Analysis of Exchange Rates and Gold Price Using Relative Noise Contribution

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Abstract

We analyze the time series of exchange rates and gold price, USD/JPY, EUR/USD, USD/CHF, GBP/USD and XAU/USD, in the period before and after the bankruptcy of Lehman Brothers by using relative noise contribution. Relative noise contribution detects the influences among multiple time series. As a result, we found the exchange rates and gold price are basically driven by their own influence. However, when the affairs happened, they sometimes were driven by other rates or price. In addition, the reaction to the affairs is changed before and after the bankruptcy of Lehman Brothers. These may result in the difference of trader’s ideas between before and after of the bankruptcy. This result implies that the framework has a potential to find some relationship among the markets and participant’s behavior.

1 Introduction

Several financial crises have broken out in these 20 years. Though they have large impact on our society, it is impossible to prevent damage from them because there are many factors to cause the financial crises. For example, disasters, economic and political activities trigger financial crises. Financial crises change the financial indicators in one direction in a short term and make the economic activity sluggish in a long term. One of the largest financial crises is the bankruptcy of Lehman Brothers in September 2008. It crashed the Dow Jones Industrial Average which kept recession for some years. Therefore, revealing factors causing a financial crisis is major problem and is treated by various approaches.

One of the approaches for finding factors causing a crisis is to analyze a temporal change of the estimates on the economic structure obtained from analysis of financial crisis dataset. Tanokura and Kitagawa [1] focused on sovereign CDSs for several areas as measurements of sovereign risk. They conducted generalized relative noise contribution analysis and detected the spillover effects of the European debt crisis. Relative noise contribution evaluates how much a time series is affected by others in terms of frequency domain [2].

In this paper, we investigate the temporary change of fluctuation structure focusing on crash by using relative noise contribution. We choose the period in September 2008 of the bankruptcy of Lehman Brothers because this affair is the beginning of recent recession. Especially, we focus on the changes before and after the bankruptcy of Lehman Brothers.

In Section 2, the analysis framework of the relative noise contribution is explained by following the reference [2]. We refer to the used data and affairs in September 2008 in Section 3, we discuss the result of analysis in Section 4, and we state our conclusion with future researches in Section 5.

2 Analytical Method

Noise contribution is one of the methods of analyzing the relationship among time series [2]. This method comes from vector autoregression model

\[
y_n = \sum_{m=1}^{M} A_m y_{n-m} + v_n,
\]

where \( y_n = (y_n(1), \ldots, y_n(\ell))^T \) is \( \ell \) dimensional time series, \( M \) is order of AR models, \( A_m \) is the coefficient matrix and \( v_n = (v_n(1), \ldots, v_n(\ell))^T \) is white noise. By calculating the Fourier transform of the autocorrelation matrix, we obtain power spectrum \( P(f) \) in the following form:

\[
P(f) = A(f)^{-1} W(A(f)^{-1})^*,
\]

where \( W \) is covariance matrix of error terms, \(^*\) is Hermite transpose and \( A(f) \) is the matrix of the following term:

\[
A(f) = I - \sum_{m=1}^{M} A_m e^{-2\pi i mf}.
\]

Then, we set \( B(f) = A(f)^{-1} \), and \( b_{ij}(f) \) is the \((i,j)\) element of \( B(f) \). Assuming that there are no correlation among the error terms, we can deform equation (2) as follows:

\[
p_{ij}(f) = \sum_{j=1}^{\ell} b_{ij}(f) \sigma_{ii} b_{ij}(f)^* = \sum_{j=1}^{\ell} |b_{ij}(f)|^2 \sigma_{ii},
\]

where \( 1 \leq i, j \leq \ell \).
Where $\sigma_{ii}$ is variance of $v_n(i)$, and $p_{ii}(f)$ is the diagonal element of $P(f)$. $p_{ii}$ represents that power spectrum of $i$ element can separate into $\ell$ pieces of noise and the effect is given by $|b_{ij}(f)|^2\sigma_{ii}$.

From (4), we can define

$$r_{ij}(f) = \frac{|a(f)_{ij}|^2\sigma_{ii}}{p_{ii}(f)}.$$  \hspace{1cm} (5)

When we regard power spectrum as one in each frequency, $r_{ij}(f)$ is the effect on time series $i$ from time series $j$ in the frequency.

In this paper, we selected four exchange rate and gold price. Therefore, $\ell = 5$ in equation (5) and the number in $i$ and $j$ which range from one to five correspond to USD/JPY, EUR/USD, USD/CHF, GBP/USD and XAU/USD. For example, $r_{11}(f)$ gives the effect on USD/JPY from USD/JPY, and $r_{12}(f)$ gives the effect on USD/JPY from USD/EUR.

