ANALYSIS AND FORECASTING THE VOLATILITY OF EURO – DOLLAR EXCHANGE RATE

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Abstract

The study on volatility and asymmetry of the exchange rate is applied to the Euro/USD relation. Starting in U.S.A., the financial and economic crisis influenced European Union with a certain delay. On the other hand, this years´ problems in Eurozone are paralleled by rising American economy. That is why we can expect both currencies to develop in different ways.

In general, the depreciation deviation of exchange rate can lead to a higher volatility than the appreciation deviation, what implicates asymmetric effects. The uncertainty of exchange rate has a tendency to be inconstant in the time-varying cases, so it has a feature of conditional heteroscedasticity. That is why the models from the ARCH family are employed to study whether the asymmetry is present in the data in question; source: ECB. The Engle – Ng tests for asymmetry in volatility are used to determine whether an asymmetric model is required as adequate. A forecast will be given including an ex post comparison as well as an ex ante prognosis. Financial support from the GA CR project 402/09/0273 and the Research Plan MSM 6138439909 is appreciated.

Key words: *Asymmetric volatility, EGARCH model, News impact curve – NIC*

1. INTRODUCTION

Starting in U.S.A., the financial and economic crisis influenced European Union with a certain delay. On the other hand, this years´ problems in Eurozone are paralleled by rising American economy. That is why we can expect both currencies to develop in different ways. In general, the depreciation deviation of exchange rate can lead to a higher volatility than the appreciation deviation, what implicates an expectation of asymmetric effects.

2. GARCH AND EGARCH MODELS

The uncertainty of exchange rate has a tendency to be inconstant in the time-varying cases, so it has a feature of conditional heteroscedasticity. The dominant model applied to financial time series analysis is GARCH model (see e.g. [1],[2]). Suppose f_{t-1} represent all the information up to t-1. GARCH(1, 1) is defined as:

$$x_t = \mu + u_t$$
$$u_t = \varepsilon_t h_t^{1/2}, \quad \varepsilon_t \middle| f_{t=1} \sim N(0,1)$$
$$h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1}, \qquad t = 1, \ldots, T.$$

The equation for h_t can be written in ARMA form using $\theta_t = u_t^2 - h_t = \left(\varepsilon_t^2 - 1\right) h_t$

$$u_t^2 = \alpha_0 + (\alpha_1 + \beta_1) u_{t-1}^2 - \beta_1 \theta_{t-1} + \theta_t. \tag{1}$$

It follows that u_t has a finite unconditional variance given by $E\left(u_t^2\right) = \alpha_0 / (1 - \alpha_1 - \beta_1)$, if and only if $\alpha_1, \beta_1 \geq 0$, $\alpha_1 + \beta_1 < 1$. In fact, it really makes sense (see [3]) if $\alpha_0, \alpha_1, \beta_1 > 0$.

Equation (1) also can be used as a basis for forecasting. Having a horizon *H*, it is

$$E\left(h_{T+H} \middle| h_T\right) = (\alpha_1 + \beta_1)^H h_t + \alpha_0 \sum_{j=0}^{H-1} (\alpha_1 + \beta_1)^j.$$

The advantage of GARCH model is that it can track the volatility clustering phenomenon very efficiently. Its weak point is that the conditional variance is dependent on the magnitude of the previous error term but is not related to its signs. To solve this problem, the exponential GARCH (EGARCH) model can be used in which the conditional variance is always positive because of its form. For EGARCH(1, 1), specified by Nelson in [7], it is:

$$\log h_t = \alpha_0 + \nu_1 u_{t-1} + \nu_2 \left| u_{t-1} \right| + \beta_1 \log h_{t-1} \tag{2}$$

Defined by (2), apart from the signs of parameters, h_t is always nonnegative. The stationarity is reduced to a question whether $\beta_1 < 1$. When $\nu_1 \neq 0$, the model allows for an asymmetric response. The parameter being negative, positive return shocks generate less volatility then negative shocks, all else being equal, and vice versa. Furthermore, in the EGARCH model, conditional variance is dependent on sign of the previous error term as well as its magnitude.

A comparison between GARCH and EGARCH model is proposed in [Engle, Ng] by analyzing the effect of news on conditional heteroscedasticity. Holding constant the information dated *t*-2 and earlier, en influence of u_{t-1} on h_t is examined. Relating past return shocks to current volatility we get news impact curve (NIC) which measures how new information incorporated into volatility estimates. As it is in details explained in [4], NIC of a GARCH model is a centered quadratic function while NIC of an EGARCH model has its minimum at $u_{t-1} = 0$ and is exponentially increasing in both directions but with different parameters.

