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Are There Some Manipulations of SHIBOR: A Hypothesis Testing Based on Financial Products Linked to SHIBOR

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Abstract

Manipulation of LIBOR events has sounded the alarm to our how to regulate the development the SHIBOR. The financial products linked to SHIBOR have emerged in recent years, bank of SHIBOR quoting may based on self-interest, there may be an intrinsic motivation for higher or lower quoting SHIBOR. Based on analysis of financial products linked to seven-days-SHIBOR and three-months-SHIBOR between 2010 and 2011, and do a hypothesis testing that are there some manipulations of SHIBOR. The testing result showed that during the date of sales financial products, the higher quoting SHIBOR behavior may be existing, in order to raise people's expectations of yield of financial products, but lower quoting SHIBOR behavior may not be existing at the date of calculating interest of financial products.

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1. Introduction

The London Interbank Offered Rate (LIBOR) is the average interest rate estimated by leading banks in London that they would be charged if borrowing from other banks. LIBOR has become one of the most important reference standards for interest rate in the global financial markets, at the same time, the change of LIBOR will impact on price of a lot of financial products. In June 2012, Exposed LIBOR manipulation event brought a huge shock to the entire industry. Thus, it is causing people to think what is the reason of LIBOR manipulation event, how it is effects of LIBOR manipulation event, and so on. The Shanghai Interbank Offered Rate (SHIBOR) is the average interest rate at which term deposits are offered between prime banks in the Shanghai wholesale money market or interbank market at China. Because there are some same mechanisms and functions between SHIBOR and LIBOR, so LIBOR manipulation event cause we think is there SHIBOR manipulation event at china financial market. According to this doubt, this paper will do a hypothesis testing on SHIBOR manipulation event based on data of financial products linked to SHIBOR.

Although the SHIBOR not like LIBOR as an important interest rate of global financial market, but it has a more and more role in domestic market. After naissance of SHIBOR, domestic scholar has studied on SHIBOR in the following aspects (1) The SHIBOR can become the benchmark interest rate on the money market in China? As well as empirical analysis of SHIBOR effectiveness [1-4]. (2) What are the characteristics of SHIBOR fluctuations [5-6]. (3) How to price the financial product of lined to SHIBOR [7-8]. (4) The term structure of SHIBOR analysis

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and empirical research [9-10]. (5) Empirical research between SHIBOR and repo rate of national bond [11-12]. Before exposing of LIBOR manipulation event, there is no scholar pay attention to the probability of SHIBOR manipulation. But LIBOR manipulation event tell us there may be also exist the probability of SHIBOR manipulation, the intrinsic reason may come from the bug of operation mechanisms.

Now, the price quotation group of SHIBOR consists of 16 commercial banks. These quoting banks are primary dealers of open market operation or market makers in the interbank market, with sound information disclosure and active RMB transactions in China's money market. In recent years, more and more commercial banks included SHIBOR price quotation member issued a lots of financial products linked to SHIBOR. So the change of SHIBOR will affect the values of more and more financial market in china. Similar to the LIBOR quotes and manipulation, some commercial banks also may be quote lower or higher SHIBOR for certain purposes, for example, while sale date of the financial products lined to SHIBOR, commercial banks may quote more higher SHIBOR, and improve the attractiveness for investors, on the other hand, at the coupon date, commercial banks may quote more lower SHIBOR for purpose of paying more lower coupon.

In short, according to SHIBOR price quotation mechanisms, commercial banks of SHIBOR price quotation member are both athletes and judges. This mechanism lead to commercial banks may have motive to manipulate SHIBOR price quotation with self-interest. Of course, whether there are real manipulating events may need to be ruled from a legal perspective, this paper only from the academic side, based on limited data and logical assumptions, do a hypothesis testing on SHIBOR manipulation event.

The paper is organized as follows. In section two, we analyzes the data of financial product lined to SHIBOR. In section three, we put forward some models to do hypothesis testing on SHIBOR manipulation event. Finally, section four offers some concluding remarks.