We basically analyze all time series data in a day, which contains 1440 data point. On the other hand, time series of every Friday and September 22 and September 29 are not used, because dealing was not happened at night in all exchange rates on Fridays. In September 22 and September 29, dealing doesn’t start at midnight because Monday is start of exchange dealing. Therefore, we use the data until noon on Fridays and use the data from 1:17 a.m. to midnight in September 22 and from 0:45 a.m. to midnight in September 29.

We choose four exchange rates and gold price, USD/JPY, EUR/USD, USD/CHF, GBP/USD and XAU/USD. We used dollar as the key currency because dollar is used as the key currency in the real world. We also select three rates in descending order of dealing times. Furthermore, we select gold price because it is deeply involved with exchange price and used as the safe asset.

We use the programming package, “timsac” in R language to analyze. We define that these rates and price are influenced by other rates or price when that effect is over 5%. We assumed that there is no week effect because we cannot find the differences among each days of the week. Also, we arrange the affairs in Table 1 for making the comparison between the results of analysis and the affairs[5][6][8][7]. The following are the results of analysis.

4 Result

4.1 Basic tendency

We found the basic tendency in normal times by relative noise analysis. Figure 2 is the example graphs of basic tendency. This graph is the stacked charts of effect ratio.

(1) USD/JPY is fluctuated by its own effect.

(2) EUR/USD is fluctuated by its own effect.

(3) GBP/USD is influenced by EUR/USD in a low frequency domain on several days.

(4) XAU/USD is influenced by EUR/USD in a low frequency domain on several days.
Table 1: The Affairs happened in Sep. 2008

| Date   | Affairs                                                                                                                                 |
|--------|----------------------------------------------------------------------------------------------------------------------------------------|
| Sep. 1 | · Dresdner Bank was taken over by Commerzbank.                                                                                         |
|        | · Prime minister Fukuda resigned.                                                                                                     |
| Sep. 3 | · The Korea paper reported that Korea Development Bank acquires share of Lehman Brothers.                                             |
| Sep. 9 | · A news agency of America reported failing in negotiation between Korea and Lehman.                                                    |
| Sep. 10| · It was announced that Lehman Brothers had financial deficit the amount of $3.9 billion from June to August.                            |
|        | · Although Lehman Brothers presented restructuring plan, radical reform and recapitalization was not included.                           |
| Sep. 15| · Lehman Brothers went into bankruptcy.                                                                                               |
| Sep. 16| · The FRB approved that they provide “American International Group, Inc” with $85 billion in financing to avoid the business failure.   |
| Sep. 18| · It was announced that the Central banks of USA, Japan, United Kingdom, Canada, EU and Switzerland decided to make a contract of “Central bank liquidity swap”. |
| Sep. 24| · It was announced that the Central banks of USA, Australia, Sweden, the King of Denmark, and Norway decided to make a contract of “Central bank liquidity swap”. |
|        | · Mr. Aso was inaugurated as Prime minister.                                                                                          |
| Sep. 25| · As the result of the financial inflow in dollar, bid price didn’t reach the $30 billion.                                              |
| Sep. 29| · “Emergency Economic Stabilization Act of 2008” was not passed.                                                                       |

Fig. 2: Graphs of noise contribution rate for exchange rates and gold prices in September 1. The vertical line shows the effect ratio of each time series and the horizontal one shows frequency. Red, blue, green, yellow, and purple represent the effect of USD/JPY, EUR/USD, GBP/USD, USD/CHF, and XAU/USD, respectively.

(5) USD/CHF is influenced by EUR/USD in a low frequency domain.

It is noted the feature of (1), (2) and (5) were found in most days. On the other hand, the feature of (3) and (4) were seen in some days, and the day not to influenced by other rates and price were found. Moreover, there were no days which were influenced by other rates in a high frequency domain. On the whole, most large effects in fluctuations are own effect in all frequency domain.

The above results show that most large effects to fluctuate is the own effect of exchange rates or gold price. This reflects that a dealer focuses on his/her own profit and loss based on the currency. This discuss also show that all rates and price are almost entirely fluctuated by their own effect in a high frequency domain.

We found that XAU/USD and GBP/USD have the similar tendencies as they showed the similar contribution in low frequency domains. Table 2 is the average number of trading per week. In fact, these two rates share the similar feature which the average number of
trading is lower than others.

