

Appendix online for the paper

“The Effects of Quantitative Easing Announcements on the Mortgage Market: An Event Study Approach”

1. Event studies

Event study methodology has been widely used by researchers to evaluate effects of economic events on asset prices. Dolley (1933) firstly uses event study to measure effects of stock splits on stock prices. During the 1930s and 1960s, event study estimation is refined by several researchers, including Myers and Bakay (1948), Baker (1956,1957,1958), Ashley (1962), Ball and Brown (1968), and Fama et al. (1969).

Generally, there are two approaches for event studies. The traditional 2-step approach involves finding the normal return by using various estimation models and then calculating the abnormal return (AR) as the difference between the actual return and the normal return (Fama et al., 1969). The regression 1-step approach incorporates regression models where the regression coefficient of an event dummy is regarded as the event effect (a.k.a., abnormal return due to the event) on the event date (Gibbons, 1980). Karafiath (1988) proves that same results can be generated by using either approach.

Campbell, Lo and MacKinlay (1997) define the AR of a security over the event window as the effect of earnings announcement on firm's equity value. They suggest that normal returns can be calculated by using “constant mean return model”, “market model”, “economics model” and other models. In addition to testing the significance of individual ARs, they also aggregate the ARs within one event window to find cumulative abnormal return (CAR) and standardized CAR (SCAR). Mckenzie et al. (2004) introduces the GARCH (1,1) extension to regression analysis in event studies. They compare OLS, GARCH (1,1) and GARCH (1,1) with Student's t distributed error term to conclude that although these three models are all powerful enough to find significant ARs, the third approach is most powerful in terms of small levels of abnormal performance. To account for contemporaneous correlation and overlapping event issues of cross-sectional average CARs, Ongena et al. (2003)

and Degryns et al. (2009) suggest using bootstrapped regression residuals to generate distribution of estimates (ARs). Some recent applications of event studies to researches include Ongena and Roscovan (2013), Li and Ongena (2015), etc.

2. ARMA and GARCH determination

To see the possible serial correlations of dependent variables in four regressions (equation (1) to (4)) and determine the lag length of autoregressive (AR) terms¹ in the mean models if serial correlations are found, we plot the autocorrelation function (ACF) and partial autocorrelation function (PACF) of ΔMR_t , ΔTR_t and $\Delta Spread_t$ with a maximum of 20 lags in **Figure A1, Panel A**. Although ACF and PACF are insignificant at most of the lags, there are significant values of ACF and PACF at several lags. The negative serial correlations for the first few lags indicate that the standard errors of coefficients for lagged variables are fairly big. High PACF of ΔMR_t at lag 4, 7, 10 and 12 and Akaike Information Criterion (AIC) both suggest AR(7), AR(10) or AR(12)². Although AR(7) has greater AIC than the other two, we still pick it as the favorite model for ΔMR_t to avoid “overfitting” problem (Enders, 2009³) in ARMA model with long lags. Similarly, AIC selects AR(5) and AR(6) models to fit ΔTR_t and $\Delta Spread_t$.

After the mean models are determined, we check GARCH and ARCH errors by plotting ACF and PACF of the squared residuals in mean models fitting ΔMR_t , ΔTR_t and $\Delta Spread_t$ in **Figure A1, Panel B**. The graphs show that the mean models for all three data series exhibit significant evidence of GARCH and ARCH errors. To find the appropriate lag length of GARCH and ARCH and distribution of errors, we start from GARCH(1,1) with a standard normal distribution (GARCH(1,1)-N) to estimate the error term for each of the three mean models.

¹ Moving Average (MA) terms are not included in the mean model for the reason that the error terms capture QE announcement effects and including MA terms would contaminate those effects when we estimate the full models later. Also, AR terms are simpler and sufficient enough to solve serial correlation in our model.

² AIC for these 3 models are -6263.059, -6266.326 and -6269.069 accordingly.

³ He argues that long lags of ARMA are due to “idiosyncrasies” in a particular sample which are not actually capturing the data-generating process.

The detailed model selection processes are reported in **Table A2**.

In the case of error terms in AR(7) fitting ΔMR_t , although the parameter estimates of GARCH(1,1)-N are all significant, the p-value of Ljung-Box test on squared standardized residual at the first lag is 0.03115 which indicates GARCH effects and insufficiency of GARCH(1,1)-N. Then we increase the lag length of GARCH and ARCH, and compare different GARCH(p,q) models. Except for GARCH(1,2)-N, the models with other combination of lag lengths show either insignificant parameter estimates or are suspected to over-fit the data. Thus, GARCH(1,2)-N is the next model we are interested in, the result of which is shown in the first column of **Table A2, Panel A**.

To test the normality, we plot the quantile of standardized residuals against the quantile of a standard normal distribution in **Figure A2, Panel A** and find that the points are off the 45-degree line at both ends, which indicates a fatter tailed distribution. Then GARCH(1,2) with a t distribution (GARCH(1,2)-t) is estimated and the result is reported in the second column of Table A2, Panel A. From the result, the degree of freedom of t-distribution is as low as 3.673 and Pearson Goodness-of-Fit test shows that t-distribution is better fitted than normal distribution.

Since there is a high probability of negative returns than positive returns of the mortgage rate during QE period, the distribution of error terms might skew to the left. We then estimate GARCH model assuming a skewed t distribution⁴ (GARCH(1,2)-skewed t) and report the result in the third column of Table A2, Panel A. We can see that both Pearson Goodness-of-fit test and AIC are in favor of GARCH(1,2)-skewed t, and the distribution of errors skews to the left with a skewness⁵ of 1.079.

We observe that the summation of parameter estimates in variance equation is close to one⁶, which suggests a unit root in GARCH process. To deal with this issue, we employ IGARCH(1,2)-skewed t model and the result is found in the fourth column of Table A2, Panel A. Although AIC increases from -3.466 to -3.450,

⁴ First introduced by Theodossiou (1998), skewed t is an extension to general t distribution when the distribution of the data has both excess kurtosis and skewness.

⁵ The skewness of $e_{i,t}$ is the third moment of the standard score of $e_{i,t}$. The distribution of $e_{i,t}$ is left-skewed when skewness is a positive number.

⁶ The 3 parameter estimates in variance equation are 0.162, 0.248 and 0.584, the sum of which is 0.994.

IGARCH is still favored since the restriction on coefficients⁷ in IGARCH boosts the AIC (Engle and Bollerslev, 1986). Furthermore, the Quantile-Quantile (QQ) plot in Figure A2, Panel A shows that points mostly drop along the 45-degree line for standardized errors in IGARCH(1,2)-skewed t model.

In case of variance reflecting the risk, we also perform GARCH in mean model and report the result at the last column of Table A2, Panel A. The risk premium parameter estimate is 0.063 and insignificant, which suggests that the variance term should not show up in the mean equation.

To measure the possible leverage effect⁸ within ΔMR_t , the Engle-Ng Sign Bias Test⁹ (Engle and Ng, 1993) is then performed. Since no leverage effect is found at the conventional significance level, the EGARCH or TGARCH models are ruled out. In conclusion, AR(7)-IGARCH(1,2)-skewed t model is appropriate and sufficient in estimating ΔMR_t . Follow the same strategy, we conclude that AR(5)-IGARCH(1,1)-skewed t and AR(6)-IGARCH(1,1)-skewed t are the best models in fitting ΔTR_t and $\Delta Spread_t$ respectively¹⁰.

To see if the models are adequate, we plot the standardized residuals and squared standardized residuals of three models fitting ΔMR_t , ΔTR_t and $\Delta Spread_t$ in **Figure A3**. From the figure, we can observe that ACF and PACF at all lags are close to one and insignificant, which indicate that both serial correlation and conditional heteroscedasticity are well controlled.

⁷ IGARCH sets constant term to 0 and restrict the summation of coefficients to 1.

⁸ Leverage effect means “unexpected drop in price (i.e., here is ΔMR_t) increases predictable volatility more than an unexpected drop in price of similar magnitude” (Engle and Ng, 1993).

⁹ Engle-Ng test sign bias test is based on the regression $e_t^2 = a + b_1 S_{t-1}^- + b_2 S_{t-1}^- \varepsilon_{t-1} + b_3 (1 - S_{t-1}^-) \varepsilon_{t-1} + \kappa_t$, where e_t^2 is the standardized residual (ε_t / σ_t) from GARCH model, S_{t-1}^- is a dummy variables taking the value 1 if ε_{t-1} is negative and 0 otherwise, and κ_t is the error term. Sign bias, negative sign bias or positive sign bias exists when b_1 , b_2 or b_3 is significantly different from 0 respectively. Joint effect exists when the hypothesis of $b_1 = b_2 = b_3 = 0$ is rejected.

¹⁰ The determination processes of these two models are reported in Appendix, Table A2 and the QQ plots of standardized errors are found in Appendix, Figure A1.

Tables and Graphs

Table A1: Dickey Fuller Unit Root Tests for Levels and Changes of Variables

Augmented Dickey Fuller tests are performed without trend and drift. There are 2 lagged dependent variables in the models for testing, and the lag lengths are determined by AIC. The test statistics and three significances are reported in the table.

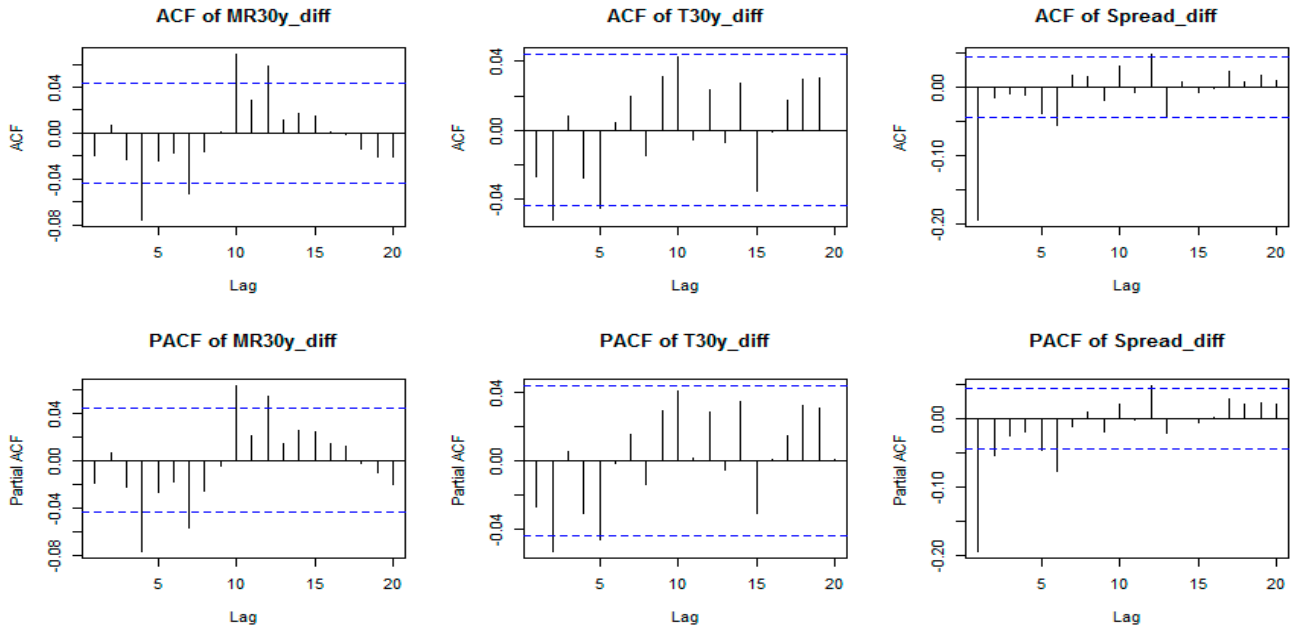
| Variable | Level | Change of Level (1 st Difference) | Change of Log Level |
|-------------------------------|----------|--|---------------------|
| 30-Year Mortgage Rate | -1.022 | -31.71*** | |
| 30-Year Treasury Rate | -0.866 | -33.728*** | |
| Mortgage-Treasury Rate Spread | -1.309 | -36.471*** | |
| Unemployment Rate | 0.001 | -5.982*** | |
| Case-Shiller HPI | 0.148 | | -2.237** |
| CPI | 3.922*** | | -7.340*** |

Note: ***, ** and * indicate statistical significance at 0.01, 0.05, 0.1 levels.

Figure A1: ACF and PACF of Data Series and Squared Residuals

Panel A: ACF and PACF of ΔMR_t , ΔTR_t and $\Delta Spread_t$

ACF and PACF of these 3 data series are shown in the top row and bottom row respectively.



Panel B: ACF and PACF of Squared Residuals in ARMA models fitting ΔMR_t , ΔTR_t and $\Delta Spread_t$

ACF and PACF of squared residuals are shown in the top row and bottom row respectively. The mean models fitting ΔMR_t , ΔTR_t and $\Delta Spread_t$ are AR(7), AR(5) and AR(6) accordingly.

