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Empirical Research on the Relations among Duration, Volume and Orderflow with Ultra-High Frequency USD JPY rate

Masayuki Susai [*1]

[*1]Nagasaki Univerisity

With special Ultra-High Frequent JPY against UDS rate data, we investigate the features of foreign exchange dealers in terms of duration, volatility, volume and orderflow. ACD model developed by Russell/Engle(1995) enables us to use tick-tick type foreign exchange data without any loss of information. In addition to ACD model, we use GARCH type model modified to fit the tick-tick data.

The relations among volatility, duration and expected duration were tried to investigate. It is clear that realized duration, surprised part of duration and expected duration have significant effect on volatility. Long run realized volatility also affects volatility. But the ways these many kinds of durations and long run volatility effect on volatility are different between 2007 and 2008. The reason for this difference may come from Subprime and Lehman's shock. But we need to do more research to confirm this reason..

1. Introduction

We have two ways to analyze tick-by-tick type data. Easiest way to estimate some models, we convert raw data into even spaced data set. In this method, we need to lose important information. For example, if we construct 5 minutes interval data, we use only one data in 5 minutes. The data we use here contains the data with every 230mili second intervals. We may lose at most 18000 data in every 5 minutes. For avoiding this lost, we intend to use Autoregressive Conditional Duration model (ACD thereafter) developed by R.Engle and J.Rusell(1995). After their wonderful works, so many researchers in this field started to use and develop new types of ACD.

In this paper, we utilize LogACD(2,2) model and GARCH type representation with Ultra-High Frequency data also developed and proposed by Engle(1996). By these models, we are going to investigate dealers trading activities in terms of duration, volatility, volume and orderflow. As Clark(1973) started to stress that volume can be the good proxy of information inflow to the markets. Lyons(2001) found that orderflow plays more informative work in the market. We will compare these two candidates of information proxy as well. As we mentioned above, we have difficulties to use traded price and volume from foreign exchange market for many years. This kind of research in this field is one of the first trials..

For exploring the features of dealers activity, we will use the basic ideas proposed by Diamond/Verrechia(1986) and Easly/O'Hara(1992). Those models are good to explain the time intervals between each trade. We call this interval as duration in this paper. In Diamond/Verrecchia(1986), if some dealers have bad information, then they might wait for next chance to trade to utilize their informational advantage. In this situation, longer duration means that bad news comes to informed dealers. On the other hand in Easly/O'Hara paper, if the market is efficient and some portion of dealers have some informational advantage, these informed dealers do not want to trade without any profitable information to them. In this case, long duration means no crucial event occurred. These two models are really the model we have to test with empirical method. In this paper, we intend to test these two ideas..

2. Data

Real traded data is difficult to use in FX market. But in this paper, we use real traded data from ICAP, named Data Mine ver.5 directly taken from EBS system. This data set provides us the foreign exchange rate at which dealers actually traded, bid or ask indicator, volume and order book in 250 millisecond interval. As we know, so many dealers in banks and financial institutions in the world are trading through this EBS system run by ICAP. The earlier versions of Data Mine do not contain volume of each trade and order book.

In this paper, we use the data at which dealers actually traded and we call this data as "deal data". Data Mine ver.5 is nearly tick by tick data. The intervals of deal data are uneven. Sometimes, this feature of the data might have some trouble when we estimate the model. Here we will use ACD and GARCH type model proposed by Engle (1996) to deal with uneven spaced Ultra-High Frequency data.

Our data spans from 1st of July to 30th of September in 2007 and 2008. In these periods, Lehman Brothers failure had occurred in September, 2008. From July to September in 2008, we had so called Subprime problem, we chose same period in 2007 as the baseline for comparison. For using same months' data, we can control month of the year effect. In 2007, we will use more than 1 million data, and more than 1.2 million in 2008.

