MODELING ROMANIAN EXCHANGE RATE EVOLUTION WITH GARCH, TGARCH, GARCH- IN MEAN MODELS

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Abstract: *In this paper we analyze the return of exchange rate in order to test and analyze the best models which are capable of forecasting accurately there evolution. We apply the GARCH family models on the exchange rate return in order to obtain the best models for there volatility. Financial time series often exhibit abnormal characteristics, such as: serial correlation, non-stationarity, heteroskedasticity, asymmetric and are leptokurtic. Due to these characteristics autoregressive models such as autoregressive (AR), moving average (MA) and autoregressive integrated moving-average (ARIMA) are unable to capture the evolution of financial series, to represent the special characteristic of financial a hole new range of models where developed : generalized autoregressive conditional heteroskedasticity (GARCH), which are taking into account the heteroskedasticity of the errors term. The GARCH model allows for lags in the autoregressive term and in the variance term incorporates lags of the previous variance and also for the errors. The GARCH family has expanded in the last years in order to incorporate for asymmetry (Threshold GARCH, TGARCH) and risk (GARCH -in Mean).*
We analyze the evolution of exchange rate for: Euro/RON, dollar/RON, yen/RON, British pound/RON, Swiss franc/RON for a period of five years from 2005 till 2011, we observe that in the analyzed period there are 2 sub-periods: 2005-2007 in which the RON appreciated constantly, and 2007-2011 in which the trend is depreciation for RON in respect to all the five currencies and the volatility was sensible higher than in the previous period. We obtain the returns on exchange rate by using the following transformation r=log(curs_t)-log(curs_t-1); the five analyzed series display an leptokurtic and asymmetric behavioral. Using the GARCH, TGARCH and GARCH-in Mean models, we explicit the evolution of volatility throw this period, choosing the best model using the following : minimizing the value of the sum of squared errors, Akaike and Bayesian Information Criterion.

Keywords: *exchange rate, GARCH, TGARCH, AIC, BIC.*

JEL Classification: *G01, G21*

1. Introduction

The evolution of Romanian exchange rate represent an important factor for a hole range of economic actors: banks, governmental agencies, companies and households, so the fluctuations of exchange rate and the ability to forecast her evolution is very important. For banks which must comply to the recommendation of the Basel Committee and which are ,usually, having open position on different currencies it is vital that they can understand and prognoses the future exchanges rates in order to minimize the risk of losses; for governmental agencies (especially the Romanian IRS) the evolution of Euro/Ron is important due to the fact that some of the taxes are expressed in Euro; exchange rate fluctuation can have a great on companies if there debts is in foreign currency or if the export/import; for households which in Romania are in debt especially in foreign currency the devaluation of Ron can lead to bankruptcy. Over 60 percent of loans are denominated in foreign currency in Romania which makes our economy very sensitive to the fluctuations in exchange rates (especially Euro, dollar, yen, swiss franc). All of these reason makes important the study of exchange rates evolution.

The evaluation or devaluation of currency is not a bad think per se, what raises difficulties is their volatility because in general financial time series, including exchange rate, often exhibit abnormal characteristics, such as: serial correlation, non-stationarity, heteroskedasticity, asymmetric and are leptokurtic.

2. Literature review

The theory of purchasing power parity (PPP) was the first which managed to explain the fluctuations in exchange rate values in real terms , but there are limits of this theory [Guglielmo&Luis,2010] because it cannot explain the volatility, the main critics brought to this theory being given by the reduced relevance of the obtained methods and the necessity to use large amount of data series. If analyzing the exchange rate evolution from a nominal point there are problems for the researchers, for eg. the structure of the data series on the financial markets (because these are generally leptokurtic, the moment of the order 3 of the series is much bigger than in the case of normal distribution), leading to an increase of the probability of the appearance of extreme phenomena, also if the series are stationary or there is any evidence for structural breaks.

