Forecasting Value-at-Risk considering scheduled events:
Evidence from the US equities market

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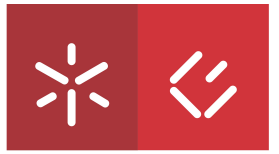

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I want to start by expressing my gratitude to Professor Nelson Areal for his support and guidance throughout the dissertation. Additionally, I want to thank all my friends, colleagues, and all the professors of the Master in Finance. Last but certainly not least, I want to express my gratitude to my family for their unwavering support.

Abstract

Previous research has shown that the average stock return surrounding earnings announcements is positive and that there is an earnings announcement premium being driven by the overall uncertainty on the results to be disclosed by the quoted company. The higher the uncertainty, the bigger the disagreement between equity analysts, and the higher the volatility leading up to the announcement day for a given stock giving rise to a higher trading volume.

Because too much volatility can present risk, it is important to know how to measure it. Value-at-risk (VaR) is a statistic that assesses an asset portfolio's riskiness by estimating the magnitude of potential financial losses within the portfolio over a given period of time. This dissertation seeks to determine whether the inclusion of earnings announcements as a dummy in VaR models improves estimates given the significant role that corporate events, such as earnings announcements, play in financial markets and the fact that few studies have looked at incorporating such events into VaR models.

First, this paper investigated several VaR models and assessed which one better forecasted the VaR by resorting to unconditional and conditional coverage and independence backtests. Second, the earnings indicator variable was added to the better model and both were compared. The results show that the addition of the indicator variable didn't improve the model significantly. The total number of VaR exceptions decreased while those occurring during earnings announcement days stayed the same. Moreover, the number of null hypotheses rejected for the conditional test increased, indicating that VaR exceedances were not independent for a greater number of models.

Keywords: Earnings Announcements, Value at Risk, Uncertainty, Volatility.

Resumo

Estudos passados apontam para um retorno médio positivo durante períodos de anúncio de resultados com o prémio de risco derivado de uma maior incerteza acerca dos resultados a serem reportados pelas empresas cotadas. Quanto maior esta incerteza, e quanto maior a discordância entre analistas, maior a volatilidade nos períodos que antecedem o anúncio de resultados devido a um maior volume de ações a serem trocadas.

Dada a relação entre volatilidade e risco, é importante entender como o quantificar. O Valor em Risco (VaR) é uma medida estatística que avalia o risco, estimando a magnitude de possíveis perdas de um determindado portfolio durante um certo período de tempo. Dada a significância que os eventos corporativos têm nos mercados financeiros, e a falta de estudos que visam incorporar estes eventos em modelos do VaR, esta dissertação tem como objetivo determinar se a adição dos anúncios de resultados como variável binária melhora as estimativas do valor em risco produzidas pelos modelos.

Primeiro, esta dissertação investiga vários modelos estatísticos e avalia qual produz melhores resultados recorrendo aos testes de coberturas incondicional e condicional e de independência. Segundo, a variável binária é adicionada ao modelo que apresentou as melhores estimativas de VaR, sendo os resultados posteriormente comparados com os do modelo original. Os resultados mostram que, a adição da variável de anúncios não melhorou o modelo de forma significativa. O número total de exceções diminuiu mas o número de exceçoes que ocorreram nos dias de anúncio de resultados manteve-se igual. O número de hipoteses nulas rejeitadas aumentou para o teste condicional aumentou, indicando que o número de modelos para quais as exceções sao independentes diminuiu.

Palavras-chave : Anúncio de resultados, Valor em Risco, Incerteza, Volatilidade.

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1. Introduction

Earnings announcements are one of the most important corporate events for a publicly quoted company. These scheduled quarterly events, disclose crucial information about the overall profitability of publicly traded firms and are, for the most part, preceded by earnings estimates issued by equity analysts. Generally, firms release guidance to help analysts make accurate estimates. Occasionally, however, unexpected news will influence the outcome, resulting in what is termed as an "earnings surprise."

Earnings surprises have, most of the time, a significant impact on a company's stock price. Several studies suggest that positive earnings surprises not only lead to an immediate hike in a stock's price but also to a gradual increase over time (Skinner & Sloan, 1999). Companies are known for consistently exceeding earnings projections, even if by a very small margin, which is not surprising given that a negative earnings surprise typically results in a drop in the share price.

These periods surrounding earnings announcements are very information-rich and there is a significant increase in stock trading activity. Patell and Wolfson (1979) and Dubinsky and Johannes (2006) document that uncertainty peaks before announcements, but it swiftly subsides after the news are released and the market has had a chance to properly process them. This appears to hold for both positive and negative news.

Many return anomalies also relate to earnings announcements. According to Engelberg, McLean, and Pontif (2018), abnormal returns increase six-fold on announcement days. Since the timing of upcoming earnings reports is generally available ex-ante to the general public, the only variable that remains uncertain are the company's fundamentals.

Uncertainty plays a key role in asset pricing but is characterized by both an unknown outcome and an unknown probability distribution making it difficult to measure and quantify directly. Risk, on the other hand, has a well-defined probability distribution that lets us measure a given outcome (Knight, F. H., 1921). In the stock market, risk can be proxied via asset return volatility. Volatility measures how much the price of a certain asset will fluctuate over a certain period of time, with higher values suggesting larger price changes and lower values indicating lower variations.

Volatility, however, weighs positive and negative deviations equally and leaves out making it a total risk measure. Volatility is still an essential component of risk management as it enables us to assess downside risk. The issue is that we want to assess future risk and future volatility

cannot be observed. Following the random walk theory, a stock price's or market's historical movement or trend cannot be used to forecast its future course. Given that prices are random, returns will also be random and the ability to forecast future standard deviation/volatility is needed if we want to assess future risks. Several models that made volatility forecasting possible have surfaced throughout the years. The ARCH model proposed by Engle (1982) was the first model that assumed conditional variance followed by the Generalized ARCH (GARCH) model proposed by Bollerslev (1986). Several extensions and improvements have been proposed to the GARCH model since and they intend to capture the many stylized facts about stock price processes that the more simple GARCH model doesn't assume.

