See http://www.dowsfinancial.cn/financial_view.asp?infoID=574
[3] See http://www.pbc.gov.cn

(BIS[2], 1999) empirically. The test involves two aspects, which are maturities and categories respectively. By using bid-ask spread as the reference indicator, the results of Kruskal-Wallis H test show that there exist significant differences of liquidity both with different maturities and different categories. Thus, we will discuss existing problems from the two aspects, one is maturity related to term structure, and the other one is bond category.

Firstly, the term structure of bonds is not so reasonable. The empirical result indicates that bonds with different maturities have different liquidity as shown in the section 4.3.1, where short-term bonds have the best liquidity, followed by medium-term bonds, and long-term bonds have the worst liquidity. Medium-term bonds are dominant in the inter-bank bond market of China, while short-term bonds and long-term bonds occupy small market shares. When demands of trade increase, they have to turn to medium-term bonds due to the lack of short-term bonds, which inevitably increases the transaction cost and undermines the liquidity.

Secondly, there is a lack of diversity of bonds in the market. Although the variety of the bonds in the inter-bank bond market of China is increasing, the main trading bonds are still government bond and policy-related financial bond based on government credits. On one hand, the data obtained from WIND database indicated that government bonds, central bank bills, policy-related financial bonds accounted for 32.03%, 21.8%, 30.13% respectively of the total market balance at the end of 2009, and the three parts took up 83.96%. On the other hand, the bonds based on commercial credit, like corporate bonds and financing debt, account for an extremely small proportion, implying that the inter-bank bond market cannot meet the financing demand of corporations.

5. Conclusions

The liquidity of bond market involves three dimensions, immediacy, transaction cost and transaction amount, while most of current indicators of liquidity merely reflect one single aspect of liquidity. This paper starts from the concept of liquidity, and applies principal-components analysis to construct a composite indicator of liquidity of the Chinese inter-bank bond market. The comprehensive score that results from the above-mentioned analysis overcomes shortcomings of previous single indicators that can merely cover one dimension of liquidity, and it is of great help to disclose the relationship between liquidity and the three factors, immediacy, transaction cost and transaction amount, and thus contributes to the further study on the microstructure of the Chinese inter-bank bond market.

This paper uses different indicators to measure the liquidity of government bond trading in the inter-bank bond market from 2007 to the first half of 2009, and examines the correlation of liquidity indicators. The results show that trading frequency is significantly positively correlated with trade size, and quote size is the indicator that has the highest correlations with other indicators, significantly negatively correlated with the bid-ask spread, trading frequency and trade size. The correlations indicate the consistence of using different liquidity indicators. However, it also proved that there is no perfect single liquidity indicator since all of them also contain specific information respectively. The result also provides a strong support of applying component analysis of these liquidity indicators.

Principal-components analysis is applied to calculate comprehensive score which is used to measure the liquidity in a more comprehensive way. The results imply that the liquidity had a tendency of decreasing in 2007. Affected by macro-economic policies and global financial crisis, the liquidity in 2008 had large fluctuations, and the liquidity increased remarkably in the first half of 2009, which was a good signal that

the economy was recovering from economic recession. Overall, the liquidity has been improved year by year. Combined with the true economy situation, the scores fit the real performance of the economy very well, and thus the efficacy of these scores is confirmed. The comprehensive score drawn from principle component approach is more overall than single liquidity measure when measuring the liquidity of a market for a specific time period. However, the score is not so convenient and easy to calculate, compared to other single liquidity measures, such as bid-ask spread, trade volume, etc, which can be used to compare among different countries directly. Hence, there leaves much space for future studies that can realize comparisons of several countries by using the comprehensive liquidity measure

This paper also compares the liquidity of China with that of other countries in year 2005 from the two dimensions, market tightness and market depth, interpreted by the bid-ask spread and turnover respectively. The results show that there exists a large gap between the liquidity of the inter-bank bond market in China and those in developed countries. BIS[3] (2002) points out that lack of liquidity becomes a challenge to the emerging market. A liquid bond market not only lowers financing costs but also facilitates assets pricing, promotes risk management and enhances the effectiveness of monetary policy. For a market, liquidity is the source of vigor and thus improving liquidity will be bound to attract different investors to enter the market, which will further boost the market liquidity due to risk diversification. Therefore, it is urgent for China to improve the liquidity.

To answer the question about how to improve liquidity, this paper tries to work on the factors with a great impact on liquidity. Kruskal-Wallis H test is employed to compare different bonds with different maturities and categories. In this test ,we choose bid-ask spread as the indicator of liquidity, and the results illustrate that there exist significant differences of liquidity both with different maturities and different categories. Hence, this provides empirical evidence for us that we can improve liquidity by optimizing bond structure.