2. Data of financial products linked to seven-days-SHIBOR and three-months-SHIBOR

Since 2010, many Chinese commercial banks have issued a lot of financial products linked SHIBOR. For example, in the past two years, a commercial bank of SHIBOR price quotation have issued more than 1100 variety financial products linked SHIBOR, and the most active financial products linked SHIBOR were linked to seven-days-SHIBOR or three-months-SHIBOR. So the following research mainly focus on the financial products linked to seven-days-SHIBOR or three-months-SHIBOR.

In the European financial market, Eurodollar deposits and LIBOR usually is highly relevant and consistent. So Eurodollar deposits also have a role to judge whether LIBOR is rational. But in Chinese, there is no an authoritative third-party rate reference to whether SHIBOR is rational. Many scholars think that the Repo rate of National bond may be a good reference to whether SHIBOR is rational, and do some empirical researches between SHIBOR and repo rate of national bond. So we collect the data of seven-days-SHIBOR, three-months-SHIBOR, seven-days-repo-rate, three-months-repo-rate between 2010 and 2011. The result of statistical analysis of the data are shown in table 1, Fig1 and Fig2.

Table 1. Statistical analysis on repo rate and SHIBOR

<table>
<thead>
<tr>
<th>Rate type</th>
<th>Number of valid data</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Unit root stationery test</th>
</tr>
</thead>
<tbody>
<tr>
<td>seven-days-SHIBOR</td>
<td>490</td>
<td>3.08%</td>
<td>1.517%</td>
<td>stationery</td>
</tr>
<tr>
<td>seven-days-repo-rate</td>
<td>490</td>
<td>3.27%</td>
<td>1.54%</td>
<td>stationery</td>
</tr>
<tr>
<td>three-months-SHIBOR</td>
<td>500</td>
<td>3.83%</td>
<td>1.520%</td>
<td>none</td>
</tr>
<tr>
<td>three-months-repo-rate</td>
<td>500</td>
<td>3.95%</td>
<td>1.59%</td>
<td>none</td>
</tr>
</tbody>
</table>
According to the statistical characteristics and the trend of Figure 1~2, and referring to the repurchase market interest rate, we can’t find there is obviously anomaly of SHIBOR; this is also consistent with some empirical studies of the interaction between SHIBOR and repo rate.

Further we have collected the data of financial products linked to SHIBOR issued by a commercial bank of SHIBOR price quotation. Those financial products’ coupon relies on the seven-days-SHIBOR or Three-months-SHIBOR. Corresponding to each rate of seven-days-SHIBOR and Three-months-SHIBOR between 2010 and 2011, we note those dates that it is the coupon date of financial products linked to seven-days-SHIBOR and Three-months-SHIBOR, and denote it by variable $d_t^7$ and $M_t^3$:

$$d_t^7 = \begin{cases} 1, & \text{it is the coupon date of financial products linked to seven-days-SHIBOR} \\ 0, & \text{other} \end{cases} \quad 1 \leq t \leq 490$$

$$M_t^3 = \begin{cases} 1, & \text{it is the coupon date of financial products linked to three-months-SHIBOR} \\ 0, & \text{other} \end{cases} \quad 1 \leq t \leq 500$$

So $d_t^7 = 1$ means it is a coupon date of a financial products linked to seven-days-SHIBOR at time $t$.

If a commercial bank of SHIBOR price quotation expects to manipulate SHIBOR for help sale the financial products linked to SHIBOR, they may will quote higher SHIBOR during the sales period and lend to investor have
more higher expected invest return. On the other hand, after over the sales activity, and at coupon date reference to SHIBOR, they may will quote lower SHIBOR for pay more lower coupon to investor. This Manipulation will give more profit to commercial bank form issued financial products linked to SHIBOR.

According to above analyzes, if there are obviously manipulation of SHIBOR, at a coupon date of financial products linked to SHIBOR, there may be a lowest quotation price for SHIBOR. So we have done a statistics analysis how much SHIBOR data on a coupon date of financial products lower than the average value of five days data (Table 2).