In our research, we use Japanese Yen against US Dollar rate. We also use transaction time, transaction volume and bid or ask indicator. At first, we define the duration between each trade. Let ti be the transaction time at time i and be as duration between each transaction.

With the bid or ask indicator, we affirm the direction of the transaction. For example, if the bid indicator is assigned to a USD rate, this means the bid side of the USD rate is hit by the counter part of the transaction. This transaction may have downward pressure to the USD rate. For these reasons, we use bid or ask indicators as the price pressure indicator and can be

recognized as orderflow direction index. Trading volume also has impact on price movement. Bigger volume usually has bigger impact on price movement. We sum up the total volume of bid transaction multiplied by bid indicator (-1) and ask transaction multiplied by ask indicator (1). This amount can be recognized as orderflow in each transaction. These variables might have impact on duration through the impact on USD rate movement.

For eliminating the seasonality from duration data, we convert the raw data to seasonality adjusted data through equation (1).

$(\tau_i)\hat{} = \tau_i/(\varphi_{(t_i)})$ (1)

$\tau\hat{}$ is adjusted series and $\varphi_{(t_i)}$ is smoothed value at time i. To get$\varphi(t_i)$ series, we use exponential smoothing with Hold-Winters additive seasonal variation method. Hereafter, we use seasonality adjusted duration in all estimations.

3. Model

3.1 ACD Model

Following Engle/Russel(1995), we assume,

$(\tau_i)\hat{} = \psi_i \varepsilon_i$, $\varepsilon_i \sim$ i.i.d . (2)

This assumption allows us to describe the duration as mean function of ψ_i .

$\ln(\psi_i) = \omega + \sum_{j=1}^{n} \alpha_i (\tau_{(i-j)})\hat{} + \sum_{j=1}^{m} [\beta_{(j)} \ln(\psi_{(i-j)}) + \sum_{j=1}^{k} \rho_j z_{(i,j)}]$ (3)

In this paper, we adopt Log ACD model as follows. With (2) and (3), we can derive the quasi-likelihood function to estimate hazard function of $(\tau_i)\hat{}$.

$\ln L = -\sum_{i=1}^{N} [\ln\psi_{i+\tau_i}/\psi_i$ (4)]

3.2 GARCH type Model

Let σ_i^2 be the conditional variance of the process per second and hi be the conditional variance of individual trade. We assume that these two conditional variances are related as follows.

$h_i = (\tau_i)\hat{}\ \sigma_i^2$ (5)

If s_i only depends on past information, the expected variance of s_i can be written as follows by using equation (4) .

$E_{(i-1)}(s_i^2) = E_{(i-1)}(h_i) = E_{(i-1)}([(\tau_i)\hat{}\ \sigma_i^2) = \psi_i\ \sigma_i^2$ (6)

$\sigma_i^2 = \omega + \alpha(\epsilon_{(i-1)}^2)/(\tau_{(i-1)}) + \beta\sigma_{(i-1)}^2$ (7)

4. Results and Discussions

4.1 Estimation Model

For accomplishing our research objectives, we employ ACD (2,2) model below.

$\ln(\psi_i) = \omega + \sum_{j=1}^{2} \alpha_i (\tau_{(i-j)})\hat{} + \sum_{j=1}^{2} [\beta_j \ln(\psi_{(i-j)}) + [\gamma_1 s_{(i-1)}]_- + \gamma_2 [s_{(i-2)}]_- + \rho_1 vol_{(i-1)} + \rho_2 of_{(i-1)} + \nu_1 D\_T + \nu_2 D\_ld$ (8)

From the discussion of Clark(1973), volume can be the proxy of information inflow to the market. On the other hand, Evans/Lyons(2002,2006) suggests that orderflow has much information relative to volume. It might be true because orderflow can be computed by order direction information and volume. By checking the parameter ν_i , we can guess which has more impact on future expected duration.