The best models used for modeling the volatility are the ARCH models [Engel, 1982] and then the GARCH generalization [Bollerslev, 1986] which lead to the appearance of some instruments advanced enough to model the financial series. The appearance of the GARCH models lead to a better understanding and a modeling of the evolution of the financial series, these models developing both in univariate and multivariate models [Bauwens, 2006]. The evolution of the Romanian exchange rate has been analyzed being used the GARCH modeling by Codirlasu [2001] on the series ROL/EURO and ROL/DOLAR for the period 2000-2001, being remarked the fact that the series follow an asymmetric ARCH process. Using series available during the period 1999-2003, Necula [2008] applies the GARCH and the Copula-GARCH modeling, concluding that the dynamic models of the type Copula-GARCH bring more information and stability concerning the obtained results.

3. Data used and methodology

The analyzed series are 5 currencies: Euro, dollar, British pound , Japanese yen and Swiss franc, the analyzed period is between January 3, 2005 and April 29, 2011, daily series; the date are obtained from Romanian National Bank official site www.bnro.ro and the econometrics software packaged used is GRETL, in order to obtain returns from the daily series we apply the following transformation:

$$r = \log(curs_t) - \log(curs_{t-1}) .$$

The ARCH models developed by Engel [1982] have the following equations:

$$y_t = B_0 + e_t \quad (1)$$

$$e_t \mid I_t\text{-}1 \sim N(0, ht) \quad (2)$$

$$h_t = ά_0 + ά_1 * e^2_{t-1}, \; ά_0 > 0, \quad 0 \leq ά1 < 1 \quad (3)$$

The equation(1) expresses the series evolution, a following a normal distribution law of conditional equations (2) and (3). Equations 2 and 3 express the ARCH type models, autoregressive models with different time variance, residuals follow a normal law of 0 mean and ht variance. The value of $ά_0$ and $ά_1$ must be positive, and $ά_1$ has a value between [0,1] in order to avoid an explosive processes, also errors(residuals) follow a normal distribution law.

ARCH models have been developed later in the GARCH (Generalized autoregressive conditional heteroskedasticity) by Bollerslev [1986], which bring the use of lags as an innovation in equation variance, equations in the GARCH (1,1) case are:

$$y_t = \beta_0 + e_t \qquad (4)$$

$$et \mid It\text{-}1 \sim N(0, ht) \qquad (5)$$

$$h_t = ά_0 + ά_1 * e^2_{t-1} + \beta_1 * h_{t-1}, \quad ά_0 > 0, \quad 0 \leq ά_1 < 1 \qquad (6)$$

It have been observed that on the financial markets the assets prices are influenced by the news (also called innovation) , so that a bad news generates more volatility than a good news. A GARCH model which treats differently the bad-good news was proposed by Zakoian [1993] – Threshold GARCH. It is an asymmetric model in which the conditional volatility is:

$$h_t = ά_0 + ά_1 e^2_{t-1} + \gamma * d_{t-1} * e^2_{t-1} + \beta_1 * h_{t-1} \qquad (7)$$

where: $d_t = 1$ if $e_t < 0$ or $d_t = 0$ if $e_t > 0$.

Also in order to reflect the relation between risk and return another models where proposed in order to incorporate this characteristics [Engle,1987], GARCH in mean model have the following characteristic:

$$y_t = \beta_0 + e_t + \theta * h_t \qquad (8)$$

$$et \mid It\text{-}1 \sim N(0, ht) \qquad (9)$$

$$h_t = ά_0 + ά_1 * e^2_{t-1} + \beta_1 * h_{t-1}, \quad ά_0 > 0, \quad 0 \leq ά_1 < 1 \qquad (10)$$

In this model as the volatility rises the return are rising too, this models are useful in order to capture the risk of the assets.