<table>
<thead>
<tr>
<th>Financial products type</th>
<th>The total number of coupon date</th>
<th>The total number of that SHIBOR on a coupon date of financial products lower than the average value of five days SHIBOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>linked to seven-days-SHIBOR</td>
<td>$63 = \sum S_{t}^{7d}$</td>
<td>$33$</td>
</tr>
<tr>
<td>linked to three-months-SHIBOR</td>
<td>$104 = \sum S_{t}^{3M}$</td>
<td>$40$</td>
</tr>
</tbody>
</table>

However, according the third column data of table 2, there isn’t a more probability to support our assumes of SHIBOR manipulation, so we will put ford a model to do a hypothesis testing in next section.

3. Hypothesis testing on SHIBOR manipulation

According above analyze for motive of SHIBOR manipulation, the manipulation may will take place at two periods, one period is during the date of sale and the other period is the coupon date of financial product. SHIBOR manipulation has different purpose and method at two periods.

So at first, we put ford following assumptions.

**Hypothesis 1**: During the date of sale financial product, there is SHIBOR manipulation event.

**Hypothesis 2**: During the coupon date of financial product, there is SHIBOR manipulation event.

Secondly, there are some variable denotations needs to introduce:

1. $d_{t}^{7d}$ denotes the data of seven-days-SHIBOR.
2. $h_{t}^{3M}$ denotes the data of three-months-SHIBOR.
3. $r_{t}^{7d}$ denotes the data of seven-days-repo-rate.
4. $r_{t}^{3M}$ denotes the data of three-months-repo-rate.

The definition of $S_{t}^{7d}$ and $S_{t}^{3M}$ see section two, and $t$ denote the one of date between 2010 and 2011.

When at time $t$, begin to sale the financial product linked to SHIBOR, the unknown information are future value of SHIBOR at coupon date, but the coupon date of financial product is known for commercial bank or investor. In the same, the future values of $S_{t}^{7d}$ or $S_{t}^{3M}$ are determinate, etc $S_{t+k}^{7d} = 1$ or $S_{t+k}^{7d} = 0$. If we known next day is the reference date of SHIBOR for determining how much coupon will be defrayed to investor, today it may be quote higher SHIBOR and let investor expect the next day will have same high SHIBOR. On the other hand, the SHIBOR market may reference to the repo market, so we have a following mode:

$$h_{t}^{7d} = c_{1} + \alpha_{1} h_{t-1}^{7d} + \beta_{1} r_{t-1}^{7d} + \rho_{1} S_{t}^{7d} + \varepsilon_{t}$$  \hspace{1cm} (1)

$$h_{t}^{7d} = c_{2} + \alpha_{2} h_{t-1}^{7d} + \beta_{2} r_{t-1}^{7d} + \rho_{2} S_{t}^{7d} + \varepsilon_{t}$$  \hspace{1cm} (2)

In Eq.(1) and Eq.(2) there are one term of lag SHIBOR and repo rate of time series. If hypothesis 1 is true,
The $\rho_1$ in Eq. (1) will be positive, and $\rho_1 > 0$ it is significative underling a certain probability, so the hypotheses equal to the following hypothesis test:

$$H_0 : \rho_1 = 0$$
$$H_1 : \rho_1 \neq 0$$

Then, we get the evaluation of coefficient in Eq. (1) by OLS:

$$\hat{h}_{t}^{7d} = 0.00122 + 0.31122 h_{t-1}^{7d} + 0.62813 r_{t-1}^{7d} + 0.00118 S_{t+1}^{7d}$$

The $t$-statistics of $\rho_1$ is $t_{\rho_1} = 1.7846$, corresponding probability $p = 0.0793$. If the confidence level is 10%, so it will refuse hypothesis $H_0$. It means that $S_{t+1}^{7d}$ is a significative dependent variable of $S_{t}^{7d}$, and because $\hat{\rho}_1 = 0.00118 > 0$, it means that next day is the reference date of SHIBOR for determining coupon of financial product linked to SHIBOR, then at date $t$ commercial bank will quote higher SHIBOR for the sake of attracting investor to buy the financial products, which means there are some potential SHIBOR manipulation event. But if the confidence level is 1% or 5%, we can’t refuse hypothesis $H_0$, which means there are not some potential SHIBOR manipulation event.