Kim et al. (1998), Bollerslev et al. (1992), West and Cho (1995), and Andersen and Bollerslev (1998) all compared various models to see which one was better at forecasting volatility. No other stochastic model outperformed the more straightforward GARCH(1,1) model, according to Hansen's research published in 2005 under the title "A forecast comparison of volatility models: does anything beat a GARCH(1,1)?". It seems that the decision on which model to choose is heavily influenced by the asset and the time frame being factored into the equation.

Rather than aiming only at studying which model best predicts volatility and consequently Value-at-Risk, this particular study also seeks to determine if the addition of an external regressor to various models improves the VaR estimates being produced. Since current models rely on past volatility to estimate Value at Risk it is important to choose a time frame that congregates a sizeable amount of information but that doesn't contain structural breaks. For this, I decided on a time period of 20 years and chose all the stocks tracked by the S&P 100.

To accomplish this, I backtest several VaR models using conditional and unconditional coverage independence tests to compare the number of expected and realized loss exceptions. The results are outlined in Chapter 5. At last, in Chapter 6 I present some closing remarks, research limitations, and what could be done in future research.

2. Literature Review

2.1. Earnings announcements

An earnings announcement is an official public statement of a company's profitability over a specific period, typically a quarter or a year. It occurs on a specific date during earnings season and portrays very important information to current and potential shareholders.

When this information enters the market, analysts will compare it to their ex-ante expectations and will reassess the fair value of the corporation. Market participants alike, will rush to trade on this new information. Beaver (1968) explores how much informational value common stock owners believe earnings announcements to have. If earnings announcements provide information in the sense of changing the equilibrium value of the current market price then the magnitude of the price change should be greater in the week of the announcement than during the non-report period. Beaver provides evidence that the variance of stock returns increases for the days immediately around earnings announcements. Patell and Wolfson (1979) also found this to be true.

This increase in volatility can be attributed to the time it takes for all market players to agree on a new fair value for a particular company. Patell and Wolfson (1984) found that this occurs within the first 15 minutes after earnings and dividend announcements. Muntermann and Guettler (2007) found that most trading activity occurs within the first 30 minutes after the announcements are made. Both these papers point to an increase in trading activity shortly after corporate announcements. This increase and overall uncertainty surrounding the results will lead to increased market volatility.

The date for earnings announcements is known prior to the event so there is no uncertainty about when the event is going to happen. Consequently, the only thing that will shoot up trading volatility is the uncertainty regarding the company's profits over the last year or quarter. Volatility will return to normal levels, like those seen before the announcements, once these events are known. This was confirmed by Patell and Wolfson (1979) and Dubinsky and Johannes (2006).

2.2. Volatility

Academics, policymakers, and investors all place a high value on the analysis of financial asset volatility. One reason for it is that volatility measures the risk exposure to a particular security or a basket of securities. As a result, economic agents must have the ability to predict volatility in order to manage risk appropriately.

Moreover, in a market risk context, it's critical to understand an asset's volatility in order to determine a portfolio's Value-at-Risk. Finally, market estimates of volatility are frequently used by policymakers as a gauge of the economy's and financial markets' susceptibility to shocks. These factors have greatly increased the interest in modeling conditional variance and many volatility models have been developed since the seminal paper of Engle (1982).

Since then, numerous studies have confirmed the statistical characteristics that asset price volatility processes share. They are prevalent across a variety of instruments, markets, and time periods and are known as stylized facts. These, are outlined below and must be taken into account for a volatility model to be useful:

1. Non-normality: Asset return distributions are typically skewed, with extremely excess kurtosis indicating non-normality and very heavy tails (Samuelson, P., 1970).

2. Autocorrelation of returns: For all lags, there is generally no linear autocorrelation of daily stock returns. Despite this, they are not independent. Absolute and squared returns autocorrelations are significant for many lags.

3. Persistence: Mandelbrot and Fama (1963) were the first to notice the propensity for periods of high and low absolute squared returns to persist. This phenomenon is termed "volatility clustering". Andersen and Bollerslev (1997) also found that major positive or negative news significantly affects estimates of future volatility.

4. Innovations may have an asymmetric impact on volatility: According to the leverage effect hypothesis, when a stock's value declines, financial leverage increases, making the stock riskier and more even volatile (Black, 1976 and Christie, 1982).

Most volatility models, including GARCH, assume that positive and negative innovations will have an equal impact on the asset's conditional volatility. Over time, non-symmetric GARCH models like the NGARCH (Engle and Ng, 1993) and EGARCH (Nelson, 1991) have emerged to address the Leverage effect problem.

2.3 Modelling volatility

Ordinary least squares (OLS) models have been and continue to be the foundation for econometrics work. Assuming an overdetermined system of linear equations X$\beta \approx$ Y that cannot be solved exactly, OLS provides approximate solutions to β, $\hat{\beta}$, such that they satisfy

$$\hat{\beta} = \arg\min_{\beta} \|Y - X\beta\|. \tag{2.3.1}$$

OLS, provides the solutions that present the minimal sum of squares among all other methods for estimating the unknown parameters in a linear regression model. This is only true when the model satisfies the Gauss-Markov assumptions. Under such assumptions, the model is deemed the best-linear-unbiased-estimator (BLUE). The homoscedasticity, or homogeneity of variances assumption, states that the error term must have the same variance for all observations across the sample. If this assumption is violated, the estimates are still valid, but they are no longer efficient, leading to greater standard errors, incorrect t-statistics and p-values thus invalidating equation (2.3.1).