To conclude in a more exact way as according to the graphics only, diagnostic tests are proposed in [4]. It is assumed that the volatility model under the null hypothesis is a special case of a more general form and relevant parameter restriction are tested. For the GARCH(1,1) and EGARCH(, 1) models an encompassing is

$$\log h_t = \log\left(\alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1}\right) + \nu_1 u_{t-1} + \nu_2 \left|u_{t-1}\right| + \beta_1^* \log h_{t-1}. \tag{3}$$

So, when $\alpha_1 = \beta_1 = 0$, the model is EGARCH while $\nu_1 = \nu_2 = \beta_1^* = 0$ means that GARCH is a true form. Technically, the parameters of (3) should be estimated by the help of non-linear methods.

3. DATA AND ESTIMATES

As a time series x_t from the previous article we use the returns r_t defined on the base of exchange rate e_t of Euro and US Dollar observed daily from June 1, 2008 to May 30, 2010 (working days only); it is $r_t = \log\left(\frac{e_t}{e_{t-1}}\right) \times 100$.

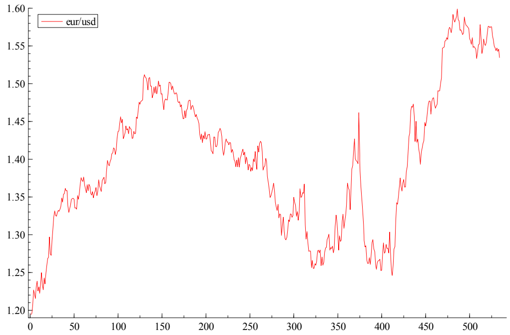

Figure 1. Exchange rate e_t

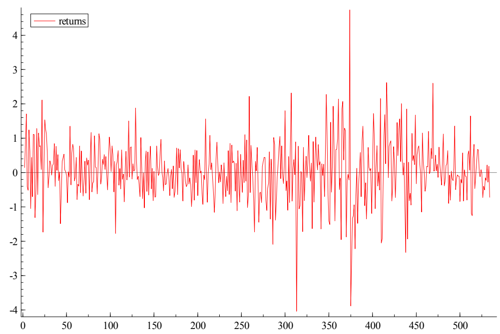

Figure 2. Returns r_t

According to ADF test, e_t is nonstationary, r_t is stationary. Jarque – Bera test for normality was used. Estimation results applied to r_t with respect to relevant h´s are summarized in Table 1.

Software PcGive is based on the BFGS maximization technique (see e.g. [5]).

Parameters	GARCH(1, 1)	EGARCH(1, 1)
α_0	0.006655 (1.14)	-0.576641 (-3.28)
α_1	0.053795 (2.40)	-
β_1	0.936664 (40.4)	-0.926872 (-28.1)
ν_1	-	0.028753 (1.35)
ν_2	-	0.097343 (2.07)
Log likelihood	-638.2407	-672.1711

Table 1. Estimated parameters, t-values in parentheses.

In case of GARCH model, $\alpha_1 + \beta_1 < 1$ as for the EGARCH variant, $|\beta_1| < 1$ what proofs a stationarity.

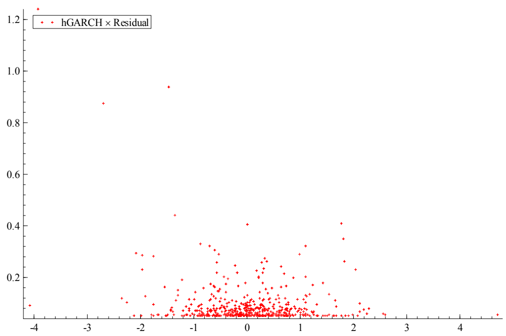

Figure 3. NIC of GARCH – selected points

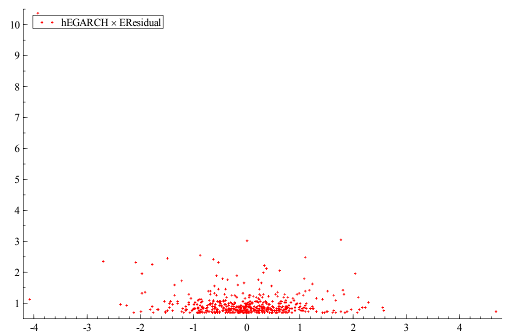

Figure 4. NIC of EGARCH – selected points

The crucial parameter ν_1 is formally a non-zero value, but it is not significant what do not support an EGARCH hypothesis. Also the relations of relevant $h_t's$ to lagged residuals are in both models very similar. That is why a validity of GARCH version is to be expected.

The application of the above described test shows that β_1^* is the only parameter in (3) which does not differ significantly from zero. It gives a slight dominancy to the GARCH model.