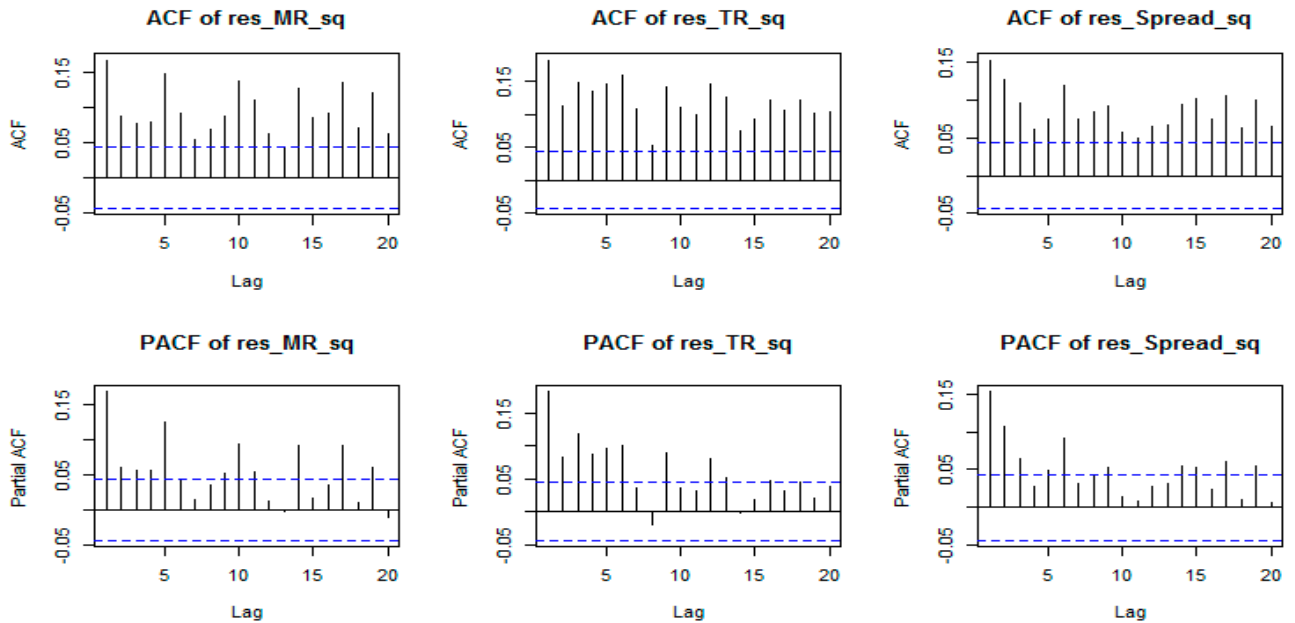


Table A2: GARCH Model Selection for ΔMR_t , ΔTR_t and $\Delta Spread_t$

The parameter estimates in mean model and variance model are reported. The p-values are shown in the table for Ljung-Box Test, ARCH-LM Test, Pearson Goodness-of-Fit Test and Engle-Ng Sign Bias Test. For Pearson Goodness-of-Fit Test, the number of bins is determined by χ^2 binning method (i.e., if $n \geq 35$, bins = largest integer below $1.88n^{0.4}$) (D'Agostino and Stephens, 1987) which is about 40 in this case. The best GARCH models after selection are highlighted.

Panel A: GARCH Model Selection for ΔMR_t with Mean Model of AR(7)

| | GARCH(1,2)-N | GARCH(1,2)-t | GARCH(1,2)-skewed t | IGARCH(1,2)-skewed t | GARCH(1,2)-skewed t in Mean |
|---|----------------------------|---------------------------|---------------------|---------------------------|-----------------------------|
| <i>Ljung-Box Test on Standardized Residuals</i> | | | | | |
| Q(1) | 0.824 | 0.878 | 0.697 | 0.567 | 0.713 |
| Q(23) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Q(39) | 0.537 | 0.429 | 0.352 | 0.464 | 0.371 |
| <i>Ljung-Box Test on Squared Standardized Residuals</i> | | | | | |
| Q(1) | 0.239 | 0.643 | 0.596 | 0.231 | 0.566 |
| Q(8) | 0.561 | 0.508 | 0.539 | 0.574 | 0.529 |
| Q(14) | 0.424 | 0.427 | 0.446 | 0.420 | 0.420 |
| <i>ARCH-LM Test</i> | | | | | |
| Lag(4) | 0.236 | 0.233 | 0.248 | 0.506 | 0.249 |
| Lag(6) | 0.549 | 0.626 | 0.636 | 0.693 | 0.635 |
| Lag(8) | 0.472 | 0.507 | 0.526 | 0.666 | 0.511 |
| <i>Mean Equation</i> | | | | | |
| Intercept | -0.002** | -0.003*** | -0.002** | -0.002*** | -0.004** |
| σ_t^2 | | | | | 0.063 |
| ΔMR_{t-1} | 0.015 | 0.005 | -0.001 | -0.004 | -0.001 |
| ΔMR_{t-2} | -0.021 | -0.028 | -0.032 | -0.031 | -0.033 |
| ΔMR_{t-3} | -0.037 | -0.044** | -0.045** | -0.048** | -0.045** |
| ΔMR_{t-4} | -0.043* | -0.044** | -0.045** | -0.046** | -0.046** |
| ΔMR_{t-5} | -0.024 | -0.027 | -0.026 | -0.025 | -0.028 |
| ΔMR_{t-6} | 0.013 | 0.013 | 0.015 | 0.013 | 0.013 |
| ΔMR_{t-7} | -0.035 | -0.039* | -0.040* | -0.042** | -0.041** |
| <i>Variance Equation</i> | | | | | |
| Intercept | 0.000*** | 0.000** | 0.000*** | | 0.000*** |
| σ_{t-1}^2 | 0.123*** | 0.170*** | 0.162*** | 0.108*** | 0.165*** |
| ε_{t-1}^2 | 0.401*** | 0.246* | 0.248* | 0.274** | 0.247* |
| ε_{t-2}^2 | 0.469*** | 0.582*** | 0.584*** | 0.618*** | 0.584*** |
| <i>Distribution of Std. Error</i> | | | | | |
| Skewness | | | 1.079*** | 1.076*** | 1.088*** |
| D.O.F. of t-distribution | | 3.673*** | 3.780*** | 4.662*** | 3.743*** |
| Pearson Goodness-of-Fit Bin(40) | $1.004 \times 10^{-26}***$ | $1.140 \times 10^{-4}***$ | 0.004*** | $6.643 \times 10^{-5}***$ | 0.024** |
| <i>Quality of Model</i> | | | | | |
| Log Likelihood | 3357.023 | 3471.073 | 3474.639 | 3456.585 | 3475.447 |
| AIC | -3.350 | -3.463 | -3.466 | -3.450 | -3.466 |
| BIC | -3.316 | -3.427 | -3.427 | -3.416 | -3.424 |
| <i>Engle-Ng Sign Bias Test</i> | | | | | |
| Sign Bias | 0.193 | 0.108 | 0.142 | 0.195 | 0.141 |
| Negative Sign Bias | 0.116 | 0.052* | 0.065* | 0.056* | 0.061* |
| Positive Sign Bias | 0.059* | 0.142 | 0.114 | 0.150 | 0.094* |
| Joint Effect | 0.099* | 0.115 | 0.113 | 0.116 | 0.092* |

Panel B: GARCH Model Selection for ΔTR_t with Mean Model of AR(5)

| | GARCH(1,1)-N | GARCH(1,1)-t | GARCH(1,1)-skewed t | IGARCH(1,1)-skewed t | GARCH(1,1)-skewed t in Mean |
|---|--------------|--------------|---------------------|----------------------|-----------------------------|
| <i>Ljung-Box Test on Standardized Residuals</i> | | | | | |
| Q(1) | 0.862 | 0.997 | 0.997 | 0.944 | 0.999 |
| Q(14) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Q(24) | 0.999 | 0.999 | 1.000 | 0.999 | 1.000 |
| <i>Ljung-Box Test on Squared Standardized Residuals</i> | | | | | |
| Q(1) | 0.621 | 0.583 | 0.630 | 0.671 | 0.612 |
| Q(5) | 0.627 | 0.626 | 0.637 | 0.595 | 0.640 |
| Q(9) | 0.547 | 0.512 | 0.550 | 0.458 | 0.551 |
| <i>ARCH-LM Test</i> | | | | | |
| Lag(3) | 0.215 | 0.261 | 0.230 | 0.212 | 0.238 |
| Lag(5) | 0.255 | 0.250 | 0.260 | 0.200 | 0.266 |
| Lag(7) | 0.275 | 0.248 | 0.280 | 0.180 | 0.282 |
| <i>Mean Equation</i> | | | | | |
| Intercept | -0.000 | -0.001 | -0.000 | -0.001 | -0.003 |
| σ_t^2 | | | | | 0.047 |
| ΔTR_{t-1} | -0.033 | -0.037 | -0.037 | -0.037 | -0.037 |
| ΔTR_{t-2} | -0.052** | -0.048** | -0.042* | -0.043* | -0.043* |
| ΔTR_{t-3} | -0.019 | -0.018 | -0.016 | -0.016 | -0.016 |
| ΔTR_{t-4} | -0.037 | -0.041* | -0.039* | -0.039* | -0.039* |
| ΔTR_{t-5} | -0.046** | -0.044* | -0.042* | -0.041* | -0.042* |
| <i>Variance Equation</i> | | | | | |
| Intercept | 0.000** | 0.000** | 0.000** | | 0.000** |
| σ_{t-1}^2 | 0.048*** | 0.045*** | 0.048*** | 0.043*** | 0.047*** |
| ε_{t-1}^2 | 0.943*** | 0.948*** | 0.945*** | 0.957*** | 0.945*** |
| <i>Distribution of Std. Error</i> | | | | | |
| Skewness | | | 1.084*** | 1.072*** | 1.084*** |
| D.O.F. of t-distribution | | 16.559*** | 16.296*** | 15.990*** | 16.075*** |
| Pearson Goodness-of-Fit Bin(40) | 0.006*** | 0.008*** | 0.670 | 0.917 | 0.128 |
| <i>Quality of Model</i> | | | | | |
| Log Likelihood | 2896.057 | 2902.287 | 2905.072 | 2899.951 | 2905.243 |
| AIC | -2.891 | -2.897 | -2.898 | -2.895 | -2.898 |
| BIC | -2.866 | -2.869 | -2.868 | -2.870 | -2.864 |
| <i>Engle-Ng Sign Bias Test</i> | | | | | |
| Sign Bias | 0.495 | 0.574 | 0.498 | 0.624 | 0.577 |
| Negative Sign Bias | 0.199 | 0.199 | 0.207 | 0.501 | 0.230 |
| Positive Sign Bias | 0.786 | 0.835 | 0.755 | 0.441 | 0.821 |
| Joint Effect | 0.621 | 0.612 | 0.627 | 0.742 | 0.663 |

Panel C: GARCH Model Selection for $\Delta Spread_t$ with Mean Model of AR(6)

| | GARCH(1,1)-N | GARCH(1,1)-t | GARCH(1,1)-skewed t | IGARCH(1,1)-skewed t | GARCH(1,1)-skewed t in Mean |
|---|------------------------|--------------|---------------------|----------------------|-----------------------------|
| <i>Ljung-Box Test on Standardized Residuals</i> | | | | | |
| Q(1) | 0.834 | 0.958 | 0.949 | 0.952 | 0.963 |
| Q(17) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Q(29) | 0.997 | 1.000 | 1.000 | 0.999 | 1.000 |
| <i>Ljung-Box Test on Squared Standardized Residuals</i> | | | | | |
| Q(1) | 0.296 | 0.346 | 0.343 | 0.185 | 0.349 |
| Q(5) | 0.586 | 0.621 | 0.623 | 0.145 | 0.638 |
| Q(9) | 0.814 | 0.834 | 0.836 | 0.262 | 0.848 |
| <i>ARCH-LM Test</i> | | | | | |
| Lag(3) | 0.461 | 0.486 | 0.485 | 0.988 | 0.473 |
| Lag(5) | 0.761 | 0.765 | 0.766 | 0.582 | 0.782 |
| Lag(7) | 0.924 | 0.926 | 0.926 | 0.753 | 0.934 |
| <i>Mean Equation</i> | | | | | |
| Intercept | -0.000 | -0.000 | 0.000 | 0.000 | 0.004 |
| σ_t^2 | | | | | -0.071 |
| $\Delta Spread_{t-1}$ | -0.220*** | -0.227*** | -0.228*** | -0.227*** | -0.229*** |
| $\Delta Spread_{t-2}$ | -0.060** | -0.054** | -0.055** | -0.056** | -0.056** |
| $\Delta Spread_{t-3}$ | -0.041* | -0.031 | -0.031 | -0.030 | -0.031 |
| $\Delta Spread_{t-4}$ | -0.047** | -0.050** | -0.051** | -0.053** | -0.051** |
| $\Delta Spread_{t-5}$ | -0.090*** | -0.076*** | -0.077*** | -0.074*** | -0.076*** |
| $\Delta Spread_{t-6}$ | -0.070*** | -0.057*** | -0.057*** | -0.057** | -0.057*** |
| <i>Variance Equation</i> | | | | | |
| Intercept | 0.000*** | 0.000** | 0.000** | | <0.001** |
| σ_{t-1}^2 | 0.071*** | 0.070*** | 0.070*** | 0.051*** | 0.070*** |
| ε_{t-1}^2 | 0.915*** | 0.922*** | 0.922*** | 0.949*** | 0.922*** |
| <i>Distribution of Std. Error</i> | | | | | |
| Skewness | | | 1.026*** | 1.030*** | 1.023*** |
| D.O.F. of t-distribution | | 6.867*** | 6.892*** | 7.259*** | 6.898*** |
| Pearson Goodness-of-Fit Bin(40) | 3.672×10 ⁻⁴ | 0.349 | 0.551 | 0.863 | 0.867 |
| <i>Quality of Model</i> | | | | | |
| Log Likelihood | 2874.944 | 2919.45 | 2919.744 | 2912.944 | 2920.747 |
| AIC | -2.869 | -2.913 | -2.912 | -2.907 | -2.912 |
| BIC | -2.841 | -2.882 | -2.879 | -2.879 | -2.876 |
| <i>Engle-Ng Sign Bias Test</i> | | | | | |
| Sign Bias | 0.086* | 0.127 | 0.149 | 0.128 | 0.090* |
| Negative Sign Bias | 0.712 | 0.666 | 0.693 | 0.542 | 0.615 |
| Positive Sign Bias | 0.067* | 0.123 | 0.132 | 0.155 | 0.110 |
| Joint Effect | 0.240 | 0.375 | 0.410 | 0.412 | 0.309 |