Combined with the analysis of existing problem discussed before, several suggestions are proposed from the perspectives of market mechanism, market

participants and product design, respectively.

First, the market maker system should be improved. The government should give market makers support politically, such as providing convenient source of financing, allowing short selling, motivating their enthusiasm and initiative. Considering that the number of market makers is still insufficient and lack of diversity, it is better for the government to lower the requirement of being a market maker to improve the efficiency of trading.

Second, lower the threshold of investors to enter the market. Different types of market participants constitute a vigorous market. The introduction of foreign investors and financial institution may create a new situation, which also may bring changes to passive operation of domestic commercial banks.

Third, when it comes to product design, it is necessary to optimize the term structure of bonds and diversify the categories of bonds. In terms of the term structure, the market should pay attention to issuing short-term bonds, so as to enhance the ability to realize capital. Meanwhile, issuing some difference kinds of bonds is also a good solution to improve liquidity. With regard to the categories of bonds, the bonds are based on government credits or commercial credits, while the latter part takes up a small proportion, for instance, corporate bonds, as shown in Table 4.7, indicating that the inter-bank bond market cannot meet the financing demand of corporations due to immature credit rating system. In this way, a mature credit rating system has to be built up in order to provide market participants with useful service focused on credit and other information, to solve asymmetry information problems properly, lower financing costs, and improve the liquidity eventually.

6. References

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7. Appendix

i) Monthly liquidity indicators used in principal-components analysis

Month	Bid-ask spread	Quote size （million）	Trading frequency	Trade volume （0.1 billion）
2007 January	0.00219103	6428.57	35.85	5540.357
February	0.00265732	5682.20	32.94	5114.961
March	0.00272684	4880.99	35.86	6338.466
April	0.00398045	4857.79	37.22	7691.711
May	0.00581474	4777.91	31.39	5903.912
June	0.00727831	4656.93	39.33	7869.181
July	0.00751946	4343.81	32.64	4745.236
August	0.00629617	4226.15	37.39	6948.827
September	0.00709548	3771.07	35.50	8371.701
October	0.00974193	3738.14	35.83	7791.980
November	0.01133898	3957.51	33.68	12042.67
December	0.00701678	4349.31	60.43	21183.75
2008 January	0.00399567	4791.41	42.32	12270.36
February	0.00556084	4118.50	31.56	15549.08
March	0.00437540	3429.61	48.38	21192.36
April	0.00400047	3672.65	39.24	13798.63
May	0.00463802	4158.36	42.43	14318.70
June	0.00652922	3774.20	39.00	10823.63
July	0.00648671	3684.60	58.78	20312.65
August	0.00494938	3956.32	62.62	16114.55
September	0.00685654	3166.82	65.48	7550.675
October	0.00927218	2645.20	71.55	8091.426

November	0.00604217	2658.87	86.30	11473.38
December	0.00722581	2383.25	96.30	14474.69
2009 January	0.00748400	2545.39	103.53	11630.30
February	0.00825700	2310.78	93.48	10772.14
March	0.00638400	2648.50	82.36	12455.61
April	0.00536200	2856.94	67.90	11202.65
May	0.00349300	3539.64	69.26	12329.51
June	0.00390300	3696.03	74.35	21610.71

ii) Monthly factor scores (FACT1_1 and FACT2_1)

2007	FACT 1_1	FACT 2_1	2008	FACT 1_1	FACT 2_1
January	-1.06252	1.87358	**January**	0.08888	1.01340
February	-1.05081	1.40522	**February**	0.20512	0.48135
March	-0.64262	1.11837	**March**	1.59268	0.85487
April	-0.59295	0.78660	**April**	0.47778	0.65936
May	-1.14367	0.08354	**May**	0.41775	0.67410
June	-0.86456	-0.34369	**June**	-0.20958	-0.28493
July	-1.34647	-0.71257	**July**	1.41975	0.19220
August	-0.79513	-0.25544	**August**	1.12632	0.52244
September	-0.65187	-0.60219	**September**	0.14475	-0.94077
October	-1.02056	-1.49537	**October**	0.19652	-1.91461
November	-0.81111	-1.64716	**November**	1.33291	-0.73190
December	1.33264	0.34182	**December**	1.85674	-1.07821
2009	FACT 1_1	FACT 2_1			
January	1.07355	-1.28184			
February	0.75448	-1.60463			
March	0.89608	-0.70577			
April	0.54920	-0.30268			
May	0.75733	0.60419			
June	1.89194	1.14717			