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Volatility Estimation of Euribor and Equilibrium Forecasting

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Abstract: *Euribor rates (Euro Interbank Offered Rate) rates are considered to be the most important reference rates in the European money market. The interest rates do provide the basis for the price and interest rates of all kinds of financial products like interest rate swaps, interest rate futures, saving accounts and mortgages. Since September 2014, this index has performed with negative rates. In recent years, several European central banks have imposed negative interest rates on commercial banks, as the only way to stimulate their nations' economies. Under these circumstances, the purpose of this study is to estimate the gap of the negative rates which are still increasing constantly. This fact puts in question the financial stability in many countries and the effect of monetary policy on stimulating economic growth around European countries. According to the daily data 2016 - 2021, this study has analyzed the volatility of the Euribor index related to efficient market hypothesis and volatility clustering. Applying advanced volatility econometric methods, GARCH volatility models are derived and the long-run equilibrium is predicted. Practical Implications are related to the empirical impacts that ought to be taken into consideration by the banking sector and other financial institutions to make decisions with the Euribor index.*

1. INTRODUCTION

Euro Interbank Offer Rate (Euribor) is a reference rate that is constructed from the average interest rate at which Eurozone banks offer unsecured short-term lending on the inter-bank market. The maturities on loans used to calculate Euribor often range from one week to one year. These Euribor rates, which are updated daily, represent the average interest rate that Eurozone banks charge each other for uncollateralized loans. Euribor rates are an important benchmark for a range of euro-denominated financial products, including mortgages, savings accounts, car loans, and various derivatives securities.

The global interest rates have been declining for many years and decades. This trend is related to fundamental factors. There are two prevailing views:

- The structural factors have pushed interest rates to record low levels. These structural factors include demographics and longer life expectancy. This affects individuals' propensity to save and invest.
- The lower interest rates are a reaction to the high financial leverage levels, which contributed to the global financial crisis. According to this view, lower interest rates are necessary to facilitate the deleveraging process, thereby they are expected to return to normal, in the future.

Euribor is not returning to equilibrium, it has been performing at negative rates for years. In *figure 1* below, we will give the trend of the Euribor rate with 12 months' maturity.

For the first time, in February 2016, this rate has become negative and has continued with a negative trend until today. This performance with negative rates is presenting new challenges for the Eurozone, since such a rate performance has exceeded the medium term.

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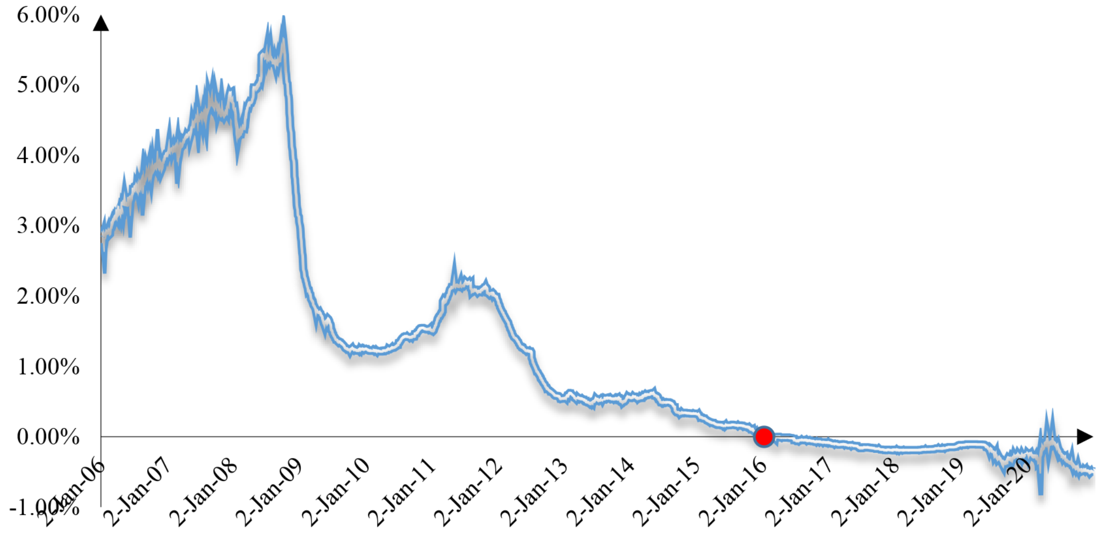