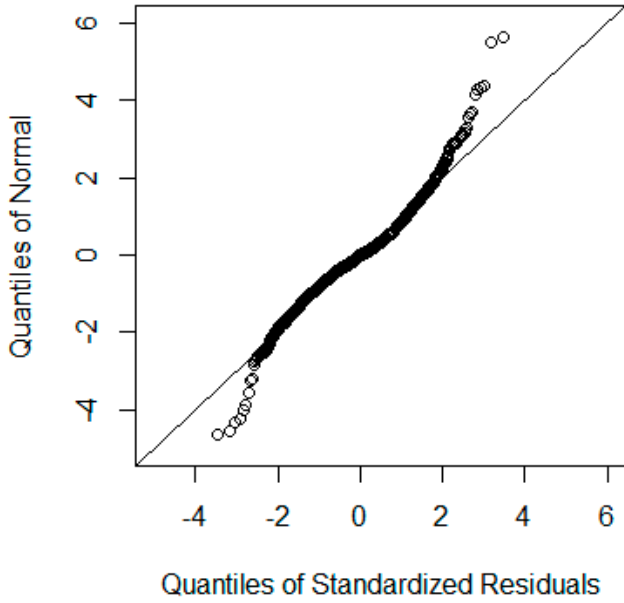
Note: ***, ** and * indicate statistical significance at 0.01, 0.05, 0.1 levels.

Figure A2: Quantile and Quantile (QQ) Plots of Standardized Residuals

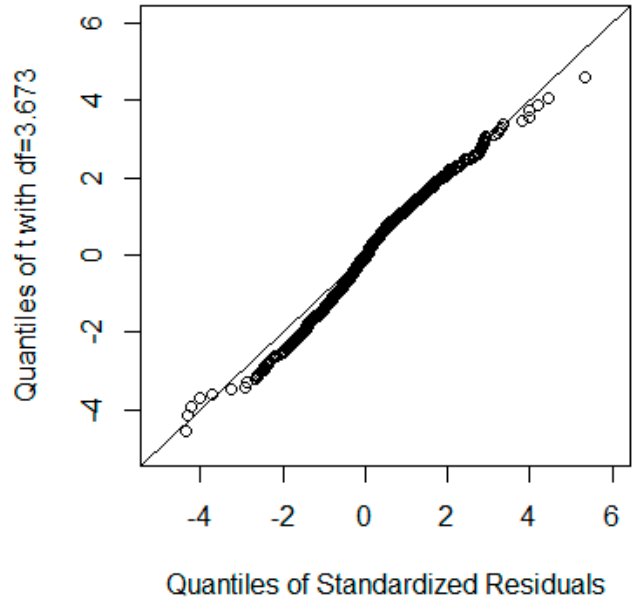
In each graph, the quantile of standardized residuals is plotted against the quantile of a theoretical distribution as indicated.