$s_i = c + \lambda_i (\tau_i)\hat{}$ (9)

$\sigma_i^2 = \omega + \alpha(\epsilon_{(i-1)}^2)/(\tau_{(i-1)})\hat{} + \beta\sigma_{(i-1)}^2 + \theta_{(1)}\xi_{(i-1)}/\psi_{(i-1)} + \theta_2(\tau_i)\hat{}/\psi_i + \theta_3(\tau_i)\hat{} + \theta_4 [\phi]_i^{(-1)}$ (10)

In equation (10), ζ_i is a so called long run volatility. We compute long run volatility as exponential smoothing series of realized volatility of si . λ_i can capture simultaneous relation between duration and foreign exchange movement. θ_i can measure the impact of long run volatility, many kinds of past durations on volatility. θ_2 captures the surprise component of duration. If the value of this variable increase, relative length of actual duration to expected one becomes longer. The difference between these two might be thought as surprise.

4.2 Results and Discussions

	2007		2008	
	Coef.	z-Stat.	Coef.	z-Stat.
ω	1.2.E-02	38019*	1.2.E-02	393973.1*
α_1	1.2.E-01	88823.46*	1.2.E-01	159.53*
α_2	-1.4.E-04	-347.19*	-8.3.E-05	-4.36*
β_1	1.3.E-01	2782.54*	1.0.E-01	29.25*
β_2	-3.6.E-03	-72.03*	-1.3.E-03	-7.75*
γ_1	-5.8.E-02	-10.73*	1.1.E-01	41.05*
γ_2	-1.5.E-01	-25.85*	-1.4.E-02	-6.13*
ρ_1	-5.8.E-06	-56.73*	-1.6.E-05	-75.32*
ρ_2	-3.7.E-06	-46.39*	-6.7.E-06	-68.86*
ν_1	1.8.E-05	75.51*	2.3.E-06	16.47*
ν_2	-4.0.E-06	-15.50*	-3.4.E-06	-26.05*
Log likelihood	-2.2.E+07		-3.5.E+07	
*:1% **:5% ***:10%				

In both years, all parameters are significantly estimated. The sign of parameters are also almost same. Past durations and past expected durations have positive impact on future expected duration. If dealers face longer duration, or if they forecast longer duration, these facts cause future longer expected duration. Persistency of the effect of past expected duration is quite big. This can be suggested by the number $\beta_1 + \beta_2$. In both years, these numbers exceed 1. This means the effect of past expected duration lives longer.

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Volume and orderflow also have same effects in both years. Past volume makes future expected duration longer. On the other hand, orderflow in the past has negative impact on future expected duration. If dealers use volume as proxy of volatility, they may change their dealing style more prudence when they face high volume. This tendency is in line with the discussion in Diamond/Verrecchia(1986). But the result from orderflow is also good for Diamond/Verrecchia(1986) implications. Buying order makes future expected duration shorter. If dealers deal with information, and they used to buy the USD when they get good news on USD value, buying order represents good news on USD.

So, selling order means bad news. Therefore, past bad news makes longer future expected duration.

Only the impact of foreign exchange rate change is opposite between both years. Appreciation of USD has negative impact on future expected duration in 2007. But the impact in 2008 is opposite. If the reaction of dealer in terms of duration can be understood as their evaluation of event, appreciation of USD used to be a good news in 2007, but not in 2008. The difference of the market condition in both years is the Lehman and Subprime shock in 2008. A lot market participant is thinking that USD belongs to high risk asset class these years, especially in 2008. Buying USD orders rise USD and accumulate USD long position at the same time. Position seems to be crucial role in financial market . If USD longer position can be taken as higher risk in 2008, this tendency might be also for the Diamond/Verrecchia(1986) implications.