It is homologous to above hypothesis $H_0$. Do a hypothesis test of $\rho_2$ in Eq. (2) by following hypothesis test:

$$H_0 : \rho_2 = 0$$
$$H_1 : \rho_2 \neq 0$$

We also get the evaluation of coefficient in Eq. (2) by OLS:

$$\hat{h}_{t}^{7d} = 0.001236 + 0.297761 h_{t-1}^{7d} + 0.644803 r_{t-1}^{7d} + 0.00054 S_{t}^{7d}$$

The $t$-statistics of $\rho_2$ is $t_{\rho_2} = 0.798807$, corresponding probability $p = 0.4248$. So underling the confidence level 10%, 5% and 1%, we can’t refuse the hypothesis $H_0$. It means that $\rho_2 = 0$ is significative, and at the reference date of SHIBOR for determining coupon of financial product linked to SHIBOR has not SHIBOR manipulation event.

Similarly, we use data of three-months-SHIBOR and three-months-repo-rate do the same hypothesis testing by following equation:

$$h_{t}^{3M} = c_3 + \alpha_3 h_{t-1}^{3M} + \beta_3 r_{t-1}^{3M} + \rho_3 S_{t}^{3M} + \epsilon_t$$

And the evaluation of Eq. (7) and Eq.(8) are following:

$$h_{t}^{3M} = 0.0000133 + 0.95476 h_{t-1}^{3M} + 0.00044868 r_{t-1}^{3M} + 0.000097 S_{t}^{3M}$$
$$h_{t}^{3M} = 0.0000171 + 0.95486 h_{t-1}^{3M} + 0.00044798 r_{t-1}^{3M} + 0.000074 S_{t}^{3M}$$

The $t$-statistics is $t_{\rho_3} = 1.8713$ and $p = 0.0619$, $t_{\rho_3} = 1.423773$ and $p = 0.1551$.

Finally, according to the confidence level 10%, 5% and 1%, the summarize result in table 3.

**Table 3. The summarize of hypothesis testing**

<table>
<thead>
<tr>
<th>Hypothesis testing</th>
<th>Data Type</th>
<th>confidence level 1%</th>
<th>confidence level 5%</th>
<th>confidence level 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesis testing 1</td>
<td>Financial product linked to seven-days-SHIBOR</td>
<td>Refusing</td>
<td>Refusing</td>
<td>Not Refusing</td>
</tr>
<tr>
<td></td>
<td>Financial product linked to three-months-SHIBOR</td>
<td>Refusing</td>
<td>Refusing</td>
<td>Not Refusing</td>
</tr>
<tr>
<td>Hypothesis testing 2</td>
<td>Financial product linked to seven-days-SHIBOR</td>
<td>Refusing</td>
<td>Refusing</td>
<td>Refusing</td>
</tr>
<tr>
<td></td>
<td>Financial product linked to three-months-SHIBOR</td>
<td>Refusing</td>
<td>Refusing</td>
<td>Refusing</td>
</tr>
</tbody>
</table>

In summary, based on the limited data and sample analysis, we think that during the period of sales financial products linked to SHIBOR. The commercial banks may quote higher SHIBOR for the sake of improve the expected
the return of financial products. But there may not be quote lower SHIBOR at the reference date of coupon of financial products.

4. Summary

In short words, there may also exist the possibility of manipulation SHIBOR in Chinese financial market in terms of logic or statistical hypothesis testing on the certain data of financial products linked to SHIBOR. Although we think that the design of financial products linked to SHIBOR will affect the motive of SHIBOR manipulation and the feasibility of SHIBOR manipulation for commercial banks. But as long as commercial banks are both issuer of financial products linked to SHIBOR and offer of SHIBOR, there are motive to manipulate SHIBOR. To reduce this intrinsic motivation of SHIBOR manipulation, it should be strong to regulate the financial products design, and optimize the quote mechanism; Of course, there are still a lot of works worth exploring.

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References