Panel A: QQ Plots of standardized residuals in ΔMR_t model

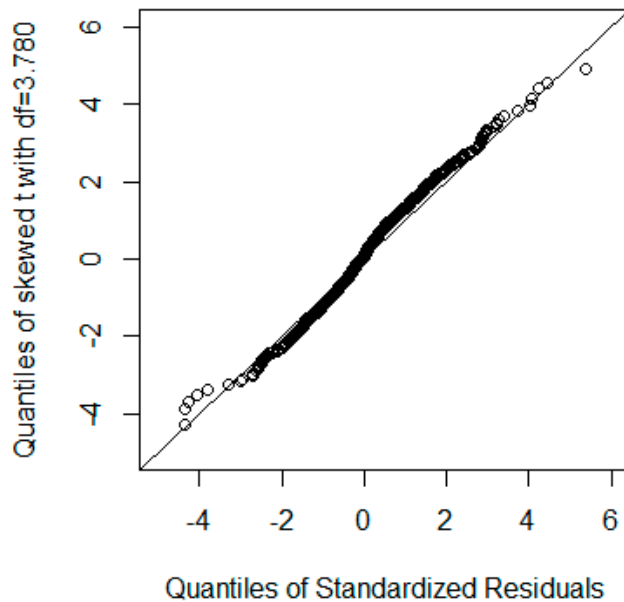
QQ Plot for GARCH(1,2)-Normal



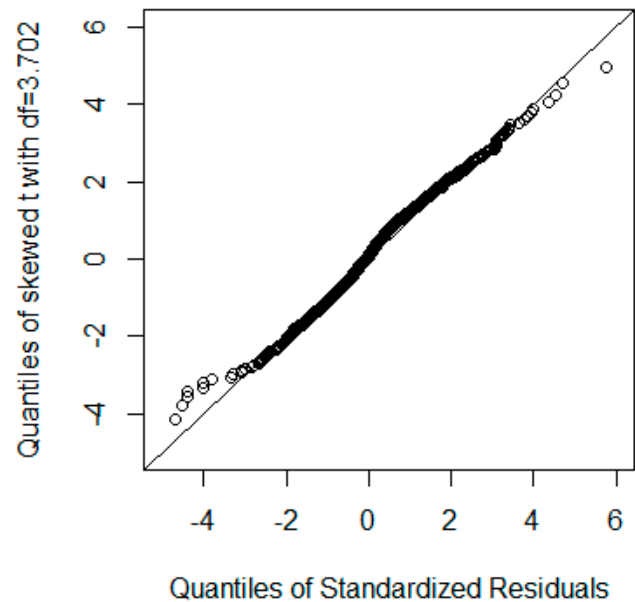
QQ Plot for GARCH(1,2)-t



QQ Plot for GARCH(1,2)-skt

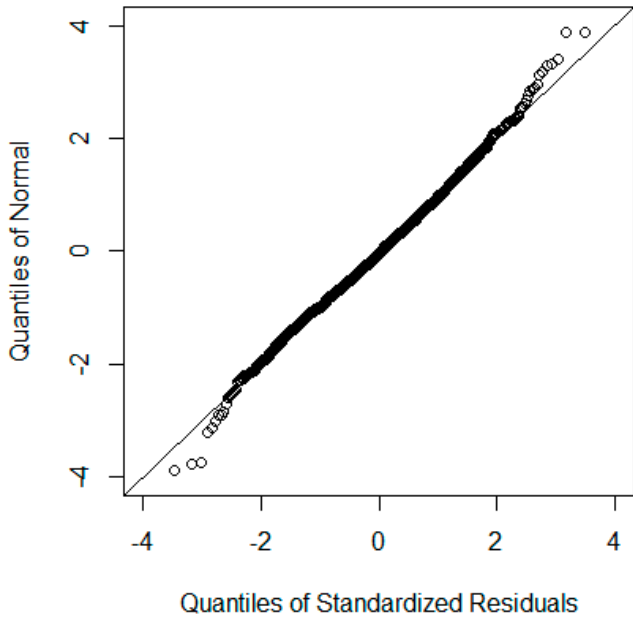


QQ Plot for IGARCH(1,2)-skt

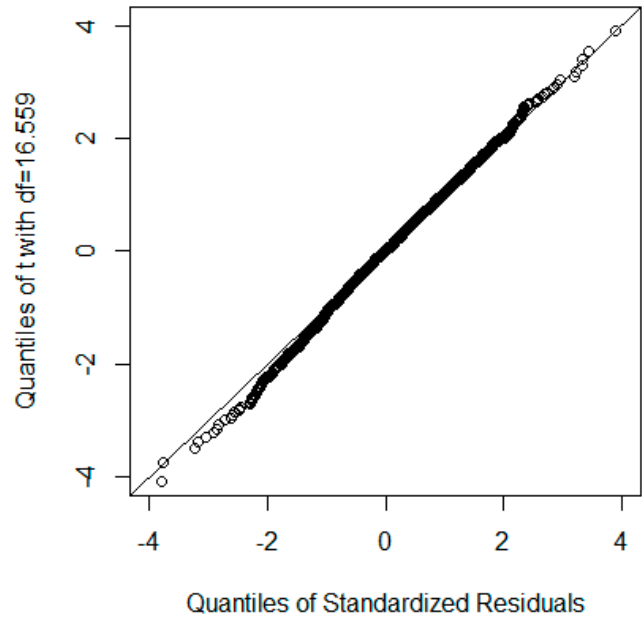


Panel B: QQ Plots of standardized residuals in ΔTR_t model

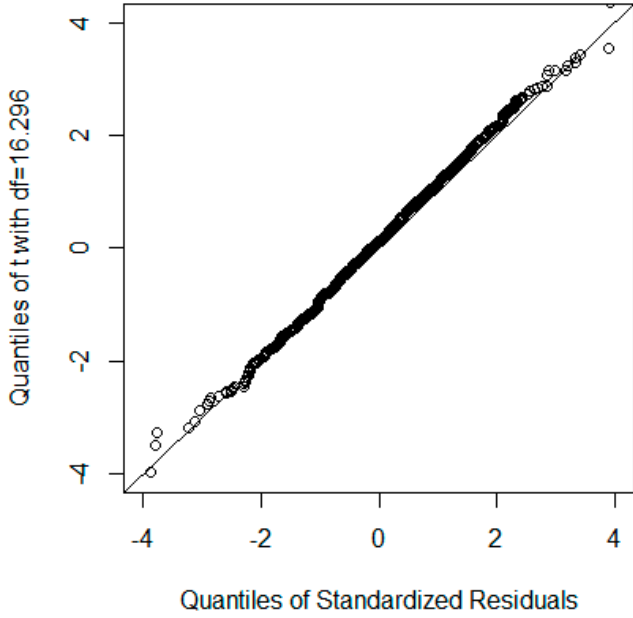
QQ Plot for GARCH(1,1)-Normal



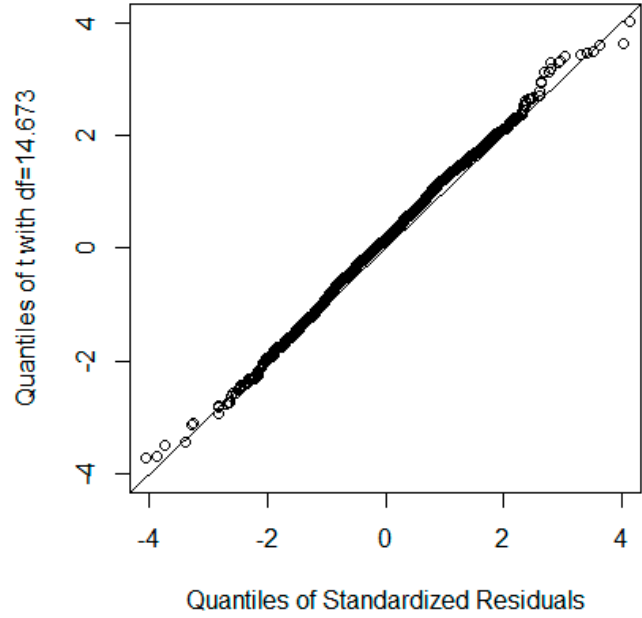
QQ Plot for GARCH(1,1)-t



QQ Plot for GARCH(1,1)-skt

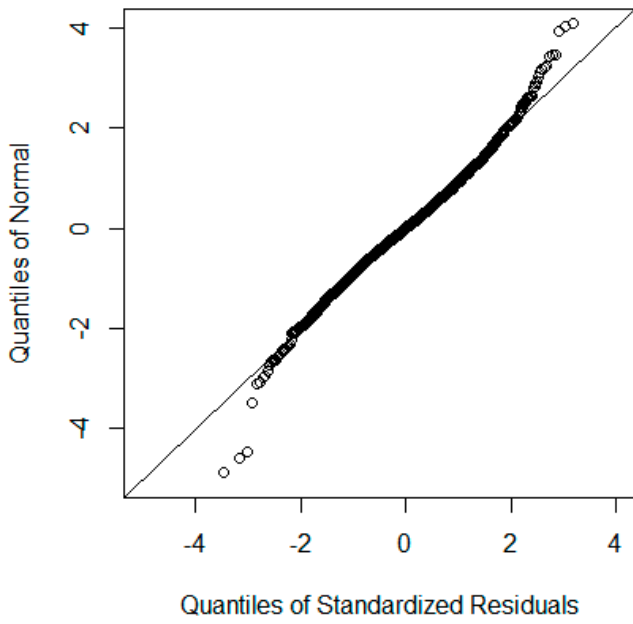


QQ Plot for IGARCH(1,1)-skt

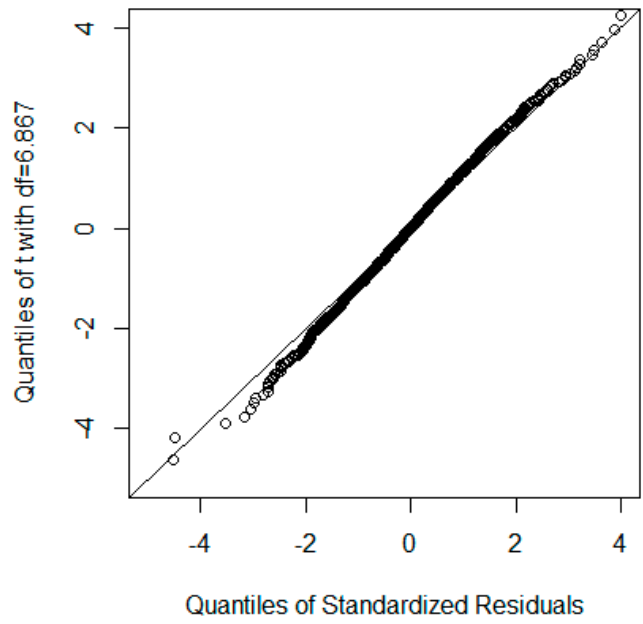


Panel C: QQ Plots of standardized residuals in $\Delta Spread_t$ model

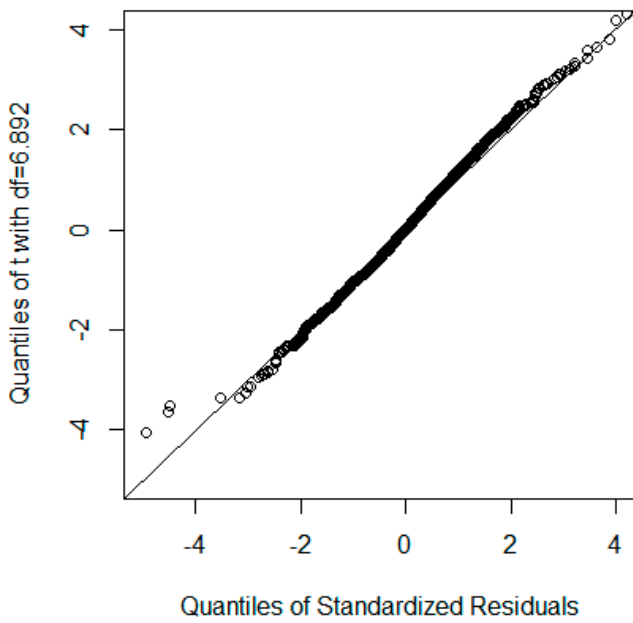
QQ Plot for GARCH(1,1)-Normal



QQ Plot for GARCH(1,1)-t



QQ Plot for GARCH(1,1)-skt



QQ Plot for IGARCH(1,1)-skt

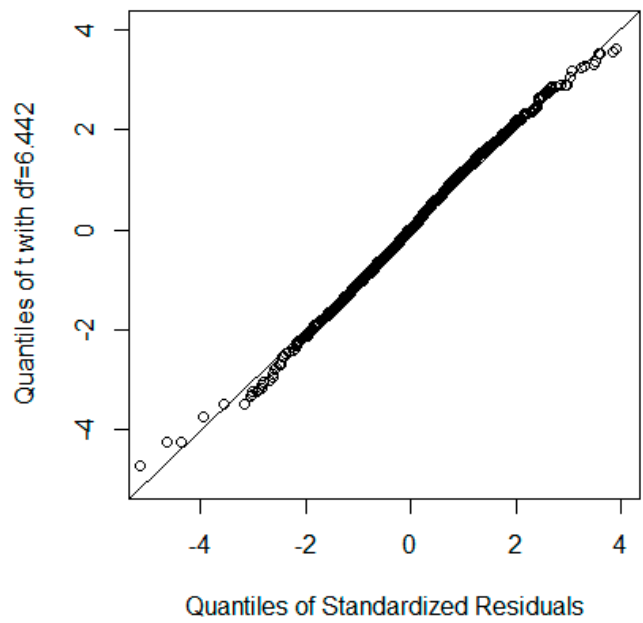
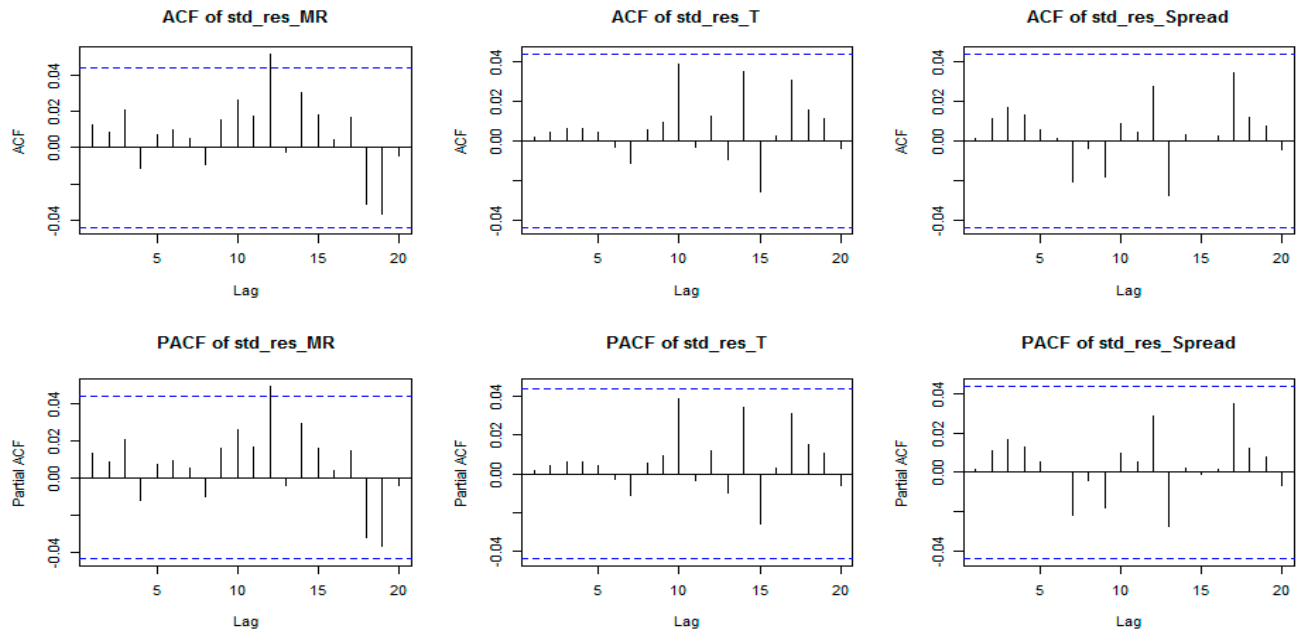


Figure A3: ACF and PACF of Standardized Residuals and Squared Standardized Residuals after Adjusting for Autocorrelation and GARCH Errors

The time series models estimating ΔMR_t , ΔTR_t and $\Delta Spread_t$ are AR(7)-IGARCH(1,2)-skewed t, AR(5)-IGARCH(1,1)-skewed t and AR(6)-IGARCH(1,1)-skewed t.

Panel A: ACF and PACF of Standardized Residuals

The upper row shows ACF of standardized residuals for 3 models estimating ΔMR_t , ΔTR_t and $\Delta Spread_t$ respectively, while the bottom row shows PACF.



Panel B: ACF and PACF of Squared Standardized Residuals

The upper row shows ACF of squared standardized residuals for 3 models estimating ΔMR_t , ΔTR_t and $\Delta Spread_t$ respectively, while the bottom row shows PACF.

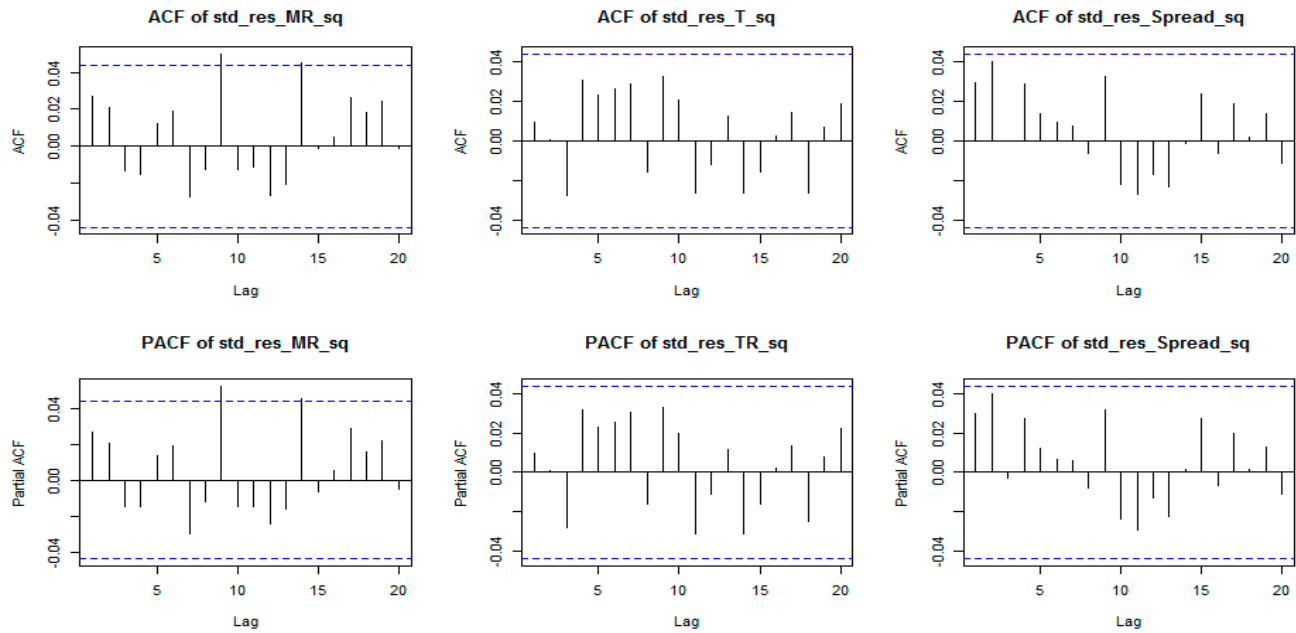


Table A3: Abnormal Returns (ARs) for QE Events in 3-day Window Case

The ARs are parameter estimates of event dummies in 4 regressions by using 3-day window. Each CAR in Table 5 is calculated by adding up 3 ARs in a 3-day event window. “Controlled” means the model is controlling for ΔTR_t , while “Uncontrolled” means the model is not controlling for ΔTR_t .