Figure 1. Euribor trend with 12-month maturity

Whatever is part of the Eurozone or not, the economies of many European countries are significantly affected by the Euribor, with several challenges:

- They complicate the estimation of the lower policy rate bound in these economies,
- There is a situation that alters the relative incentives toward domestic and foreign currency denominated assets and liabilities when currency is different from Euro,
- Related to the required reserves' system, the lower return on foreign exchange reserve assets (at times, negative) is the scope for currency diversification, which is more limited.

According to the daily data 2016 - 2021, this study has analyzed the volatility of the Euribor index related to efficient market hypothesis and volatility clustering. Applying advanced volatility econometric methods, GARCH volatility models are derived and the long-run equilibrium is predicted. The aim of this research is to measure the financial stability of Euribor index and the effect of the euro monetary policy.

2. LITERATURE REVIEW

Euribor performance analysis must estimate in the three-time dimensions. There are three types of classification methods based on the time period, which are short-term forecasting, medium-term forecasting, and long-term forecasting (Montgomery et al., 2008). According to these researchers the short-term forecasting is used to forecast daily, weekly, and monthly basis forecasting, such as forecasting of the market model (Neslihanoglu et al., 2017), with typical forecasting volatility by using GARCH (1,1) model (Chia et al., 2016; Tsung-Han and Yu-Pin, 2013). In the financial investment field exists a relationship between volatility in the capital market and the greatest uncertainty or yield, known as "Risk and Return Tradeoff"-phenomenon. As consequence, in the low volatility share price, receiving capital gain, investors have to hold the share as a long-term investment. When the daily volatility of a share price is high, there could arise high increase or decrease of share prices which provides a space for trading in order to receive gain by the differences of the opening and closing share prices, which can be called as "High Risk High Return" (Hull, 2015). Volatility is also considered as fundamental to asset pricing and important information for investment (Kongsilp and Mateus, 2017). According to Blaskowitz and Herwartz (2009) in the benchmark models, like Euribor, the adaptive approach offers additional forecast accuracy in terms of directional accuracy and directional forecast value.

According to a study by the European Central Bank conducted by researchers Ivanova and Gutiérrez (2014), it was analyzed that the option-implied interest rate forecasts and the development of risk premium and state prices in the Euribor futures options market. They found out that the real-world option-implied distributions can be used to forecast the futures rate, while the forecasting ability of the risk-neutral distributions is rejected. Also, there is documented a negative market price of interest rate risk which generates positive premium for the futures contract. Whereas other authors Pelizzon, L., & Sartore, D., (2013), concluded that the Euribor rates cannot be used anymore as a benchmark for all market rates except credit risk indicators. They studied that credit risk and liquidity tensions in the short-term securities market are mainly unrelated to Euribor interest rate dynamics with central bank target rates. In accordance with the importance of Euribor volatility, Alfred (2019) found out that the Euribor-Overnight Indexed Swap (credit risk isn't a major factor in determining the OIS rate) spread incorporates rich information regarding future FX market uncertainty. He expressed that "this result supports the view that adverse information flow over the sample period is transitory, suggesting that market participants are mainly concerned about currency jumps during periods surrounding the crises, and prior crises jumps are generally ignored." The importance of Euribor volatility estimation is widely viewed as a risk indicator of financial distress associated with insolvency within the interbank lending market (Thornton, 2009). Therefore, this study motivates in estimating the Euribor volatility, because for years it performs with negative rates, causing the reduction of the monetary policy efficiency.

3. RESEARCH METHODOLOGY

The volatility of a variable is its standard deviation. Performing the annual standard deviation of the compounded returns, it is needed to highlight two main assumptions: *The first assumption* is that interest rates are not correlated over time or that the weak form of efficient market hypothesis approximately holds, i.e. the interest rates are not predictable from past interest rates. *The second assumption i*s that the expected value of the interest rates is equal to zero. We make this assumption of zero mean return in calculation of standard deviation for a short period.