Given that exogenous economic events, such as earnings announcements, occur sparsely and can have various interpretations, it is unlikely that the variance of the errors will be constant over time in financial time series. It is thus preferred to consider a model that does not assume constant variance and which can describe how the variance of the errors evolves (Bollerslev et. al, 1994). The most commonly used financial models to measure volatility are the non-linear ARCH and GARCH models.

2.3.1 ARCH and GARCH models

Engle (1982) introduced the AutoRegressive Conditional Heteroskedasticity (ARCH) model whose objective was to address the assumptions made about the second-order moment by classic time series models and to capture volatility clustering in financial time series. His work has ever since become an essential part of financial econometrics. In the ARCH model, the variance is modeled as a linear function of lagged squared prediction errors.

Bollerslev (1986) and Taylor (1986) independently generalised Engle's model to improve its forecasts of conditional volatility. This generalisation, known as GARCH, included both an autoregressive and a moving average component allowing for the modeling of conditional changes in variance over time as well as longer memory. GARCH-family models are currently the most extensively used financial time series models, and since then, a number of authors have

added new features in an effort to capture the various return characteristics that have proven to have a significant impact on the estimation of conditional volatility.

Although ARCH models provide good volatility forecasts (Andersen and Bollerslev (1998)), GARCH models tend to outperform them as they're less likely to breach negativity constraints (Akgiray, 1989). GARCH models also tend to predict volatility better using fewer variables avoiding overfitting (Brooks, 2014). The models discussed so far only take into account the magnitude of returns and don't include information on their direction and there is very strong evidence that direction matters. (Black, 1976; Nelson, 1991; Bollerslev et al., 1992; Glosten et al., 1993).

Many different asymmetric GARCH models are now present, such as the Exponential-GARCH model of Nelson (1991), the Threshold-ARCH and GJR models credited to Zakoian (1994) and Glosten et al (1993), the Quadratic-GARCH model by Sentana (1995), and the Nonlinear-GARCH model by Higgins and Bera (1992). Asymmetric GARCH models with fat-tailed densities have also been demonstrated to improve conditional variance estimates by Liu et al. (2009), Alberg et al. (2008), Chong et al. (1999), and Kisinbay (2010).

Moreover, for stock data and stock index data, although asymmetric models tend to be better than the GARCH(1,1) model, the improvements are not as significant for longer forecast horizons. Hansen and Lunde (2005) have also found conclusive evidence that, for most loss functions, the more simplistic GARCH (1,1) model was not significantly outperformed by other non-asymmetric GARCH models. The results the models produce seem to depend on the data we utilize, the time frame used and the distribution used for the innovations. Throughout the study, I will use a GARCH (1,1) model as I will be dealing with stocks that compose the S&P100.

2.4. Value at Risk

Since its inception, Value at Risk has become a key metric to measure market risk faced by a certain financial institution. According to the Bank for International Settlements (BIS), market risk can be defined as the risk of losses arising from movements in market prices.

VaR is thus a statistical risk measure whose purpose is to quantify the possible loss on a portfolio that would occur if relatively unfavorable market movements occurred over a specific time period associated with a specific confidence interval (Jorion, 2006). As a result, three underlying factors must be provided in order to measure possible loss (and the severity of the adverse price move) – the holding time under consideration, the appropriate statistical distribution and a confidence interval α such that,

$$Prob[r_t > VaR] = 1 - \alpha \tag{2.3.2}$$

where r_t is the return on a given underlying or basket of underlyings and 1 - α the level of confidence for the VaR.

Assuming that returns follow a normal distribution with zero mean, VaR for t+1 can be calculated as follows:

$$VaR_{\alpha}^{t+1} = -\sigma_{t+1}\Phi_{\alpha}^{-1}$$

where σ_{t+1} represents the standard deviation of stock returns at t+1 and Φ_{α}^{-1} the standard score for a confidence level of α.

The standard score, or z-score describes the relationship between a certain subset of values in the distribution and the mean value. It connotes data dispersion and quantifies how much a result deviates from the mean by the number of standard deviations. A z-score of 0 indicates that a value is on the mean, whereas a value of +/-2.5 indicates that a value is +/- 2.5 standard deviations off the mean.

Asset returns though do not follow a normal distribution. The distributions are skewed and fat-tailed. Tail risk is one of the key concepts in risk management and one that gives investors a cautionary tale as it includes events that have a very small probability of occurring. As a result, how we see these events and how likely we think they are to occur will depend on how we define the tails of the distribution. Investors are not overly concerned about right tail risk because these would represent huge gains to their investments, but left tail risk is much more concerning as it represents the possibility of extremely unexpected losses.

Throughout this paper, I will go through several statistical distributions that model the tails of the distribution slightly differently. Although the evidence that asset returns do not follow a normal distribution, this bell-shaped distribution will still be used to forecast VaR and will serve as a control distribution so that I can compare the results it produces against other distributions such as the student-t, skewed student-t and generalised error distribution.

In an updated publication, Nieto and Ruiz (2016) further contrasted the forecasting abilities of several GARCH-based VaR models with those of the alternatives. Surprisingly, the analysis revealed that both the time period being looked at and the quantity of out-of-sample data have an impact on forecasting outcomes. So and Yu (2006) found that several GARCH-based VaR models perform better at various levels of significance. For this study, I assumed an estimation

window of 500 trading days and an alpha of 0.01.

2.5. Estimating Value at Risk

While VaR is a very clear construct, its measurement isn't quite so simple. There are several different models to calculate Value at Risk differing from the way they mark-to-market a portfolio to the way they calculate the density function of portfolio returns. Beder (1995) implements eight standard VaR techniques to three hypothetical portfolios. With VaR estimates varying by more than fourteen times for the same portfolio, the results reveal that the differences between methods can be quite substantial.