| Date | Dependent Variable | | | | | | | |
|-------------------|----------------------------|-------|------------------------------|-------|--------------|-------|-------------------|-------|
| | ΔMR_t (Controlled) | | ΔMR_t (Uncontrolled) | | ΔT_t | | $\Delta Spread_t$ | |
| | Estimate | SE | Estimate | SE | Estimate | SE | Estimate | SE |
| 11/25/2008 - 1day | -0.020 | 0.039 | 0.002 | 0.042 | 0.069 | 0.084 | -0.074 | 0.077 |
| 11/25/2008 | -0.118** | 0.046 | -0.163*** | 0.045 | -0.159* | 0.084 | 0.004 | 0.073 |
| 11/25/2008 + 1day | -0.011 | 0.037 | -0.042 | 0.047 | -0.109 | 0.083 | 0.076 | 0.072 |
| 12/1/2008 - 1day | 0.037 | 0.037 | 0.006 | 0.048 | -0.094 | 0.083 | 0.122* | 0.072 |
| 12/1/2008 | 0.012 | 0.036 | -0.052 | 0.045 | -0.213*** | 0.074 | 0.187*** | 0.071 |
| 12/1/2008 + 1day | -0.044 | 0.043 | -0.051 | 0.039 | -0.035 | 0.082 | -0.034 | 0.074 |
| 12/16/2008 - 1day | -0.003 | 0.032 | -0.037 | 0.040 | -0.083 | 0.074 | 0.067 | 0.065 |
| 12/16/2008 | 0.046 | 0.033 | 0.010 | 0.035 | -0.114 | 0.075 | -0.119* | 0.071 |
| 12/16/2008 + 1day | -0.188*** | 0.034 | -0.243*** | 0.036 | -0.190*** | 0.071 | -0.036 | 0.066 |
| 1/28/2009 - 1day | 0.003 | 0.038 | -0.019 | 0.033 | -0.097 | 0.070 | 0.066 | 0.069 |
| 1/28/2009 | -0.060* | 0.035 | -0.009 | 0.040 | 0.213*** | 0.070 | -0.211*** | 0.068 |
| 1/28/2009 + 1day | -0.027 | 0.032 | 0.009 | 0.033 | 0.149** | 0.069 | -0.139** | 0.065 |
| 3/18/2009 - 1day | 0.032 | 0.020 | 0.052** | 0.021 | 0.087 | 0.078 | -0.055 | 0.066 |
| 3/18/2009 | 0.062** | 0.025 | -0.006 | 0.021 | -0.246*** | 0.068 | 0.248*** | 0.067 |
| 3/18/2009 + 1day | -0.101*** | 0.022 | -0.083*** | 0.022 | 0.065 | 0.068 | -0.153** | 0.065 |
| 8/12/2009 - 1day | 0.039* | 0.024 | 0.021 | 0.032 | -0.069 | 0.070 | 0.099* | 0.052 |
| 8/12/2009 | -0.028 | 0.028 | -0.001 | 0.034 | 0.093 | 0.069 | -0.089* | 0.053 |
| 8/12/2009 + 1day | -0.077*** | 0.028 | -0.100*** | 0.027 | -0.094 | 0.069 | -0.014 | 0.052 |
| 9/23/2009 - 1day | -0.005 | 0.031 | -0.028 | 0.036 | -0.026 | 0.061 | 0.028 | 0.050 |
| 9/23/2009 | 0.054* | 0.028 | 0.056* | 0.031 | 0.009 | 0.061 | 0.041 | 0.051 |
| 9/23/2009 + 1day | -0.014 | 0.029 | -0.017 | 0.034 | -0.043 | 0.061 | 0.020 | 0.050 |
| 11/4/2009 - 1day | -0.024 | 0.036 | -0.003 | 0.040 | 0.081 | 0.055 | -0.090 | 0.055 |
| 11/4/2009 | 0.029 | 0.034 | 0.048 | 0.036 | 0.079 | 0.054 | -0.032 | 0.056 |
| 11/4/2009 + 1day | 0.025 | 0.036 | 0.031 | 0.039 | 0.004 | 0.055 | 0.016 | 0.055 |
| 8/10/2010 - 1day | -0.069*** | 0.013 | -0.064*** | 0.013 | 0.009 | 0.056 | -0.061 | 0.041 |
| 8/10/2010 | 0.048*** | 0.012 | 0.043*** | 0.013 | -0.010 | 0.056 | 0.052 | 0.042 |
| 8/10/2010 + 1day | 0.005 | 0.012 | -0.014 | 0.012 | -0.069 | 0.056 | 0.065 | 0.041 |
| 8/27/2010 - 1day | 0.033** | 0.015 | 0.020 | 0.018 | -0.054 | 0.048 | 0.069 | 0.045 |
| 8/27/2010 | -0.180*** | 0.014 | -0.134*** | 0.017 | 0.170*** | 0.048 | -0.296*** | 0.046 |
| 8/27/2010 + 1day | 0.019 | 0.013 | -0.006 | 0.017 | -0.086** | 0.048 | 0.093** | 0.042 |
| 9/21/2010 - 1day | -0.144** | 0.042 | -0.146*** | 0.043 | -0.024 | 0.055 | -0.104 | 0.065 |
| 9/21/2010 | 0.016 | 0.039 | -0.001 | 0.044 | -0.076 | 0.055 | 0.050 | 0.063 |
| 9/21/2010 + 1day | -0.012 | 0.038 | -0.030 | 0.049 | -0.038 | 0.055 | 0.038 | 0.061 |
| 10/15/2010 - 1day | -0.057 | 0.051 | -0.030 | 0.057 | 0.083* | 0.045 | -0.126** | 0.062 |
| 10/15/2010 | 0.128** | 0.040 | 0.155*** | 0.045 | 0.085* | 0.045 | 0.073 | 0.064 |
| 10/15/2010 + 1day | -0.078 | 0.048 | -0.088* | 0.046 | -0.039 | 0.052 | -0.056 | 0.062 |
| 11/3/2010 - 1day | 0.045 | 0.042 | 0.041 | 0.047 | -0.063 | 0.045 | 0.053 | 0.060 |
| 11/3/2010 | -0.060 | 0.040 | -0.015 | 0.044 | 0.174*** | 0.045 | -0.170*** | 0.057 |
| 11/3/2010 + 1day | 0.001 | 0.040 | -0.016 | 0.045 | -0.041 | 0.045 | 0.029 | 0.055 |
| 8/9/2011 - 1day | 0.040*** | 0.010 | 0.000 | 0.016 | -0.143** | 0.063 | 0.143*** | 0.043 |
| 8/9/2011 | 0.036*** | 0.010 | 0.002 | 0.018 | -0.117* | 0.063 | 0.137*** | 0.044 |
| 8/9/2011 + 1day | -0.133*** | 0.011 | -0.136*** | 0.016 | -0.022 | 0.075 | -0.105** | 0.044 |
| 8/26/2011 - 1day | 0.028 | 0.018 | 0.020 | 0.028 | -0.020 | 0.082 | 0.034 | 0.055 |
| 8/26/2011 | -0.021 | 0.017 | -0.034 | 0.023 | -0.056 | 0.082 | 0.043 | 0.056 |
| 8/26/2011 + 1day | 0.011 | 0.017 | 0.034 | 0.027 | 0.092 | 0.082 | -0.046 | 0.055 |
| 9/21/2011 - 1day | 0.008 | 0.012 | 0.008 | 0.020 | -0.002 | 0.068 | 0.022 | 0.056 |
| 9/21/2011 | 0.021* | 0.012 | -0.025 | 0.016 | -0.154** | 0.068 | 0.135** | 0.056 |
| 9/21/2011 + 1day | -0.027* | 0.014 | -0.095*** | 0.018 | -0.236*** | 0.068 | 0.143** | 0.056 |
| 6/20/2012 - 1day | -0.014 | 0.013 | 0.005 | 0.015 | 0.063 | 0.049 | -0.050 | 0.036 |
| 6/20/2012 | 0.018 | 0.014 | 0.014 | 0.016 | -0.006 | 0.043 | 0.026 | 0.036 |
| 6/20/2012 + 1day | -0.006 | 0.014 | -0.016 | 0.018 | -0.036 | 0.048 | 0.014 | 0.038 |
| 8/22/2012 - 1day | -0.053*** | 0.015 | -0.059*** | 0.020 | -0.018 | 0.043 | -0.033 | 0.030 |
| 8/22/2012 | -0.041*** | 0.013 | -0.061*** | 0.018 | -0.069 | 0.043 | 0.008 | 0.030 |
| 8/22/2012 + 1day | -0.024* | 0.014 | -0.031* | 0.018 | -0.025 | 0.043 | -0.003 | 0.029 |
| 8/31/2012 - 1day | -0.001 | 0.015 | -0.005 | 0.016 | -0.011 | 0.037 | 0.002 | 0.031 |
| 8/31/2012 | 0.023* | 0.013 | 0.005 | 0.019 | -0.062* | 0.036 | 0.071** | 0.031 |
| 8/31/2012 + 1day | -0.019 | 0.015 | -0.014 | 0.016 | 0.020 | 0.036 | -0.036 | 0.030 |
| 9/13/2012 - 1day | 0.012 | 0.012 | 0.035** | 0.016 | 0.088** | 0.042 | -0.049* | 0.028 |
| 9/13/2012 | -0.045*** | 0.013 | -0.034* | 0.018 | 0.036 | 0.041 | -0.078*** | 0.028 |
| 9/13/2012 + 1day | -0.047*** | 0.012 | -0.007 | 0.018 | 0.141*** | 0.041 | -0.145*** | 0.028 |
| 12/12/2012 - 1day | -0.005 | 0.009 | 0.005 | 0.012 | 0.039 | 0.030 | -0.031 | 0.023 |
| 12/12/2012 | -0.026*** | 0.009 | -0.004 | 0.012 | 0.077** | 0.030 | -0.083*** | 0.023 |
| 12/12/2012 + 1day | 0.023*** | 0.009 | 0.026** | 0.011 | 0.008 | 0.030 | 0.025 | 0.022 |
| 5/1/2013 - 1day | 0.001 | 0.015 | 0.004 | 0.018 | 0.008 | 0.033 | -0.006 | 0.025 |

| | | | | | | | | |
|-------------------|-----------|-------|-----------|-------|----------|-------|-----------|-------|
| 5/1/2013 | -0.011 | 0.015 | -0.024 | 0.018 | -0.041 | 0.033 | 0.018 | 0.026 |
| 5/1/2013 + 1day | 0.027* | 0.014 | 0.024 | 0.017 | -0.001 | 0.033 | 0.017 | 0.028 |
| 5/22/2013 - 1day | 0.000 | 0.015 | -0.010 | 0.021 | -0.029 | 0.038 | 0.022 | 0.023 |
| 5/22/2013 | 0.067*** | 0.017 | 0.090*** | 0.023 | 0.075** | 0.038 | 0.012 | 0.024 |
| 5/22/2013 + 1day | 0.046*** | 0.015 | 0.050** | 0.020 | 0.000 | 0.037 | 0.054** | 0.023 |
| 6/19/2013 - 1day | 0.042 | 0.031 | 0.039 | 0.037 | 0.000 | 0.038 | 0.042 | 0.039 |
| 6/19/2013 | 0.029 | 0.032 | 0.053 | 0.039 | 0.081** | 0.038 | -0.030 | 0.039 |
| 6/19/2013 + 1day | 0.175*** | 0.031 | 0.197*** | 0.038 | 0.084** | 0.038 | 0.117*** | 0.038 |
| 12/18/2013 - 1day | -0.020 | 0.022 | -0.023 | 0.031 | -0.013 | 0.033 | -0.014 | 0.028 |
| 12/18/2013 | 0.011 | 0.021 | 0.018 | 0.025 | 0.030 | 0.033 | -0.009 | 0.029 |
| 12/18/2013 + 1day | 0.062** | 0.025 | 0.070*** | 0.025 | 0.017 | 0.033 | 0.060** | 0.027 |
| 1/29/2014 - 1day | -0.010 | 0.019 | -0.008 | 0.024 | 0.010 | 0.036 | -0.024 | 0.025 |
| 1/29/2014 | -0.001 | 0.019 | -0.021 | 0.023 | -0.057* | 0.031 | 0.043* | 0.025 |
| 1/29/2014 + 1day | -0.006 | 0.019 | 0.005 | 0.019 | 0.031 | 0.031 | -0.032 | 0.025 |
| 3/19/2014 - 1day | 0.015 | 0.019 | 0.010 | 0.024 | -0.012 | 0.034 | 0.020 | 0.027 |
| 3/19/2014 | 0.043** | 0.017 | 0.052** | 0.021 | 0.037 | 0.034 | 0.017 | 0.028 |
| 3/19/2014 + 1day | 0.060*** | 0.016 | 0.065*** | 0.022 | 0.005 | 0.034 | 0.060** | 0.028 |
| 4/30/2014 - 1day | 0.039 | 0.037 | 0.045 | 0.035 | 0.023 | 0.027 | 0.021 | 0.046 |
| 4/30/2014 | -0.027 | 0.032 | -0.034 | 0.039 | -0.017 | 0.031 | -0.017 | 0.047 |
| 4/30/2014 + 1day | 0.008 | 0.032 | -0.011 | 0.040 | -0.055** | 0.027 | 0.061 | 0.045 |
| 5/7/2014 - 1day | -0.112*** | 0.032 | -0.112*** | 0.034 | -0.025 | 0.027 | -0.107** | 0.046 |
| 5/7/2014 | -0.019 | 0.040 | -0.001 | 0.038 | 0.022 | 0.032 | -0.033 | 0.047 |
| 5/7/2014 + 1day | 0.005 | 0.032 | 0.022 | 0.039 | 0.049 | 0.032 | -0.029 | 0.046 |
| 6/18/2014 - 1day | 0.055** | 0.024 | 0.068** | 0.027 | 0.042 | 0.032 | 0.024 | 0.035 |
| 6/18/2014 | 0.007 | 0.026 | 0.004 | 0.028 | -0.014 | 0.032 | 0.018 | 0.036 |
| 6/18/2014 + 1day | -0.043** | 0.022 | -0.035 | 0.027 | 0.036 | 0.032 | -0.067* | 0.035 |
| 7/15/2014 - 1day | 0.004 | 0.027 | 0.003 | 0.029 | 0.017 | 0.032 | 0.010 | 0.034 |
| 7/15/2014 | 0.019 | 0.021 | 0.023 | 0.022 | 0.006 | 0.032 | 0.001 | 0.035 |
| 7/15/2014 + 1day | -0.021 | 0.022 | -0.025 | 0.024 | -0.019 | 0.032 | 0.000 | 0.035 |
| 7/30/2014 - 1day | 0.107*** | 0.040 | 0.105** | 0.044 | -0.037 | 0.032 | 0.118** | 0.054 |
| 7/30/2014 | -0.118*** | 0.035 | -0.092** | 0.037 | 0.094*** | 0.032 | -0.180*** | 0.055 |
| 7/30/2014 + 1day | 0.019 | 0.038 | 0.019 | 0.041 | 0.010 | 0.032 | 0.020 | 0.055 |
| 8/22/2014 - 1day | 0.054 | 0.047 | 0.052 | 0.052 | -0.031 | 0.033 | 0.048 | 0.055 |
| 8/22/2014 | 0.007 | 0.048 | -0.008 | 0.055 | -0.025 | 0.033 | 0.042 | 0.056 |
| 8/22/2014 + 1day | -0.019 | 0.045 | -0.031 | 0.050 | -0.020 | 0.028 | -0.021 | 0.054 |
| 9/17/2014 - 1day | -0.026 | 0.034 | -0.029 | 0.043 | 0.027 | 0.036 | -0.054 | 0.051 |
| 9/17/2014 | 0.006 | 0.040 | 0.014 | 0.044 | 0.016 | 0.036 | -0.008 | 0.052 |
| 9/17/2014 + 1day | 0.025 | 0.033 | 0.022 | 0.042 | -0.006 | 0.037 | 0.027 | 0.048 |
| 10/29/2014 - 1day | -0.032 | 0.032 | -0.022 | 0.036 | 0.029 | 0.031 | -0.054 | 0.047 |
| 10/29/2014 | 0.015 | 0.036 | 0.020 | 0.033 | 0.008 | 0.031 | 0.014 | 0.048 |
| 10/29/2014 + 1day | 0.008 | 0.031 | 0.004 | 0.034 | -0.011 | 0.031 | 0.011 | 0.050 |

Note: ***, ** and * indicate statistical significance at 0.01, 0.05, 0.1 levels.