Efficient market hypothesis (EMH): The weak form of efficient market hypothesis (EMH) says that interest rates are almost unpredictable from their history. There are many tests of EMH in the academic literature and below we will perform one simple test for correlation between interest rates at time *t* and past returns at times $t-1$, $t-2,.., t-k$. Correlation for a variable with its own lags is called autocorrelation. The null hypothesis: H_0: $Q = 0$ (no autocorrelation up to order *k*, lags = *k*), this means the market is efficient. We are going to perform Ljung-Box Q test for this purpose. The Q statistics is based on the normalized sum of squared autocorrelations and has chi-squared distribution. Note that the underlying assumption of the Q test under the null hypothesis is the independent identical distribution for the interest rates:

$$Q = n(n+2)\sum_{j=1}^{k}\frac{\rho_j^2}{n-j} \tag{1}$$

Where $\rho_j = correl(r_t, r_{t-j})$ with *n* data sample.

Volatility Clustering: Testing for volatility clustering performs the time varying amplitude of the interest rates. In order to test for volatility clustering we can test for autocorrelation of the squared interest rates. After squaring the interest rates we find autocorrelations (Ljung-Box Q test). We test the following null hypothesis: H_0: Q = 0 (no autocorrelation of squared interest rates up to order k, lags = k), which means no volatility clustering, where $\rho_j = correl(r_t^2, r_{t-j}^2)$ with n data sample.

GARCH volatility models: One of the most widely used models in risk management is the GARCH model, but this model is understood if we first know the ARCH model. ARCH (autoregressive conditional heteroscedasticity model) was introduced by Engel (1982), this model makes the prediction of time variance based on information obtained from daily squared returns. The ARCH(p) model is:

$$\sigma_t^2 = w + \alpha_1 r_{t-1}^2 + \alpha_2 r_{t-2}^2 + \ldots + \alpha_p r_{t-p}^2 \quad (2)$$

The model includes an autoregressive structure in the form of a regression based on past square returns observations. This model is conditioned by past information and by the variance of returns which varies with respect to time. So, the variance of the dependent variable is a function of the retrospective values of the dependent variable, or exogenous variables. The generalized ARCH form is the GARCH model (generalized ARCH), introduced by Bollerslev (1986). The forecast of variance at time t is the weighted average of the long-term variances, i.e. from the forecast of variances and information on the squared returns. The general form of the GARCH(p,q) model indicates that the parameter "p" is ARCH (p), while the parameter "q" shows that we have $lag = q$ of the variances:

$$\sigma_t^2 = w + \sum_{i=1}^{p} \alpha_i r_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 \quad (3)$$

The main properties of GARCH coefficients to satisfy a good model are: (1) positivity parameters and (2) stability parameters. In general a GARCH(1,1) model will be sufficient to capture the volatility clustering in the data, and rarely is any higher order model estimated or even entertained in the academic finance literature (Brooks, 2014). GARCH(p,q) model testing is performed by maximum log-likelihood method; this means that AIC and SIC information criteria are computed based on the negative log likelihood with added penalty for number of parameters included in the model. The smaller is the information criterion the better is the model.

4. EMPIRICAL ANALYSIS AND FINDINGS

The Euribor rate data series is taken from official Thomson Reuters publications (from February 2016 to May 2021, the period in which Euribor rate performed negative values). The following are the statistical measurements of autocorrelation and the volatility model:

```
Autocorrelations of series 'y', by lag

    0     1     2     3     4     5     6     7     8     9    10
1.000 0.995 0.989 0.983 0.977 0.971 0.965 0.958 0.952 0.945 0.938
> Box.test(y,lag=10,type="Ljung-Box")

        Box-Ljung test

data:  y
X-squared = 11782, df = 10, p-value < 2.2e-16
```

Figure 2. Time series autocorrelations Q-test for EMH

Note: 'y' shows that the series of Euribor rate 12-month maturity.

Source: Author's calculation in R programming.