2.5.1 Non-parametric models

Non-parametric models are the simplest models to estimate Value at Risk. They make no hypothesis regarding the distribution of a given security's (or basket of) returns and accommodate nonlinearities and all kinds of distributions such that the estimation of the distribution parameters (mean and standard deviation) are avoided.

2.5.1.1. Historical Simulation

Among all non-parametric methods, Historical simulation (HS) is perhaps the simplest and most widely used Value at Risk model by financial institutions. In this model, almost no statistical distributional assumptions about the underlying market factors need to be made. This approach relies on using historical changes in portfolio returns for a certain time window and each historical observation forms a possible scenario (Butler and Schachter, 1996). Each scenario within this window is sorted in ascending order and the VaR is then the value at the 1-α quantile such that only α% of returns are worse than the VaR.

Although the simplicity and the more realistic resulting portfolio distribution, as it is based on the empirical distribution of returns, there are several apparent disadvantages with this approach.

The first, is the total reliance on the dataset. If the data period was unusually quiet/agitated, HS will often produce VaR values that are too low/high for the risks we are facing. HS models are slow to incorporate major events.

The second is concerned with the size of the time window. Under HS, the forecasts are only useful if they have the same distribution as the historical data used to make such forecasts. If the market is now relatively more/less volatile than historically and the time window is too large, the VaR forecasts will be biased as won't take into account more recent changes in market conditions.

On the other hand, if the time window is too short, VaR forecasts will reflect such conditions more harshly understating (correspondingly overstating) the true Value at Risk. The length of the window must also be chosen in a way that it avoids the risk of taking observations outside a current volatility cluster. If this happens, HS ignores the fact that asset risks are constantly changing.

2.5.1.2. Weighted Historical Simulation

The weighted historical simulation (WHS) model (Boudoukh, Richardson & Whitelaw, 1998) improves upon the Historical Simulation model by combining the RiskMetrics model (JPMorgan, 1994) and the HS model by giving greater weight to more recent data.

This method is called age weighting and to implement it we only need to replace the HS probabilities 1/n with the new age-weighted probabilities, w(i). This method is thus very similar to the HS model with the nuance of each set of P/L values being paired with each associated weight, instead of equal weights. The weighted returns are then sorted and the VaR is chosen as in HS.

This approach has some major attractions when compared to its direct counterpart. The first, is that it allows for the decay of more distant observations. Age-weighting, allows us to let the size of our sample grow over time, ensuring that no useful data is ever lost. This increases the models' effectiveness and gets rid of "ghost effects" there would be no 'jumps' in our sample brought on by dismissing old observations. Under an equally-weighted HS model, we would be stuck with very distant, not up-to-date observations which could under/overestimate the VaR.

Second, we can change how much we age each observation. This choice can make the VaR estimates much more responsive to more recent large loss observations resulting in a more accurate VaR. This not only makes age-weighted VaR estimates more responsive to significant losses but also improves their ability to handle significant loss clusters.

These benefits are empirically supported by Boudoukh et al. (1998), whose research shows that their age-weighting approach can produce much higher VaR estimations than the HS model. Although this, it seems that even with age weighting, VaR estimates can still be somewhat unresponsive to changes in the risks of a certain asset, Pritsker (2001, pp. 7-8), and it does not appear to adequately account for some of the risk shifts implied by shifting market volatilities.

2.5.2. Semi-parametric models: Filtered Historical Simulation

Some techniques, such as bootstraps, have been introduced to overcome the parametric assumptions regarding the distributions of returns. The central idea is to generate an empirical distribution by sampling the observed returns and measuring the risk associated with simulated scenarios (Ruiz & Pascual, 2002).

An alternative to the non-parametric models described in the previous sections is the semi-parametric Filtered Historical Simulation method (FHS) by Barone-Adesi et al. (1998, 1999) that uses available observations to construct empirical densities for VaR estimations. The more traditional HS approaches so far have failed to address conditionally time-varying volatilities. One could handle these with a GARCH model but it would require us to specify the underlying distribution and that is not in the nature of a non-parametric approach.

The FHS model succeeds at combining the simplicity of the HS model with the power and flexibility of conditional volatility models e.g. GARCH. In order to put this concept into practice, we must first determine the predicted volatility from a sample of the returns on our portfolio. This can be done by fitting a model from the GARCH family. Next, in order to standardize them and get usable i.i.d returns, we divide each return by its volatility.

Once we have the standardized returns, we can bootstrap from this vector of returns by multiplying them by t+1's volatility forecast. The resulting returns are all of tomorrow's potential returns, including the worse outcomes. As in HS and WHS, our VaR will be the number at the Nth percentile or an interpolation of the closest two values of the percentile. The FHS produces a wider range of losses and very clearly dominates the traditional HS (Barone-Adesi and Giannopoulos, 2000).

2.5.3. Parametric models

Parametric models or variance-covariance methods, start by assuming that stock returns follow a certain statistical distribution. Value at Risk is then calculated for a given percentile, dependent on the level of confidence, using the mean and standard deviation of returns as determined by the volatility of stock returns. Therefore, an integral part of a good parametric VaR model is a good volatility forecast. The GARCH models in 2.3.1.2 are the most widely used model to forecast the volatility of stock returns.

Apart from assuming a statistical distribution for stock returns, these models also specify the distribution of the error term, the ϵ. The most generally used distribution is the standard normal

(Bollerslev & Woolridge, 1992). Another key aspect of these models is the assumption that the standardised residuals are i.i.d with mean 0 and variance 1. Since the variance is constant it is consequently homoscedastic. This assumption is necessary to estimate the unknown parameters.