Table A4: Abnormal Returns (ARs) for QE Events in 5-day Window Case

The ARs are parameter estimates of event dummies in 4 regressions by using 5-day window. Each CAR in Table 6 is calculated by adding up 5 ARs in a 5-day event window. “Controlled” means the model is controlling for ΔTR_t , while “Uncontrolled” means the model is not controlling for ΔTR_t . 2 dates included in parenthesis are overlapping days from 2 different windows.

| Date | Dependent Variable | | | | | | | |
|---------------------|----------------------------|-------|------------------------------|-------|--------------|-------|-------------------|-------|
| | ΔMR_t (Controlled) | | ΔMR_t (Uncontrolled) | | ΔT_t | | $\Delta Spread_t$ | |
| | Estimate | SE | Estimate | SE | Estimate | SE | Estimate | SE |
| 11/25/2008 - 2day | -0.012 | 0.043 | -0.006 | 0.047 | 0.045 | 0.081 | 0.008 | 0.074 |
| 11/25/2008 - 1day | -0.019 | 0.037 | 0.002 | 0.039 | 0.066 | 0.081 | -0.075 | 0.075 |
| 11/25/2008 | -0.117*** | 0.036 | -0.162*** | 0.039 | -0.161** | 0.080 | 0.003 | 0.070 |
| (11/25/2008 + 1day) | -0.010 | 0.035 | -0.039 | 0.038 | -0.108 | 0.080 | 0.079 | 0.069 |
| (12/1/2008 - 1day) | 0.038 | 0.035 | 0.007 | 0.038 | -0.094 | 0.079 | 0.123* | 0.068 |
| 12/1/2008 | 0.013 | 0.034 | -0.051 | 0.037 | -0.217*** | 0.077 | 0.183*** | 0.068 |
| 12/1/2008 + 1day | -0.039 | 0.034 | -0.053 | 0.036 | -0.033 | 0.078 | -0.024 | 0.067 |
| 12/1/2008 + 2day | -0.050 | 0.033 | -0.049 | 0.035 | -0.003 | 0.077 | -0.040 | 0.066 |
| 12/16/2008 - 2day | 0.034 | 0.032 | 0.042 | 0.034 | 0.012 | 0.074 | 0.025 | 0.066 |
| 12/16/2008 - 1day | -0.007 | 0.036 | -0.037 | 0.037 | -0.081 | 0.064 | 0.056 | 0.063 |
| 12/16/2008 | 0.046 | 0.031 | 0.009 | 0.033 | -0.110* | 0.064 | 0.122* | 0.066 |
| 12/16/2008 + 1day | -0.195*** | 0.036 | -0.245*** | 0.035 | -0.187*** | 0.064 | -0.056 | 0.066 |
| 12/16/2008 + 2day | 0.033 | 0.030 | 0.000 | 0.031 | -0.119* | 0.063 | 0.106 | 0.065 |
| 1/28/2009 - 2day | -0.023 | 0.035 | 0.007 | 0.040 | 0.095 | 0.077 | -0.100* | 0.061 |
| 1/28/2009 - 1day | 0.004 | 0.036 | -0.021 | 0.032 | -0.102 | 0.076 | 0.088 | 0.065 |
| 1/28/2009 | -0.056* | 0.033 | -0.006 | 0.037 | 0.206*** | 0.065 | -0.210*** | 0.062 |
| 1/28/2009 + 1day | -0.030 | 0.031 | 0.007 | 0.032 | 0.145** | 0.066 | -0.137** | 0.060 |
| 1/28/2009 + 2day | 0.022 | 0.031 | 0.033 | 0.040 | 0.023 | 0.065 | 0.001 | 0.059 |
| 3/18/2009 - 2day | -0.009 | 0.024 | 0.023 | 0.021 | 0.119* | 0.067 | -0.103* | 0.057 |
| 3/18/2009 - 1day | 0.032* | 0.019 | 0.051** | 0.023 | 0.081 | 0.075 | -0.030 | 0.058 |
| 3/18/2009 | 0.062*** | 0.024 | -0.007 | 0.020 | -0.253*** | 0.070 | 0.244*** | 0.062 |
| 3/18/2009 + 1day | -0.102*** | 0.023 | -0.085*** | 0.022 | 0.061 | 0.065 | -0.142** | 0.061 |
| 3/18/2009 + 2day | 0.012 | 0.022 | 0.020 | 0.022 | 0.034 | 0.074 | -0.020 | 0.060 |
| 8/12/2009 - 2day | -0.002 | 0.023 | -0.027 | 0.033 | -0.074 | 0.068 | 0.048 | 0.051 |
| 8/12/2009 - 1day | 0.040* | 0.023 | 0.022 | 0.025 | -0.064 | 0.067 | 0.086* | 0.052 |
| 8/12/2009 | -0.027 | 0.026 | 0.002 | 0.032 | 0.098 | 0.067 | -0.089* | 0.051 |
| 8/12/2009 + 1day | -0.074*** | 0.022 | -0.099*** | 0.025 | -0.090 | 0.067 | -0.013 | 0.051 |
| 8/12/2009 + 2day | -0.032 | 0.022 | -0.040 | 0.030 | -0.022 | 0.067 | -0.003 | 0.050 |
| 9/23/2009 - 2day | 0.075*** | 0.024 | 0.073*** | 0.025 | -0.002 | 0.059 | 0.056 | 0.049 |
| 9/23/2009 - 1day | -0.013 | 0.026 | -0.027 | 0.029 | -0.024 | 0.058 | 0.012 | 0.052 |
| 9/23/2009 | 0.051** | 0.022 | 0.055* | 0.028 | 0.013 | 0.058 | 0.041 | 0.049 |
| 9/23/2009 + 1day | -0.014 | 0.026 | -0.022 | 0.028 | -0.038 | 0.058 | 0.010 | 0.048 |
| 9/23/2009 + 2day | -0.012 | 0.025 | -0.029 | 0.027 | -0.065 | 0.058 | 0.045 | 0.047 |
| 11/4/2009 - 2day | -0.006 | 0.032 | 0.003 | 0.030 | 0.036 | 0.054 | -0.024 | 0.053 |
| 11/4/2009 - 1day | -0.025 | 0.033 | -0.003 | 0.035 | 0.080 | 0.053 | -0.081 | 0.054 |
| 11/4/2009 | 0.031 | 0.032 | 0.051 | 0.034 | 0.079 | 0.048 | -0.031 | 0.053 |
| 11/4/2009 + 1day | 0.028 | 0.031 | 0.030 | 0.034 | 0.004 | 0.053 | 0.033 | 0.050 |
| 11/4/2009 + 2day | -0.081*** | 0.030 | -0.084** | 0.033 | -0.014 | 0.053 | -0.075 | 0.048 |
| 8/10/2010 - 2day | 0.009 | 0.012 | -0.006 | 0.012 | -0.043 | 0.053 | 0.051 | 0.039 |
| 8/10/2010 - 1day | -0.071*** | 0.014 | -0.064*** | 0.013 | 0.012 | 0.053 | -0.074* | 0.040 |
| 8/10/2010 | 0.047*** | 0.012 | 0.043*** | 0.013 | -0.008 | 0.053 | 0.053 | 0.039 |
| 8/10/2010 + 1day | 0.004 | 0.012 | -0.013 | 0.012 | -0.068 | 0.053 | 0.059 | 0.039 |
| 8/10/2010 + 2day | 0.013 | 0.012 | 0.014 | 0.011 | 0.005 | 0.053 | 0.019 | 0.041 |
| 8/27/2010 - 2day | -0.011 | 0.015 | -0.009 | 0.016 | 0.021 | 0.046 | -0.009 | 0.042 |
| 8/27/2010 - 1day | 0.034** | 0.015 | 0.020 | 0.016 | -0.054 | 0.046 | 0.071* | 0.042 |
| 8/27/2010 | -0.179*** | 0.013 | -0.133*** | 0.015 | 0.171*** | 0.045 | -0.296*** | 0.042 |
| 8/27/2010 + 1day | 0.019 | 0.014 | -0.006 | 0.015 | -0.084* | 0.045 | 0.087** | 0.039 |
| 8/27/2010 + 2day | 0.005 | 0.014 | -0.015 | 0.015 | -0.073 | 0.045 | 0.054 | 0.043 |
| 9/21/2010 - 2day | 0.029 | 0.038 | 0.024 | 0.043 | -0.008 | 0.047 | 0.010 | 0.060 |
| 9/21/2010 - 1day | -0.154*** | 0.044 | -0.153*** | 0.040 | -0.023 | 0.053 | -0.111* | 0.064 |
| 9/21/2010 | 0.018 | 0.043 | 0.002 | 0.041 | -0.074 | 0.052 | 0.053 | 0.060 |
| 9/21/2010 + 1day | -0.015 | 0.036 | -0.033 | 0.039 | -0.039 | 0.052 | 0.031 | 0.060 |
| 9/21/2010 + 2day | 0.018 | 0.035 | 0.011 | 0.047 | -0.004 | 0.052 | 0.027 | 0.061 |
| 10/15/2010 - 2day | -0.070* | 0.042 | -0.055 | 0.043 | 0.048 | 0.049 | -0.128** | 0.059 |
| 10/15/2010 - 1day | -0.053 | 0.046 | -0.032 | 0.051 | 0.082* | 0.042 | -0.097 | 0.059 |
| 10/15/2010 | 0.129*** | 0.038 | 0.157*** | 0.042 | 0.084** | 0.042 | 0.071 | 0.059 |
| 10/15/2010 + 1day | -0.076* | 0.044 | -0.086* | 0.049 | -0.040 | 0.041 | -0.053 | 0.058 |
| 10/15/2010 + 2day | -0.003 | 0.043 | -0.010 | 0.041 | -0.020 | 0.041 | 0.003 | 0.057 |
| 11/3/2010 - 2day | -0.105** | 0.045 | -0.101** | 0.050 | 0.031 | 0.041 | -0.101* | 0.056 |
| 11/3/2010 - 1day | 0.057 | 0.037 | 0.041 | 0.040 | -0.068 | 0.041 | 0.079 | 0.057 |
| 11/3/2010 | -0.060 | 0.037 | -0.015 | 0.041 | 0.169*** | 0.041 | -0.172*** | 0.053 |
| 11/3/2010 + 1day | -0.003 | 0.035 | -0.013 | 0.039 | -0.045 | 0.041 | 0.029 | 0.053 |