We can observe from *figure 2* that autocorrelation values are outside of the 95% confidence intervals. Based on the Q test, the p-value of 2.2e-16 is very small, much smaller than 5% or 10% significance level. Thus, we reject the null hypothesis of no autocorrelation (Q=0). Thus, rejecting H0 hypothesis may be either evidence against EMH (autocorrelation) or evidence of changing volatility, or both. So, Euribor rate is not an efficient market index.

```
Autocorrelations of series 'y^2', by lag

    0     1     2     3     4     5     6     7     8     9    10
1.000 0.993 0.986 0.978 0.971 0.963 0.955 0.947 0.939 0.931 0.922
> Box.test(y^2,lag=10,type="Ljung-Box")

        Box-Ljung test

data:  y^2
X-squared = 11570, df = 10, p-value < 2.2e-16
```

Figure 3. Time series autocorrelations Q-test for Volatility Clustering

Note: 'y^2' shows that the series of Euribor rate squared 12-month maturity.

Source: Author's calculation in R programming.

We can observe from *figure 3* again that autocorrelation values are outside of the 95% confidence intervals. Based on the Q test the p-value of 2.2e-16 is very small, much smaller than 5% or 10% significance level. Thus, we reject the null hypothesis of no autocorrelation (Q=0). So, Euribor rate is not an efficient market index because it has volatility clustering.

The reported coefficients in figure 4 include the intercept for the Euribor rates equation (mu), and GARCH parameters: omega, alpha, beta. We can observe that all GARCH parameters are positive and that the model is not stable since alpha + beta = 0.5571 + 0.4639 = 1.021 > 1. The equation to be used in this case is:

$$\sigma^2_{t(daily,tomorrow)} = 5.057 \times 10^{-8} + 0.55708 r^2_{t-1} + 0.46394 \sigma^2_{t-1}$$

Therefore, this model can be used for the daily forecast of the Euribor rate volatility but not for the equilibrium rate volatility (long-run equilibrium).

```
Coefficient(s):
         mu        omega       alpha1        beta1
-1.8916e-01   5.0568e-08   5.5708e-01   4.6394e-01

Std. Errors:
 based on Hessian

Error Analysis:
         Estimate  Std. Error   t value Pr(>|t|)
mu     -1.892e-01   8.914e-05 -2122.146   <2e-16 ***
omega   5.057e-08   1.522e-06     0.033    0.973
alpha1  5.571e-01   5.093e-02    10.939   <2e-16 ***
beta1   4.639e-01   4.176e-02    11.110   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Log Likelihood:
 2011.638    normalized:  1.608024
```

Figure 4. GARCH(1,1) model estimation.

Source: Author's calculation in R programming.

5. CONCLUSION

From February 2016, until now, Euribor 12-month maturity has been performing at negative rates, by presenting new challenges for the Eurozone in the monetary policies. Based on the daily data from 2016 to 2021, this study has analyzed the volatility of the Euribor index related to efficient market hypothesis and volatility clustering. GARCH volatility model helps us to figure out if there exists long-run equilibrium and how big is it. So, the biggest findings in this study are:

1. Even though we checked with the large length of lags (10 lags), there doesn't exist an equilibrium of Euribor index (12-month maturity).
2. The autocorrelation statistical approach and the Ljung-Box test shows a large correlation of the Euribor value. The statistical test was applied to the Euribor rates and the Euribor squared rates; due to this fact, both findings figure out that the Euribor rate is not an efficient market index.
3. The optimal GARCH model for the Euribor index (for negative rates) is GARCH(1,1), which parameters are positive but not stable. Therefore, this model can be used for the daily forecast of the Euribor volatility, but not for the long-run equilibrium volatility.
4. Also, we found out that the largest parameter weight in the GARCH(1,1) model (i.e. with the largest coefficient) is the squared rate and not the variance (per lag = 1). This phenomenon shows a big problem in forecasting volatility because the rate of return fluctuates more than the variance-variable according to lag = 1.

We conclude that the Eurozone monetary policy is losing its influential impact on the optimal financial stability of lending and deposit interest rates. This fact is a concern for the financial stability (more than short-term) in many countries, and the effect of monetary policy on stimulating economic growth around European countries.

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Data (official open data): https://www.suomenpankki.fi/en/Statistics/interest-rates/charts/korot_kuviot/euriborkorot_pv_chrt_en/