	2007		2008	
	Coef.	z-Stat.	Coef.	z-Stat.
Mean Equation				
C	-5.9E-08	-0.64	8.2.E-07	9.50*
λ	-6.0E-09	-0.12	-1.0E-06	-16.09*
Variance Equation				
C	4.8E-09	36.82*	4.2.E-09	1858.89*
α	-3.9E-14	7.50*	4.9.E-06	617.08*
β	1.7E-01	-0.14*	6.9.E-02	269.13*
φ_1	-7.0E-09	-21.72*	2.7.E-08	169.01*
φ_2	4.5E-12	37.01*	-7.9.E-12	-79.50*
φ_3	-8.1E-11	-26.77*	1.5.E-09	398.64*
φ_4	-5.2E-13	-2.96*	2.0.E-12	42.54*
AIC	-16.185		-16.012	
SBIC	-16.185		-16.012	
*:1% **:5% ***:10%				

In terms of the relations between volume and volatility, we can get some implication from Table 6. In the first step, we check the result in mean equation (9). Duration does not have any impact on USD change in 2007, but has negative impact in 2008. Longer duration makes USD to depreciate. If dealers take the longer duration as bad news on USD as in Diamond/Verrechia(1986), USD moves downward.

Almost all signs of parameters are different in both years. The mean value and standard deviation of long run volatility in 2007 is smaller than those in 2008. Besides that, the mean and standard deviation of expected duration in 2008 is much higher. In both indicators, market conditions in 2008 are much worse, higher volatility and longer duration, which means more risky and more bad news. This difference might have some effect on this discrepancy. But, still we have to do more research on the reason for this discrepancy.

φ_1 represents the effect of long run realized volatility on volatility. Long run volatility has negative impact in 2007, and positive impact in 2008. It is natural that increase in long run volatility leads to high volatility and we can find this in 2008.

As for the effect of three kinds of durations on volatility, the sign of all these parameters are different in both years, and all three are opposite between both years. In 2007, surprise and expected duration makes volatility high and realized duration has negative impact on volatility. It is easy to guess that unexpected bad news and its expectation cause higher volatility if we can relate unexpected part of duration to unexpected bad news. Longer duration means fewer trades in a given time. Therefore, Longer duration leads to lower volatility.

In 2008, we might say that dealers react not the unexpected bad news but realized new bad news. Because we cover the Lehman's shock and bankruptcy of many US private banks in our data set in 2008. This can be the part of the reason which causes these tendencies. But we need to do more research on this subject.

5. Results and Discussions

With special Ultra-High Frequent JPY against UDS rate data, we investigate the features of foreign exchange dealers in terms of duration, volatility, volume and orderflow. ACD model developed by Russell/Engle(1995) enables us to use tick-tick type foreign exchange data without any loss of information. In addition to ACD model, we use GARCH type model modified to fit the tick-tick data.

As for the daily seasonality of duration, we found some features in Tokyo (or Asian) time zone, London time zone and London and New York time zone. Especially in London time, duration might be a bit longer than any other zone. One of the candidates to explain this tendencies is the rate we picked here. In London market, major currencies they usually trade is GBP or EUR based foreign exchange rates. In this case, JPY_USD rate can be traded as cover trade.

With the ACD model, we found clear results in both years. In both year, we confirmed that persistency of expected duration exists. From this result, we need to doubt the market efficiency. As for the comparison of Diamond/Verrecchia(1986) model and Easly/O'Hara(1992) model. In both data sets, impact of volume and orderflow can lead to Diamond/Verrecchia model. This model usually is good in the market where participant cannot sell short or prohibited to do so. In foreign exchange market, the notation of short selling does not exist. Because a dealer wants to sell USD against JPY, this can be the same trade when he or she buys the JPY against USD. Therefore, in the market condition such as mentioned above, still Diamond/Verrecchia model can be appried.

The relations among volatility, duration and expected duration were tried to investigate. It is clear that realized duration, surprised part of duration and expected duration have significant effect on volatility. Long run realized volatility also affects volatility. But the ways these many kinds of durations and long run volatility effect on volatility are different between 2007 and 2008. The reason for this difference may come from Subprime and Lehman's shock. But we need to do more research to confirm this reason.

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