| | | | | | | | | |
|-------------------|-----------|-------|-----------|-------|-----------|-------|-----------|-------|
| 11/3/2010 + 2day | 0.082** | 0.035 | 0.109*** | 0.039 | 0.089** | 0.041 | 0.012 | 0.055 |
| 8/9/2011 - 2day | -0.008 | 0.009 | 0.021 | 0.017 | 0.107 | 0.067 | -0.048 | 0.042 |
| 8/9/2011 - 1day | 0.040*** | 0.010 | -0.002 | 0.017 | -0.152** | 0.068 | 0.156*** | 0.042 |
| 8/9/2011 | 0.037*** | 0.009 | 0.000 | 0.016 | -0.126* | 0.067 | 0.137*** | 0.042 |
| 8/9/2011 + 1day | -0.133*** | 0.009 | -0.138*** | 0.014 | -0.032 | 0.067 | -0.099** | 0.042 |
| 8/9/2011 + 2day | -0.043*** | 0.009 | 0.032** | 0.015 | 0.270*** | 0.068 | -0.219*** | 0.045 |
| 8/26/2011 - 2day | 0.006 | 0.016 | 0.053** | 0.021 | 0.163*** | 0.056 | -0.103** | 0.048 |
| 8/26/2011 - 1day | 0.028* | 0.015 | 0.022 | 0.022 | -0.025 | 0.056 | 0.057 | 0.046 |
| 8/26/2011 | -0.021 | 0.016 | -0.036** | 0.018 | -0.057 | 0.066 | 0.040 | 0.046 |
| 8/26/2011 + 1day | 0.011 | 0.016 | 0.031 | 0.021 | 0.095 | 0.066 | -0.053 | 0.045 |
| 8/26/2011 + 2day | -0.001 | 0.016 | -0.029 | 0.020 | -0.095 | 0.066 | 0.054 | 0.048 |
| 9/21/2011 - 2day | -0.012 | 0.011 | -0.044*** | 0.014 | -0.104* | 0.057 | 0.069 | 0.047 |
| 9/21/2011 - 1day | 0.009 | 0.011 | 0.007 | 0.018 | -0.003 | 0.057 | 0.008 | 0.048 |
| 9/21/2011 | 0.021* | 0.011 | -0.024* | 0.014 | -0.154*** | 0.057 | 0.136*** | 0.048 |
| 9/21/2011 + 1day | -0.025** | 0.011 | -0.093*** | 0.015 | -0.237*** | 0.056 | 0.157*** | 0.044 |
| 9/21/2011 + 2day | -0.006 | 0.010 | 0.025* | 0.014 | 0.117** | 0.056 | -0.090* | 0.047 |
| 6/20/2012 - 2day | -0.001 | 0.014 | -0.009 | 0.016 | -0.027 | 0.047 | 0.025 | 0.034 |
| 6/20/2012 - 1day | -0.014 | 0.013 | 0.004 | 0.014 | 0.062 | 0.047 | -0.055 | 0.035 |
| 6/20/2012 | 0.019 | 0.013 | 0.014 | 0.015 | -0.007 | 0.047 | 0.026 | 0.034 |
| 6/20/2012 + 1day | -0.005 | 0.012 | -0.015 | 0.016 | -0.038 | 0.046 | 0.024 | 0.034 |
| 6/20/2012 + 2day | -0.006 | 0.012 | 0.016 | 0.014 | 0.075* | 0.045 | -0.053 | 0.034 |
| 8/22/2012 - 2day | 0.054*** | 0.012 | 0.063*** | 0.017 | 0.013 | 0.042 | 0.050* | 0.028 |
| 8/22/2012 - 1day | -0.059*** | 0.013 | -0.061*** | 0.016 | -0.019 | 0.041 | -0.046 | 0.028 |
| 8/22/2012 | -0.042*** | 0.012 | -0.063*** | 0.017 | -0.071* | 0.041 | 0.009 | 0.028 |
| 8/22/2012 + 1day | -0.027** | 0.011 | -0.035** | 0.016 | -0.027 | 0.041 | -0.008 | 0.028 |
| 8/22/2012 + 2day | 0.007 | 0.011 | 0.008 | 0.018 | 0.001 | 0.041 | 0.010 | 0.028 |
| 8/31/2012 - 2day | 0.008 | 0.010 | 0.016 | 0.014 | 0.026 | 0.035 | -0.011 | 0.028 |
| 8/31/2012 - 1day | -0.002 | 0.012 | -0.006 | 0.016 | -0.013 | 0.035 | 0.006 | 0.029 |
| 8/31/2012 | 0.023** | 0.010 | 0.005 | 0.013 | -0.063* | 0.035 | 0.069** | 0.028 |
| 8/31/2012 + 1day | -0.018* | 0.010 | -0.015 | 0.013 | 0.018 | 0.034 | -0.027 | 0.028 |
| 8/31/2012 + 2day | -0.020** | 0.010 | -0.016 | 0.013 | 0.018 | 0.034 | -0.038 | 0.029 |
| 9/13/2012 - 2day | 0.020* | 0.011 | 0.024 | 0.016 | 0.019 | 0.039 | 0.009 | 0.026 |
| 9/13/2012 - 1day | 0.010 | 0.010 | 0.034** | 0.015 | 0.089** | 0.039 | -0.050* | 0.026 |
| 9/13/2012 | -0.046*** | 0.011 | -0.035** | 0.015 | 0.038 | 0.039 | -0.077*** | 0.026 |
| 9/13/2012 + 1day | -0.049*** | 0.011 | -0.008 | 0.015 | 0.143*** | 0.039 | -0.158*** | 0.027 |
| 9/13/2012 + 2day | 0.020* | 0.010 | 0.007 | 0.015 | -0.059 | 0.039 | 0.067*** | 0.025 |
| 12/12/2012 - 2day | 0.007 | 0.010 | 0.003 | 0.014 | -0.004 | 0.029 | 0.003 | 0.022 |
| 12/12/2012 - 1day | -0.006 | 0.008 | 0.005 | 0.011 | 0.039 | 0.029 | -0.032 | 0.022 |
| 12/12/2012 | -0.027*** | 0.009 | -0.004 | 0.011 | 0.078*** | 0.029 | -0.082*** | 0.022 |
| 12/12/2012 + 1day | 0.022*** | 0.008 | 0.025** | 0.011 | 0.009 | 0.028 | 0.021 | 0.020 |
| 12/12/2012 + 2day | 0.012 | 0.008 | 0.005 | 0.011 | -0.022 | 0.028 | 0.027 | 0.021 |
| 5/1/2013 - 2day | 0.000 | 0.015 | 0.007 | 0.018 | 0.017 | 0.031 | -0.013 | 0.023 |
| 5/1/2013 - 1day | -0.001 | 0.017 | 0.002 | 0.019 | 0.006 | 0.030 | -0.002 | 0.023 |
| 5/1/2013 | -0.011 | 0.014 | -0.024 | 0.017 | -0.044 | 0.030 | 0.018 | 0.023 |
| 5/1/2013 + 1day | 0.025* | 0.015 | 0.023 | 0.016 | -0.005 | 0.030 | 0.027 | 0.024 |
| 5/1/2013 + 2day | 0.026* | 0.014 | 0.066*** | 0.017 | 0.147*** | 0.030 | -0.078*** | 0.022 |
| 5/22/2013 - 2day | 0.015 | 0.017 | 0.013 | 0.025 | 0.020 | 0.032 | -0.003 | 0.020 |
| 5/22/2013 - 1day | 0.000 | 0.014 | -0.008 | 0.018 | -0.030 | 0.032 | 0.022 | 0.022 |
| 5/22/2013 | 0.066*** | 0.016 | 0.090*** | 0.021 | 0.074** | 0.032 | 0.012 | 0.022 |
| 5/22/2013 + 1day | 0.046*** | 0.013 | 0.048*** | 0.018 | -0.001 | 0.032 | 0.053*** | 0.020 |
| 5/22/2013 + 2day | -0.007 | 0.014 | -0.010 | 0.019 | -0.011 | 0.031 | 0.003 | 0.020 |
| 6/19/2013 - 2day | 0.017 | 0.032 | 0.039 | 0.038 | 0.074** | 0.036 | -0.033 | 0.036 |
| 6/19/2013 - 1day | 0.039 | 0.030 | 0.037 | 0.036 | -0.005 | 0.033 | 0.048 | 0.037 |
| 6/19/2013 | 0.029 | 0.030 | 0.051 | 0.036 | 0.075** | 0.033 | -0.030 | 0.037 |
| 6/19/2013 + 1day | 0.170*** | 0.034 | 0.193*** | 0.037 | 0.080** | 0.038 | 0.106*** | 0.039 |
| 6/19/2013 + 2day | 0.106*** | 0.030 | 0.129*** | 0.035 | 0.072* | 0.038 | 0.060 | 0.037 |
| 12/18/2013 - 2day | -0.008 | 0.021 | 0.000 | 0.025 | 0.025 | 0.032 | -0.025 | 0.027 |
| 12/18/2013 - 1day | -0.019 | 0.021 | -0.021 | 0.024 | -0.012 | 0.031 | -0.009 | 0.027 |
| 12/18/2013 | 0.011 | 0.021 | 0.019 | 0.024 | 0.031 | 0.031 | -0.008 | 0.027 |
| 12/18/2013 + 1day | 0.063*** | 0.023 | 0.070*** | 0.024 | 0.019 | 0.030 | 0.053** | 0.025 |
| 12/18/2013 + 2day | -0.006 | 0.020 | -0.030 | 0.023 | -0.084*** | 0.030 | 0.047* | 0.026 |
| 1/29/2014 - 2day | 0.004 | 0.016 | 0.020 | 0.020 | 0.027 | 0.033 | -0.017 | 0.022 |
| 1/29/2014 - 1day | -0.011 | 0.018 | -0.008 | 0.019 | 0.010 | 0.033 | -0.020 | 0.024 |
| 1/29/2014 | 0.000 | 0.018 | -0.021 | 0.022 | -0.057** | 0.029 | 0.043* | 0.023 |
| 1/29/2014 + 1day | -0.004 | 0.015 | 0.004 | 0.017 | 0.032 | 0.028 | -0.028 | 0.023 |
| 1/29/2014 + 2day | -0.037** | 0.017 | -0.044** | 0.018 | -0.034 | 0.028 | -0.006 | 0.022 |
| 3/19/2014 - 2day | 0.014 | 0.015 | 0.027 | 0.019 | 0.038 | 0.031 | -0.022 | 0.026 |
| 3/19/2014 - 1day | 0.014 | 0.017 | 0.011 | 0.020 | -0.012 | 0.031 | 0.024 | 0.028 |
| 3/19/2014 | 0.042** | 0.017 | 0.052*** | 0.019 | 0.039 | 0.031 | 0.017 | 0.026 |
| 3/19/2014 + 1day | 0.060*** | 0.014 | 0.062*** | 0.019 | 0.007 | 0.031 | 0.054** | 0.026 |
| 3/19/2014 + 2day | -0.009 | 0.014 | -0.026 | 0.018 | -0.057* | 0.030 | 0.038 | 0.026 |
| 4/30/2014 - 2day | 0.015 | 0.035 | 0.026 | 0.037 | 0.022 | 0.028 | -0.020 | 0.043 |
| 4/30/2014 - 1day | 0.035 | 0.034 | 0.042 | 0.035 | 0.021 | 0.027 | 0.025 | 0.043 |
| 4/30/2014 | -0.030 | 0.033 | -0.036 | 0.035 | -0.017 | 0.024 | -0.015 | 0.042 |
| 4/30/2014 + 1day | 0.002 | 0.033 | -0.012 | 0.030 | -0.056** | 0.024 | 0.041 | 0.042 |

| | | | | | | | | |
|-------------------|-----------|-------|-----------|-------|-----------|-------|-----------|-------|
| 4/30/2014 + 2day | 0.181*** | 0.029 | 0.171*** | 0.030 | -0.036 | 0.024 | 0.201*** | 0.042 |
| 5/7/2014 - 2day | -0.059* | 0.032 | -0.050 | 0.033 | 0.045* | 0.024 | -0.080** | 0.040 |
| 5/7/2014 - 1day | -0.112*** | 0.027 | -0.118*** | 0.029 | -0.026 | 0.023 | -0.096** | 0.039 |
| 5/7/2014 | -0.024 | 0.031 | -0.013 | 0.028 | 0.021 | 0.028 | -0.040 | 0.040 |
| 5/7/2014 + 1day | 0.003 | 0.026 | 0.018 | 0.027 | 0.050* | 0.028 | -0.039 | 0.040 |
| 5/7/2014 + 2day | 0.012 | 0.026 | 0.015 | 0.031 | 0.020 | 0.028 | -0.006 | 0.037 |
| 6/18/2014 - 2day | -0.012 | 0.023 | -0.016 | 0.025 | -0.006 | 0.025 | -0.003 | 0.032 |
| 6/18/2014 - 1day | 0.056** | 0.022 | 0.067*** | 0.024 | 0.043 | 0.028 | 0.024 | 0.032 |
| 6/18/2014 | 0.006 | 0.022 | 0.004 | 0.024 | -0.011 | 0.028 | 0.018 | 0.031 |
| 6/18/2014 + 1day | -0.044** | 0.019 | -0.034 | 0.023 | 0.039 | 0.028 | -0.073** | 0.030 |
| 6/18/2014 + 2day | 0.011 | 0.022 | 0.005 | 0.023 | -0.029 | 0.028 | 0.032 | 0.031 |
| 7/15/2014 - 2day | 0.072*** | 0.021 | 0.060*** | 0.021 | -0.038 | 0.024 | 0.088*** | 0.030 |
| 7/15/2014 - 1day | -0.006 | 0.021 | -0.001 | 0.022 | 0.020 | 0.025 | -0.012 | 0.031 |
| 7/15/2014 | 0.019 | 0.018 | 0.024 | 0.020 | 0.011 | 0.028 | 0.003 | 0.028 |
| 7/15/2014 + 1day | -0.025 | 0.020 | -0.030 | 0.021 | -0.015 | 0.023 | -0.009 | 0.030 |
| 7/15/2014 + 2day | 0.237*** | 0.019 | 0.217*** | 0.020 | -0.074*** | 0.023 | 0.282*** | 0.030 |
| 7/30/2014 - 2day | -0.127*** | 0.026 | -0.120*** | 0.026 | 0.024 | 0.024 | -0.141*** | 0.038 |
| 7/30/2014 - 1day | 0.115*** | 0.024 | 0.100*** | 0.030 | -0.037 | 0.023 | 0.150*** | 0.036 |
| 7/30/2014 | -0.119*** | 0.022 | -0.093*** | 0.023 | 0.095*** | 0.026 | -0.185*** | 0.036 |
| 7/30/2014 + 1day | 0.016 | 0.026 | 0.022 | 0.023 | 0.011 | 0.027 | 0.005 | 0.036 |
| 7/30/2014 + 2day | 0.106*** | 0.022 | 0.097*** | 0.023 | -0.031 | 0.028 | 0.123*** | 0.038 |
| 8/22/2014 - 2day | -0.016 | 0.041 | 0.003 | 0.049 | 0.012 | 0.030 | -0.040 | 0.045 |
| 8/22/2014 - 1day | 0.055 | 0.038 | 0.055 | 0.045 | -0.031 | 0.030 | 0.059 | 0.046 |
| 8/22/2014 | 0.007 | 0.034 | -0.010 | 0.047 | -0.026 | 0.030 | 0.042 | 0.045 |
| 8/22/2014 + 1day | -0.016 | 0.032 | -0.028 | 0.038 | -0.022 | 0.025 | -0.006 | 0.043 |
| 8/22/2014 + 2day | -0.019 | 0.038 | -0.006 | 0.039 | 0.024 | 0.025 | -0.052 | 0.045 |
| 9/17/2014 - 2day | 0.049 | 0.037 | 0.047 | 0.042 | -0.001 | 0.028 | 0.048 | 0.043 |
| 9/17/2014 - 1day | -0.030 | 0.030 | -0.025 | 0.033 | 0.030 | 0.033 | -0.065 | 0.044 |
| 9/17/2014 | 0.000 | 0.036 | 0.009 | 0.040 | 0.018 | 0.033 | -0.009 | 0.044 |
| 9/17/2014 + 1day | 0.022 | 0.034 | 0.021 | 0.037 | -0.002 | 0.033 | 0.013 | 0.041 |
| 9/17/2014 + 2day | 0.029 | 0.034 | 0.015 | 0.033 | -0.066 | 0.033 | 0.076* | 0.042 |
| 10/29/2014 - 2day | 0.020 | 0.035 | 0.017 | 0.036 | -0.001 | 0.029 | 0.024 | 0.044 |
| 10/29/2014 - 1day | -0.034 | 0.030 | -0.023 | 0.033 | 0.029 | 0.029 | -0.059 | 0.044 |
| 10/29/2014 | 0.012 | 0.034 | 0.016 | 0.035 | 0.007 | 0.029 | 0.012 | 0.044 |
| 10/29/2014 + 1day | 0.007 | 0.029 | 0.004 | 0.031 | -0.013 | 0.029 | 0.011 | 0.044 |
| 10/29/2014 + 2day | 0.019 | 0.028 | 0.026 | 0.034 | 0.034 | 0.029 | -0.008 | 0.043 |

Note: ***, ** and * indicate statistical significance at 0.01, 0.05, 0.1 levels.