2.6 Backtesting risk measures

Backtesting is a statistical method where actual and observed returns are compared against matching VaR estimates for a specific period. The effectiveness of risk management is consequently determined by the predictability power of an estimator, which is crucial in VaR forecasts. A number of back-testing techniques have been created to compare the effectiveness of various VaR models as well as to confirm the accuracy of the VaR.

Comparing a model's predictions with actual returns is a relatively quick and easy way to determine whether or not it is useful at predicting Value at Risk. A portfolio loss that is greater in absolute value than what the model has predicted represents a violation, breach, or exception.

Unconditional methods for VaR models assess exactly this. The unconditional test (LRuc) proposed by Kupiec (1995) compares whether or not the number of violations are within the statistical limits. The model is then accepted or rejected accordingly. Unconditional tests provide a simple yet very useful benchmark for assessing the accuracy of a given VaR model.

Though the simplicity of the test, it is not only important to know if a certain VaR model produces the correct amount of exceptions. It is also important to see whether the exceptions are evenly spread over time i.e. are independent of each other. This is called the independence property (Christoffersen, 1998). VaR exceptions tend to cluster since they mostly occur when market conditions are grim. This clustering effect on exceptions suggests that the model must be modified as it does not correctly reflect how the current market's volatility. Conditional coverage tests allow for the joint examination of both properties and provide an opportunity to detect defective VaR models in a more straightforward fashion.

Although this, conditional coverage frameworks have a decreased ability to detect VaR models that only violate one of the two unconditional and independence coverage properties. As an example, if a certain VaR model complies with the unconditional property but not the independence property, the conditional framework will be less accurate than the standalone independence test at detecting this defect.

2.7.1. Unconditional tests

Some of the first VaR backtests proposed, focused exclusively on the unconditional coverage property. The widely known test for unconditional coverage of Kupiec (1995), also known as the POF-test (proportion of failures test), measures whether or not, the number of actual exceptions is consistent with the number of expected VaR exceedances for a selected confidence level. Under the null Hypothesis of the model being correctly accurate, the number of exceptions follows the binomial distribution. The POF-test of Kupiec though, has some shortcomings. According to Campbell (2005), the test may fail to rule out a model that generates clustered exceptions as it only takes into account the frequency of losses rather than their timing. Consequently, backtesting shouldn't solely rely on tests for unconditional coverage. As important as it may be to have the correct number of exceptions, it is also important to have them spread evenly over time.

2.7.2. Independence property tests

A good model should be able to respond to changing market volatility so that VaR exceptions occur independently of one another (Finger, 2005). This independence property can be tested using the interval forecast test (Christoffersen, 1998). It investigates whether the probability of a VaR violation at t relied on whether a VaR violation had happened at t-1. This test falls short of acknowledging that a violation might be dependent on observations at time intervals t-2 or those prior.

2.7.3. Conditional tests

A VaR model must demonstrate both the independence and the unconditional coverage properties in order to be considered accurate (Jorion, 2006 and Campbell, 2005). Tests that jointly examine both, provide a cost-efficient way to detect VaR models that are deficient in one or both properties at the expense of a reduced capacity to capture a VaR model that only violates one of the two. The joint test is challenged by the fact that VaR should already satisfy by nature the unconditional coverage tests. Hence, it is harder for the joint test to identify the independence shortcomings of the VaR model because one of the two properties is already satisfied Christoffersen (2012).

3. Data

A sample period of 20 years, from 2002-12-01 to 2022-12-01, was used to conduct this research. This will allow for the inclusion of a market crash, a financial crisis and several other events that affect market conditions. This large time period also allowed for the usage of multiple estimation windows.

Given the overall uncertainty and noisiness surrounding earnings announcements, it's important not to include any other factors that could magnify this uncertainty and to retrieve a significant amount of data. Thus, I have collected daily stock prices of all the constituents that make up the S&P100 (ticker: OEX) as of the 1st of December 2022 for the period specified above (Table 2.1 presents the constituents in greater detail). The choice of index was in part due to the liquidity of the U.S. equities market but also due to their respective market cap. The constituents are all big-cap stocks meaning that they have more shares outstanding when compared to their smaller counterparts. This results in a larger number of shares being traded and limits the noise of price movements that are observed for small-cap stocks. Both the earnings calendar and daily stock prices were collected from Refinitiv. The portfolio returns were calculated as in equation 2.3.4.

For illustrative purposes, I will be using Apple's stock as they do show the characteristics of stock returns quite well. Figure 2.2 presents a plot of Apple's returns from Dec 2nd, 2002 up to and including Dec 1st, 2022. It is easy to observe the return clusters both in 2008 and 2020. This could be problematic for both the independence property of exceptions in our Value at Risk models.

Figures 2.3 and 2.4 also show that the returns do not seem to follow a normal distribution. Although a normal distribution will be used in the first iteration of the semi-parametric and parametric models, these will only be used as a base of comparison to all the other distributions.

Table 2.2 presents a summary of the statistical aspects of not only Apple but all 85 equities. The standard normal distribution has a skewness value of zero and kurtosis equal to 3. It is very clear that no stock has a kurtosis value close to 3. Apart from Bristol Myers Squibb, whose kurtosis < 3, all stock returns distributions are leptokurtic. Skewness values are harder to interpret, some equities such as Ford, Johnson, Qualcomm and Walmart have skewness values of zero whereas others are either negatively or positively skewed. Nonetheless, most of the equities have skewed return distributions. Due to this, non-normal distributions may prove superior for parametric models.