Table 2: The average of trading in a week

| Rates   | Week   | Sep.1 | Sep.8 | Sep.15 | Sep.22 | Sep.29 |
|---------|--------|-------|-------|--------|--------|--------|
| USD/JPY | 14451.8| 16740.4| 22438.4| 14639.2| 15566.8|
| EUR/USD | 20468.8| 24078.6| 27322.8| 21909.2| 23804.4|
| GBP/USD | 763.6  | 606.2 | 830.6 | 581.8 | 756.8  |
| XAU/USD | 1004   | 1353.8| 1488.4| 889.4 | 735.2  |
| USD/CHF | 6606.4 | 7384.6| 10290.6| 7452  | 7892   |

4.2 Particular tendencies

We also found several tendencies which are different from basic tendency stated in the previous section. The different tendencies are as follows:

1. The maximal amount of influence to USD/JPY and EUR/USD from other rates and gold price is more than 10% in a low frequency domain.

2. The maximal amount of influence to USD/CHF from other rates and gold price is more than 40% in a low frequency domain.

3. The influence to USD/CHF from other rates and gold price is less than 5% in low frequency.

4. The maximal amount of influence from other rates and gold price is more than 5% in a high frequency domain.

Table 3 is the results of the days when the different tendencies were seen and shows which feature is different from basic tendencies. Figure 3 is the example how the different tendencies were. Where, concerning GBP/USD and XAU/USD, if these exchange rates are influenced in a low frequency domain, we do not regard these exchange rates as having particular tendencies because these exchange rates are influenced in a low frequency domain on several days. Comparing between before and after the bankruptcy of Lehman Brothers, the number of days which USD/JPY and EUR was affected by other rates and gold price increased.

Table 1 and Table 3 show that affairs did not affect the fluctuations of exchange rates and gold price before the bankruptcy of Lehman Brothers. However, affairs affected the fluctuations structure of exchange rate fluctuation after the bankruptcy of Lehman Brothers. Although the different tendency was seen on September 4, there was no affairs. If we take the time-zone difference between Korea and United Kingdom and it is assumed that the news of the Korean paper had influenced on the market structure, different tendency could be observed not on September 4 but on September 3. Moreover, on September 9, we also did not find different tendencies from the basic one. In contrast, on September 16, 25 and 29, we found different tendencies.

Table 3: The day when different tendencies were seen

| Day       | Exchange rates and Gold Price | State |
|-----------|-------------------------------|-------|
| September 4 | USD/JPY                      | (1)   |
|           | USD/CHF                      | (2)   |
| September 8 | USD/CHF                      | (3)   |
| September 16 | USD/JPY                      | (1),(4) |
|           | EUR/USD                      | (4)   |
|           | USD/CHF                      | (4)   |
| September 25 | USD/JPY                      | (1)   |
|           | USD/CHF                      | (2)   |
| September 29 | USD/JPY                      | (1),(4) |
|           | EUR/USD                      | (1),(4) |
|           | GBP/USD                      | (4)   |
|           | XAU/USD                      | (4)   |
|           | USD/CHF                      | (2),(4) |

Fig. 3: Graph of noise contribution rate on September 29. The vertical line shows the effect ratio of each time series and the horizontal one shows frequency. Red, blue, green, yellow, and purple represent the effect of USD/JPY, EUR/USD, GBP/USD, USD/CHF, and XAU/USD, respectively.

These investigations show the change of a dealer’s idea before and after the bankruptcy of Lehman Brothers. The dealers thought that Lehman Brothers was one of the largest financial companies and the United States would give a loan to the Lehman same as the
case with Bear Stearns in 2007. However, the company went into bankruptcy, many people pay attention to decrease the risk of the loss and then market structure had likely to change.

Although the days of September 18, 24 and 29 are in the same situation from the point of view of publication of economic policies, September 29 has the different tendency and September 18 and 24 do not have the tendency. It may come from the difference of the purpose of economic policy. That is, September 18 and 24 were the dates of announcement of Central bank liquidity swap, and September 29 was announcement date of the economic bailout against the banks.

Compared between the graphs of September 16 and 29, USD/JPY was affected by other exchange rates and gold price in high frequency. It comes from the same fluctuations, decreasing in one direction, when the we saw the original data.

5 Conclusion

This paper analyzes relationship of fluctuation among exchange rates of the USD/JPY, EUR/USD, USD/CHF, GBP/USD, and gold price of XAU/USD in a minute data in September 2008 using relative noise contribution. As the result, the exchange rates and the gold price basically fluctuate due to their own price fluctuations. However, the fluctuation structure of these rates and gold price significantly changed because of the bankruptcy of Lehman Brothers. These findings imply that the market structure had changed at the time.

By using the relative contribution analysis, affairs can be classified from the viewpoint of change of fluctuation structure. This can be useful to clarify impacts of affairs. For example, if an affair occurs and fluctuation structure does not change, the affair has not impact on exchange rate. Furthermore, this result implies that the framework has a potential to find some relationship among the markets and participant’s behavior.

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