Figure A4: Cumulative Effects of QE Announcements on the Mortgage Rate and the Treasury Rate around Announcement Events

In addition to Table 8, Cumulative abnormal returns of 30-year mortgage rate (from model of controlling for Treasury rate or not), 30-year Treasury rate and the spread between them across all announcements in each round of QE with 1-day, 3-day and 5-day event windows from my estimation are graphed.

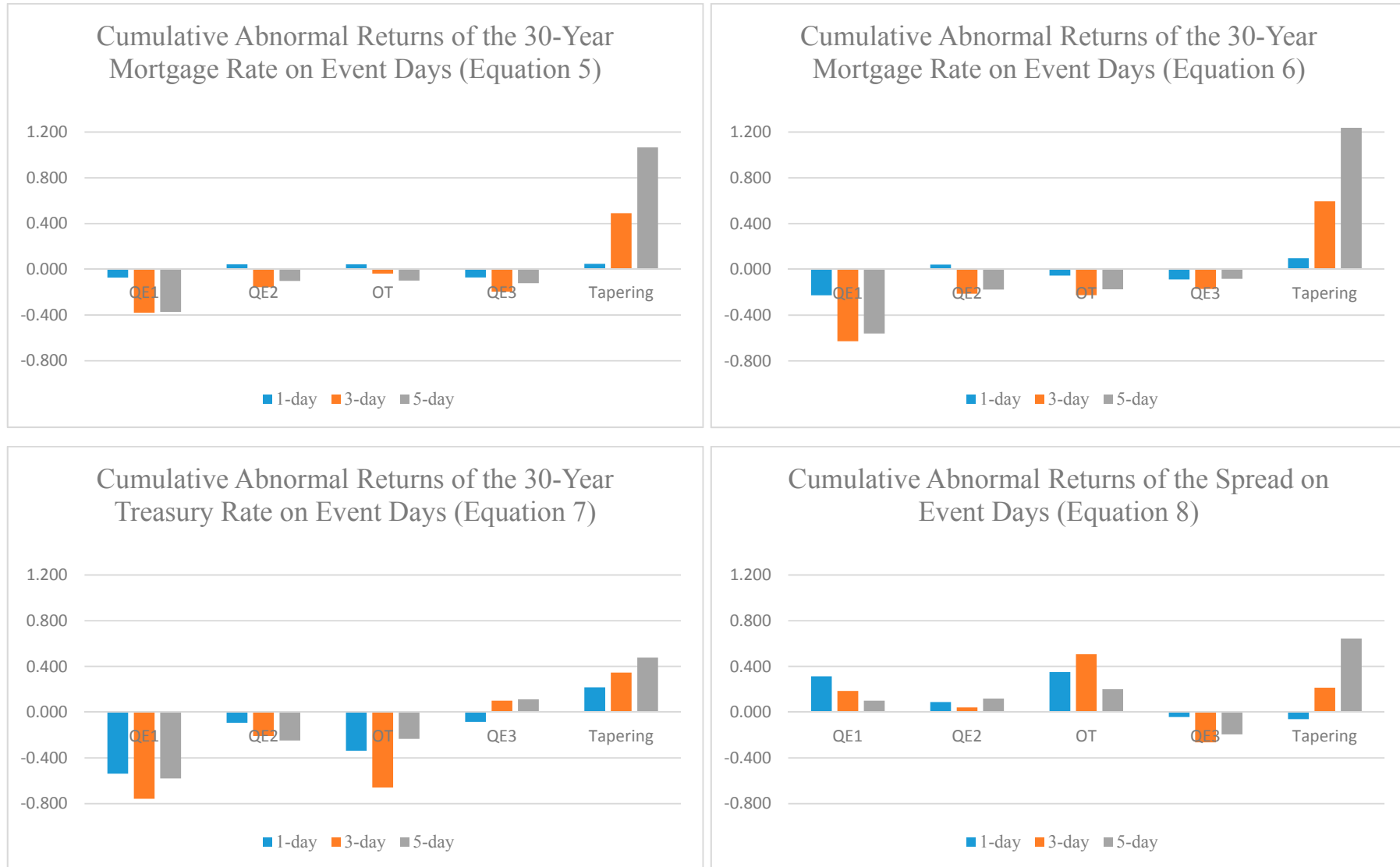


Figure A5: ACF and PACF of $\Delta \ln(CPI)$, $\Delta \ln(HPI)$ and ΔUER

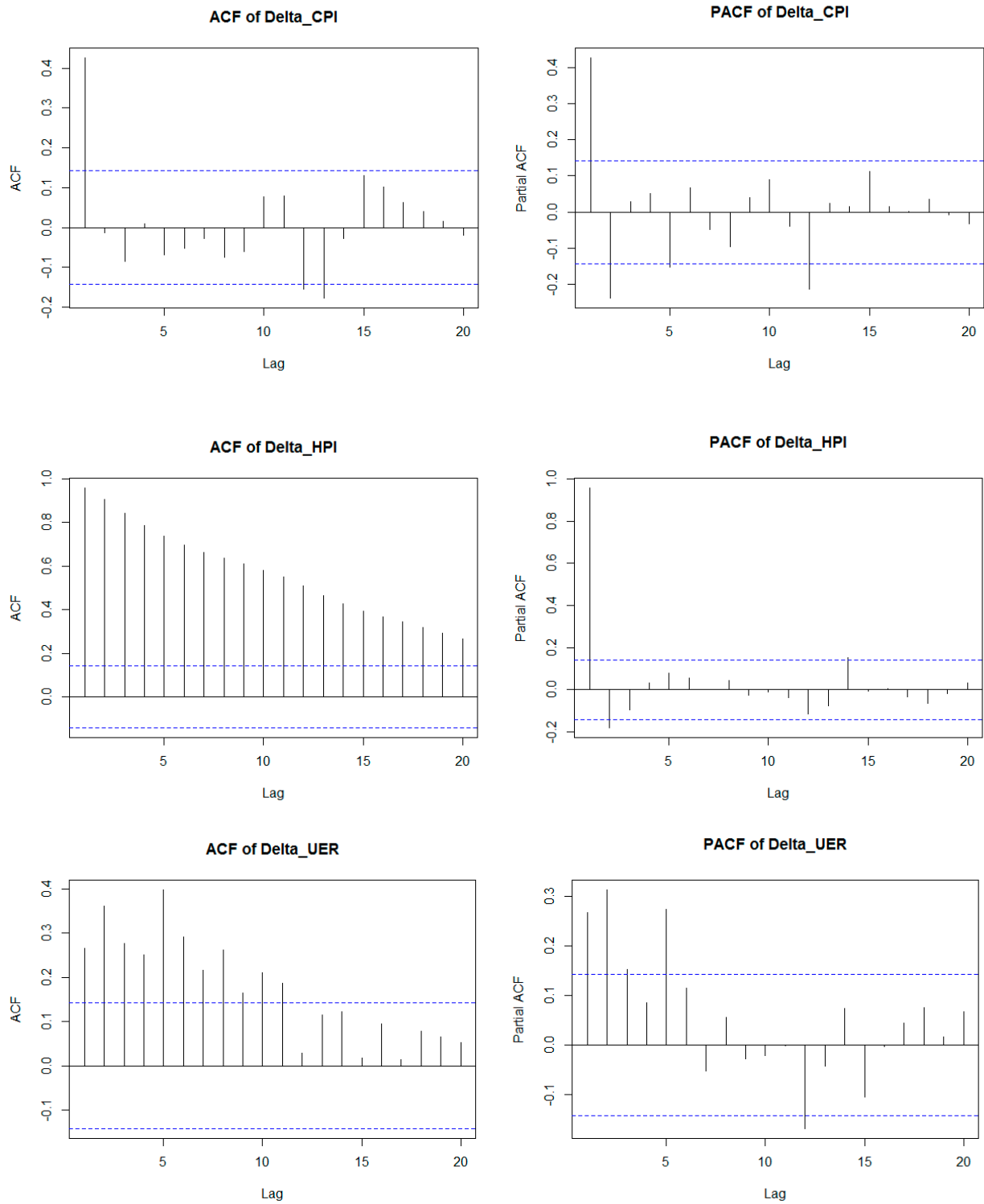
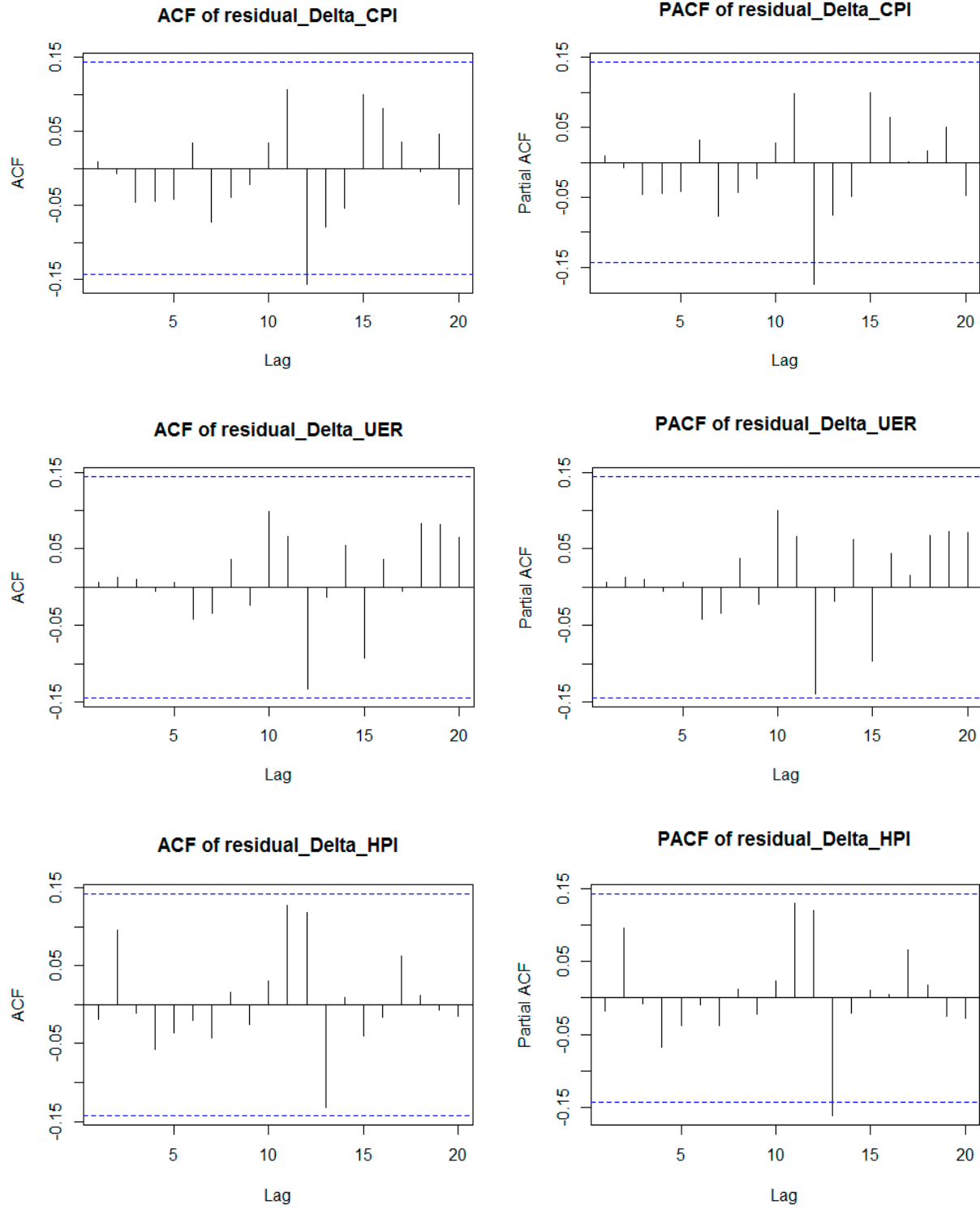


Figure A6: ACF and PACF of Residuals in ARMA Models Fitting $\Delta\ln(CPI)$, $\Delta\ln(HPI)$ and ΔUER
 ARMA models are ARMA(3,2), ARMA(2,0) and ARMA(1,5) for $\Delta\ln(CPI)$, $\Delta\ln(HPI)$ and ΔUER respectively.



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