Using both variants, a prognosis was performed as ex post comprising 5 last observations and ex ante concerning further 15 days.

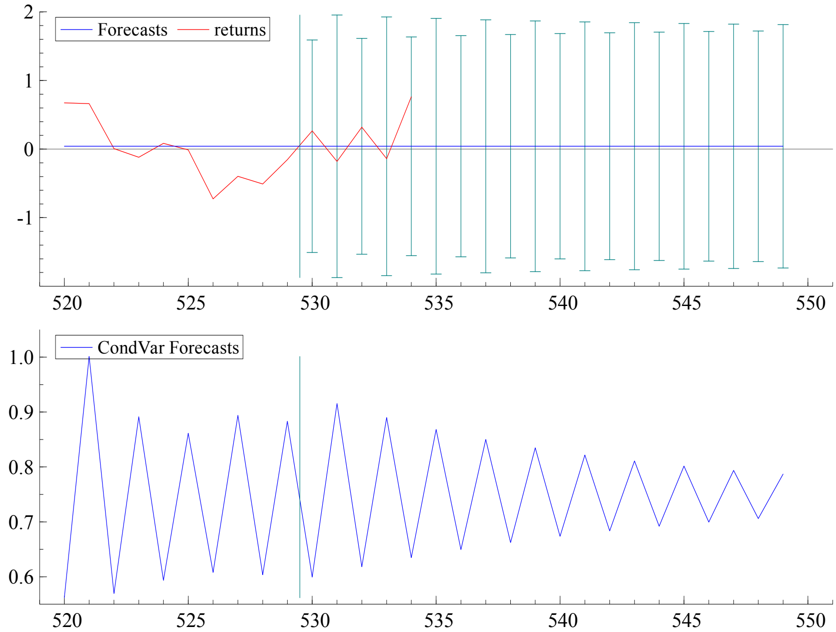

Figure 5. Forecast of returns and conditional variances- EGARCH.

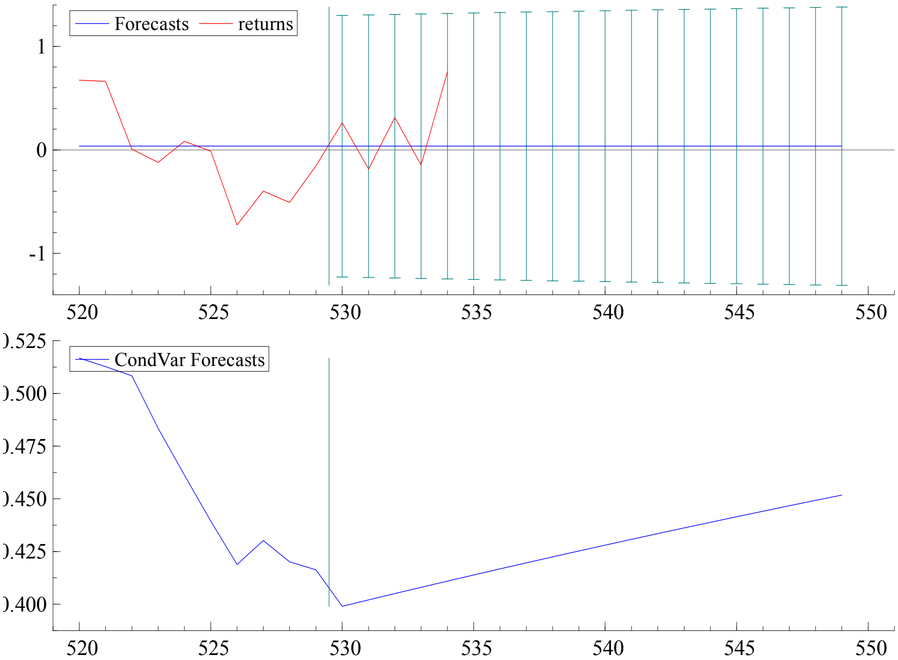

Figure 6. Forecast of returns and conditional variances - GARCH.

Comparing Figure 5 and 6, GARCH offers a more narrow forecast band (EGARCH ∓ 2, GARCH ∓ 1.2). The forecast of conditional variances tends to zero in EGARCH but is more realistic in GARCH.

4. CONCLUSION

Despite of all turbulences on financial markets in last two years, there is no apparent asymmetry in the Euro and USD relations. In comparison with an EGARCH(1, 1), a GARCH(1, 1) variant fits the process of exchange rate development better. The regime shifts of euro – dollar exchange rates during the years 2008 to 2010 can occur attributed to economic crisis. In this case, it would be sensible to use two classes of regim switching models. There are the Markov regime switching model [6] ort he non linear threshold autoregressive model associated with Tong [8].

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