4. Exchange rate models: GARCH, TGARCH and GARCH in Mean

Using the return

$r = \log(curs_t) - \log(curs_{t-1})$,

we obtain the following evolution of the series:

	R_DOLAR	R_EURO	R_FRANC	R_LIRA	R_YEN
Mean	-0.003560	0.002223	0.013383	-0.012068	0.010834
Median	-0.048804	-0.017661	-0.020991	-0.038889	-0.091837
Maximum	4.434815	3.385650	5.223699	4.018345	10.80639
Minimum	-4.968370	-5.106356	-5.027989	-4.838047	-7.547544
Std. Dev.	0.874067	0.487860	0.702979	0.746555	1.133958
Skewness	0.277802	0.050525	0.290114	0.072925	0.678837
Kurtosis	6.729989	16.06188	9.472018	7.815664	11.90174
Jarque-Bera	955.2118	11460.17	2836.024	1559.066	5446.158
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	-5.739149	3.582965	21.57408	-19.45334	17.46505
Sum Sq. Dev.	1230.792	383.4293	796.1225	897.8817	2071.521
Observations	1612	1612	1612	1612	1612

The return of the series are different from zero for all the return, the highest return is obtain for the Swiss franc 1.33% and the lowest for the British pound – 1.20%; from the 5 currency two have negative return: the British pound -1.20% and the American dollar -0.3%. The standard deviation which measures the risk associated with these currency are the highest for Yen 1.13 and the lowest for EURO 0.48, also all the currency are asymmetric and leptokurtic. All the series where tested for stationarity using the ADF test and also for the ARCH effect: the series are stationary and the ARCH effect is present. The evolution of the return (Fig.1) are having the characteristic of an GARCH model with periods of high volatility followed by periods of low volatility, also we can observe that the highest volatility is in 2008-2009 when the financial crisis hit the markets.

Fig.1. Evolution of return 2005 -2011

We explicit the TARCH model for dollar as being:

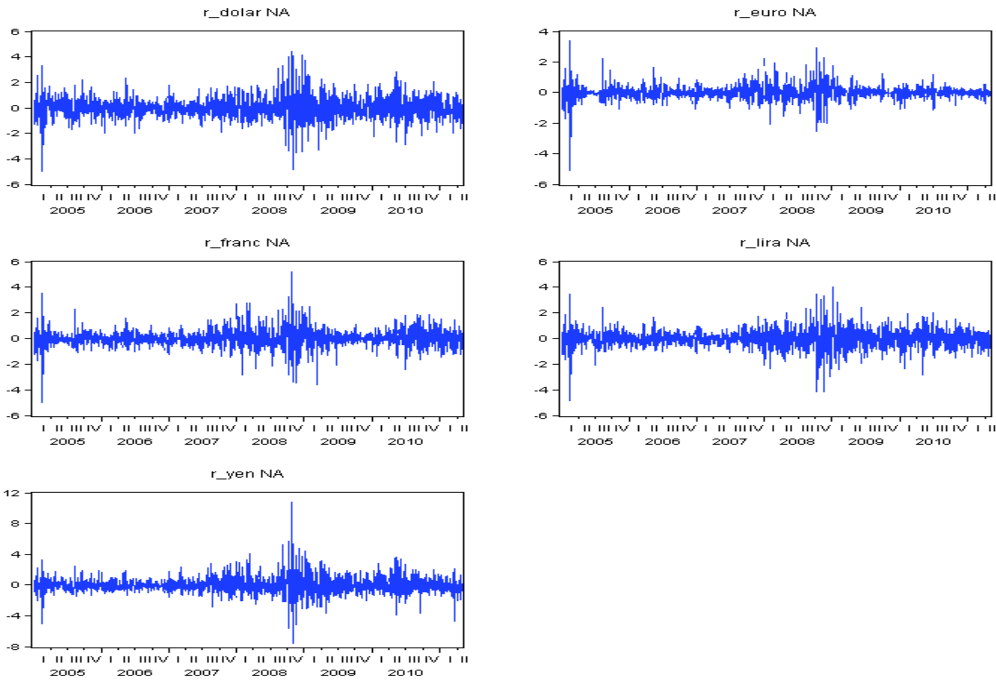


Table 1. TARCH Model dollar

Dependent Variable: R_DOLAR
Sample (adjusted): 1/07/2005 4/29/2011
Included observations: 1609 after adjustments

Variable	Coefficient	Std. Error	z-Statistic	Prob.
R_DOLAR(-1)	0.048747	0.025227	1.932310	0.0533
R_DOLAR(-2)	-0.029834	0.027110	-1.100462	0.2711
R_DOLAR(-3)	-0.046187	0.025247	-1.829397	0.0673
		Variance Equation		
C	0.009057	0.002396	3.780163	0.0002
RESID(-1)^2	0.071693	0.009958	7.199375	0.0000
RESID(-1)^2*(RESID(-1)<0)	-0.026388	0.013414	-1.967209	0.0492
GARCH(-1)	0.928206	0.008137	114.0695	0.0000