4. Methodology

4.1. Returns

After collecting the data, the second step to compute VaR is to calculate the returns (or price changes) of all the assets in the portfolio in the chosen time interval. Returns can be described as the overall relative gain or loss from an investment over a set time frame. They are calculated as the difference in price between two time periods plus any cash distributions (i.e. dividends):

$$R_t = \frac{P_t - P_{t-1} + D_t}{P_t} \tag{2.3.3}$$

where P_t and D_t are the stock price at time t and cash received from the investment during the same investment period. On the other hand, Hansen et al (2005) compute logarithmic returns as:

$$r_t = ln\left(\frac{P_t}{P_{t-1}}\right) \tag{2.3.4}$$

where r_t is the daily returns and P_t is the daily prices and where,

$$r_t = ln(1 + R_t) \tag{2.3.5}$$

Although R_t may seem like a more intuitive description of returns, r_t is often preferred for time series modeling. One major advantage of using log returns is the symmetry property. For example, if an investment doubles in value in one year and halves its value in two years, by (2.3.3) you would've gained 25% ($\frac{100\%+(-50\%)}{2}$) which is, ignoring the time value of money, incorrect since you're back where you started.

Using the definition in 2.3.4 the year one gain and year two loss would sum to zero. Stock prices are also assumed to follow a log-normal distribution (Black & Scholes, 1973). For these reasons, equation 2.3.4 will be used throughout the paper to compute stock returns.

4.2. Volatility

Although not all assets are affected by the same events in the same way, the seemingly random changes in asset values do share several fairly non-trivial statistical aspects. These changes are a measure of return variability over a certain period of time and are referred to as volatility.

Volatility is often used as a measure of market risk and is used in a variety of financial models such as Value-at-risk models, option pricing models and Sharpe ratios, making this measure a very important concept in financial economics.

Volatility is often expressed in terms of standard deviation, σ or variance, σ^2. The standard deviation is calculated as follows:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(r_i - \bar{r})^2}{N-1}} \tag{2.3.6}$$

where r_i represents the return of a certain stock or portfolio of stocks at time i and $\bar{r}$ the mean return.

4.3. Historical Simulation

The first and simplest method to estimate Value at Risk is the Historical Simulation method. To calculate the VaR for a given asset or portfolio of assets using this approach, returns are ranked in ascending order and the resulting empirical distribution is viewed as the probability distribution of future hypothetical returns. The VaR is then determined as the n^{th} quantile of the hypothetical return distribution for a given confidence level.

For a given stock, at time t, its return can be computed as in equation 2.3.4. The returns are then sorted in ascending order where, for a given confidence level p, the VaR can be described as:

$$Pr[r_t \leq -VaR_p] = p \tag{2.3.7}$$

and

$$p = \int_{-inf}^{-VaR_p} f(x)dx \tag{2.3.8}$$

where f(x) is the density function of the empirical PnL distribution.

Finally:

$$HS - VaR(1-\alpha) = quantile(\{r_t\}_{t=1}^{T}, (1-\alpha\%)) \tag{2.3.9}$$

4.4. Weighted Historical Simulation

Whereas in the HS model all returns are given equal weight, in the WHS model more weight is given to more recent observations and less weight to returns further in the past.

The weights, W(n), decline exponentially through the past and are calculated as:

$$W(n) = \frac{\lambda^{i-1}(1-\lambda)}{1-\ \lambda_n} \tag{2.3.10}$$

where lambda is the decay factor in [0,1]. The closer to 0, the less weight we place on distant returns (i.e. it decays faster). For this particular study, I chose a λ equal to 0.98.

These weights are then multiplied by each matching return where:

$$r_t^W = W(t) * r_t \tag{2.3.11}$$

As in the HS method, the returns are then sorted in ascending fashion such that:

$$Pr[r_t^W \leq -VaR_p] = p \tag{2.3.12}$$

and p as in 2.3.8.

At last:

$$WHS - VaR(1-\alpha) = quantile(\{r_t^W\}_{t=1}^{T}, (1-\alpha\%)) \tag{2.3.13}$$

4.5. GARCH(1,1)

Let the dependent variable be labeled r_t, which could be the return on an asset or a portfolio of assets, μ and σ_t^2 the mean value and volatility of r_t respectively. Accordingly, the return, r, at time t will be the expected value of r based on past information, μ, plus the square root of the variance of r, σ times a residual ϵ.

Thus,

$$r_t = \mu + \sigma_t z_t, \quad z_t \sim white\ noise(0,1). \tag{2.3.14}$$

A residual term, ϵ_t can then be constructed such that it equals $r_t - \mu$. By rearranging equation (2.3.14) we obtain,

$$\epsilon_t = \sigma_t z_t \tag{2.3.15}$$

If we consider the conditional mean to be zero then $r_t = \epsilon_t$ and:

$$r_t = \sigma_t z_t \tag{2.3.16}$$

Variance, σ^2, can then be modelled by Engle's ARCH(q) model such that:

$$\sigma_t^2 = \alpha_0 + \sum_{n=1}^{q} \alpha_i \epsilon_{t-i}^2 \tag{2.3.17}$$

where $\alpha_0 > 0$ and $\alpha_i \geq 0$ to ensure positive variance and $i > 0$. For i=1, we obtain the simpler ARCH(1) model where volatility at time t, σ_t^2 depends only the previous day residual, ϵ_{t-1}^2. As in 2.3.16, volatility at time t will depend only on the previous day volatility times a Gaussian white noise variable.

The GARCH model by Bollerslev (1986) and Taylor (1986) builds upon the ARCH model in 2.3.17 where now the conditional volatility at time t depends not only on previous residuals but also on previous volatilities. The GARCH(1,1) model can be constructed such that,

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \tag{2.3.18}$$

Moreover, the model can be extended to a GARCH(p,q) model such that it carries additional lag terms,

$$\sigma_t^2 = \alpha_0 + \sum_{n=1}^{q} \alpha_i \epsilon_{t-i}^2 + \sum_{n=1}^{p} \beta_i \sigma_{t-i}^2 \tag{2.3.19}$$

Such higher-order models are frequently helpful when dealing with a large time period and a significant amount of data. The added lags allow for both fast and slow decay of information. It's also straightforward to see that for p = 0 the process reduces to the ARCH(q) process as in (2.3.17). For p = q = 0, the model is simply white noise.