R-squared	0.011721	Mean dependent var	-0.004295
Adjusted R-squared	0.010490	S.D. dependent var	0.874680
S.E. of regression	0.870080	Akaike info criterion	2.352069
Sum squared resid	1215.805	Schwarz criterion	2.375490
Log likelihood	-1885.240	Durbin-Watson stat	1.918807

We observe that the coefficient of the equation are representative at the population level with a 95% confidence except for the second lag of the return. The normality of the estimation is analyzed throw the Durbin-Watson test which is under the critical level of 2.

Using the information criterion: Akaike, Schwarz we have selected this model for being the most performant from the TGACRH family models.

Table 2. GARCH in Mean for dollar

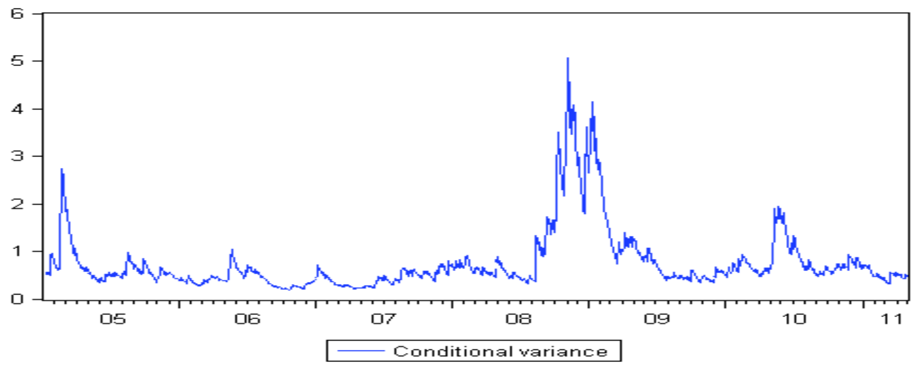
Dependent Variable: R_DOLAR
Date: 05/14/11 Time: 15:35
Sample (adjusted): 1/07/2005 4/29/2011
GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
LOG(GARCH)	0.043134	0.020789	2.074855	0.0380
R_DOLAR(-1)	0.045477	0.025094	1.812215	0.0700
R_DOLAR(-2)	-0.033026	0.027023	-1.222125	0.2217
R_DOLAR(-3)	-0.053874	0.025031	-2.152348	0.0314
Variance Equation				
C	0.008319	0.002410	3.452184	0.0006
RESID(-1)^2	0.061833	0.007541	8.199630	0.0000
GARCH(-1)	0.926816	0.008588	107.9201	0.0000

R-squared	0.014756	Mean dependent var	-0.004295
Adjusted R-squared	0.012914	S.D. dependent var	0.874680
S.E. of regression	0.869013	Akaike info criterion	2.351012
Sum squared resid	1212.071	Schwarz criterion	2.374433
Log likelihood	-1884.389	Durbin-Watson stat	1.918963

For the GARCH in Mean model we used for quantifying the risk in the mean equations after testing the model with a variance that the best way to integrate risk is using the logarithm of variance.

Fig.2 The evolution of conditional variance for dollar in a TGARC model



5. Conclusion

The purpose of using TGARCH and GARCH in Mean models is to offer a better understanding of the volatility which is found on financial markets, because financial assets have some abnormal characteristics, such as: serial correlation, non-stationarity, heteroskedasticity, asymmetric and are leptokurtic it is important to take into account them. GARCH asymmetric models , like TGARCH and GARCH in Mean, are offering the possibility for better forecasting on these assets. In this models we postulated that the error term is following a normal distribution : et | It-1 ~ N(0, ht) but there are others possibilities: student, Generalized Error *Distribution, student skewed and skewed Generalized Error Distribution. Another factor which we need to take into the consideration is the possibility of structural breaks in the series.*

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