4.6. Filtered Historical Simulation

The parametric and HS approaches to risk calculation are combined in filtered historical simulation. The non-parametric technique is used to model the standardized returns, with the assumption that the volatility of the portfolio return can be described with a GARCH specification.

First, we need to calculate a sequence of past standardized residuals $\epsilon_{t+1-\tau}$ from observed past returns,$r_{t+1-\tau}$, and from estimated standard deviations $\sigma_{t+1-\tau}$ as:

$$\epsilon_{t+1-\tau} = \frac{r_{t+1-\tau}}{\sigma_{t+1-\tau}} \tag{2.3.20}$$

Rather than selecting a value at random from a particular distribution, we can draw with replacement, or bootstrap, from our previous standardized residuals $\epsilon_{t+1-\tau}{}_{\tau=1}^{m}$

The returns can the simulated such that:

$$r_{t+1} = \hat{\mu} + \epsilon_{t+1} \tag{2.3.21}$$

where $\hat{\mu} = 0$.

creating a bootstrapped sample $\{r_{t+1-\tau}\}_{\tau=1}^{B}$.

The FHS-VaR can then be obtained from the sample as the$(1-\alpha\%)$ quantile of the bootstrapped distribution:

$$FHS - VaR(1-\alpha) = quantile(\{r_{t+1-\tau}\}_{\tau=1}^{B}, (1-\alpha\%)) \tag{2.3.22}$$

4.7. Adding exogenous variables

The GARCH specification described above captures the volatility only based on its past volatility and past squared residuals. Due to its univariate structure, it does not take into account how exogenous variable(s) may affect the volatility process. Exogenous variables may play a crucial role in the volatility process and, as a direct consequence, in VaR predictions. Consequently, an exogenous variable may have a significant impact on the performance of a VaR model.

4.7.1. The GARCHX(1,1) model

The need for the inclusion of exogenous variables in GARCH models gave birth to the GARCHX family of models. (Hwang & Satchell, 2005) It can be obtained by extending a GARCH(p,q) model such that it includes an exogenous variable in the mean and/or variance equations. By taking equation 2.3.18 we can construct a GARCHX(1,1) as:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma' x_{t-1} \tag{2.3.23}$$

4.8. Backtesting

By its very own definition, a VaR forecast for t+1 promises that a given return will be better than it $1 - \alpha$ percent of the time. For a confidence interval of 99%, or an α of 1%, 99% of every possible return for t+1 will be greater than or equal to the VaR. An exception occurs when this rule is broken and the return is lower than the VaR.

This way, it is possible to define a historical hit sequence of exceptions as,

$$I_{t+1} = \begin{cases} 1 \; if \; r_{t+1} < -VaR_{t+1} \\ 0 \; if \; r_{t+1} \geq -VaR_{t+1} \end{cases} \tag{2.3.24}$$

It shouldn't be possible for us to anticipate if and when the VaR will be violated. If we can, we should use that knowledge to build a more accurate model. The hit sequence should be entirely unexpected and dispersed independently across time as a Bernoulli sequence, with the likelihood of a VaR violation, or a 1, in each trial being α for every t.

4.8.1. Unconditional coverage

Unconditional coverage tests assess whether the proportion of exceedances in the sample is consistent with the confidence level set out for the VaR. For a certain confidence interval, 1 - α, exceedances should occur every $(1-\alpha)^{-1}$ periods. For a daily VaR at 95% confidence interval, we should expect around one exceedance per month or twelve days per year.

From 2.3.24 we can construct the null hypothesis, H_0 where comparisons are i.i.d. Bernoulli trials with probabilities:

$$\begin{cases} \alpha \; if \; 1 \; i.e. \; VaR \; is \; exceeded \\ 1-\alpha \; if \; 0 \; i.e. \; VaR \; is \; not \; exceeded \end{cases} \tag{2.3.25}$$

Defining P_{UC} as the probability of a failure during period t,

$$P_{UC} = \frac{P_{01} + P_{11}}{P_{00} + P_{01} + P_{10} + P_{11}} \tag{2.3.26}$$

where,

$$P_{00} = \frac{\alpha_{00}}{\alpha_{00} + \alpha_{01}} \tag{2.3.27}$$

$$P_{01} = \frac{\alpha_{01}}{\alpha_{00} + \alpha_{01}} \tag{2.3.28}$$

$$P_{10} = \frac{\alpha_{10}}{\alpha_{10} + \alpha_{11}} \tag{2.3.29}$$

$$P_{11} = \frac{\alpha_{11}}{\alpha_{10} + \alpha_{11}} \tag{2.3.30}$$

$$\begin{aligned} P_{00} &= Pr(I_{t+1} = 0 | I_t = 0) \\ P_{11} &= Pr(I_{t+1} = 1 | I_t = 1) \end{aligned} \tag{2.3.31}$$

$$\begin{aligned} P_{00} &= 1 \ - \ P_{01} \\ P_{10} &= 1 \ - \ P_{11} \end{aligned} \tag{2.3.32}$$

The likelihood function for T_1 number of exceptions on N i.i.d observations is:

$$L(\alpha; x) = (1-\alpha)^{T_1} \ \alpha^{N-T_1} \tag{2.3.33}$$

The Maximum likelihood estimator (MLE) for $\alpha = \frac{T_1}{N}$ and we can rewrite 2.3.33 as

$$L(\frac{T_1}{N}; x) = (1 - \frac{T_1}{N})^{T_1} \ \frac{T_1}{N}^{N-T_1} \tag{2.3.34}$$

The test statistic is the log-likelihood ratio:

$$LR_{uc} = 2\Big\{ln[L(\frac{T_1}{N}; x)] \ - \ ln[L(\alpha; x)]\Big\} \tag{2.3.35}$$

which, if H_0 is true and for a large enough N, follows a χ^2 distribution with one degree of freedom.

The p-value can be obtained as 1 - $F_{\chi^2_1}(LR_{uc})$ where F is the cdf of the chi-squared distribution with 1 degree of freedom as in Figure 2.1 below.

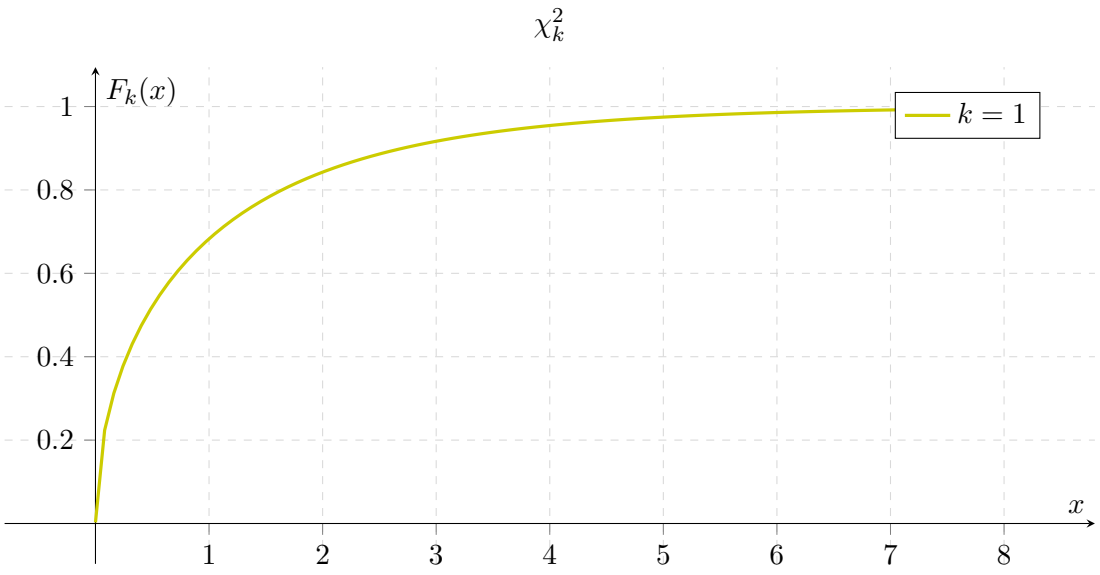

Figure 2.1: Cumulative distribution function of a chi-squared distribution with one degree of freedom

4.8.2. Independence

Independence tests are a type of backtest that evaluate the level of independence in a value-at-risk measure from one period to the next. Results obtained for a value-at-risk measure may be put in doubt if it fails an independence test. Christoffersen's independence test (1998) is a likelihood ratio test that looks for unusually frequent consecutive exceedances — i.e. when, for some t, both $I_{t-1} = I_t = 1$.

Where n = k = {0,1}, P_{nk} can be defined as the probabilities of observing a k at t+1 when an n was observed at time t as in expressions 2.3.23 to 2.3.26. The hit sequence of exceptions can be described as a Markov chain with a transition probability matrix of,

$$\hat{\Pi_1} = \begin{bmatrix} P_{00} & P_{01} \\ P_{10} & P_{11} \end{bmatrix} = \begin{bmatrix} 1-P_{01} & P_{01} \\ 1-P_{11} & P_{11} \end{bmatrix} = \begin{bmatrix} \frac{\alpha_{00}}{\alpha_{00}+\alpha_{01}} & \frac{\alpha_{01}}{\alpha_{00}+\alpha_{01}} \\ \frac{\alpha_{10}}{\alpha_{10}+\alpha_{11}} & \frac{\alpha_{11}}{\alpha_{10}+\alpha_{11}} \end{bmatrix} \tag{2.3.36}$$

The probabilities P_{01} and P_{11} describe the entire markov process. Given a set of N observations then the likelihood of the function is:

$$L(\Pi_1) = (1-P_{01})^{\alpha_{00}} P_{01}^{\alpha_{01}} (1-P_{11})^{\alpha_{10}} P_{11}^{\alpha_{11}} \tag{2.3.37}$$

If exceptions are independent over time, then $P_{01} = P_{11} = \Pi$ and,

$$\hat{\Pi} = \begin{bmatrix} 1-\Pi & \Pi \\ 1-\Pi & \Pi \end{bmatrix} \tag{2.3.38}$$

and,

$$L(\hat{\Pi}) = (1-\Pi)^{\alpha_{00}} \Pi^{\alpha_{01}} (1-\Pi)^{\alpha_{10}} \Pi^{\alpha_{11}} \tag{2.3.39}$$

Assuming that the null hypothesis, H_0 is true, it follows a chi-squared distribution with one degree of freedom i.e. χ_1^2 and our likelihood function is:

$$LR_{ind} = 2ln\frac{L(\hat{\Pi})}{L(\hat{\Pi_1})} \tag{2.3.40}$$

The 0.95 quantile of the χ_1^2 distribution is 3.841, so we reject the null at the .05 significance level if $LR_{ind} \geq$ 3.841. Similarly, we reject it at the .01 significance level if $LR_{ind} \geq$ 6.635.

4.8.3. Conditional coverage

The conditional coverage test proposed by Christoffersen et al. (2001) assesses independence and unconditional coverage simultaneously. This test combines the likelihoods from the null hypothesis from the unconditional coverage test, LR_{uc} and the independence test, LR_{ind} which are computed as in expressions 2.3.35 and 2.3.40 respectively.

Therefore, keeping P_{UC}'s definition unchanged, the likelihood ratio of the CC test, LR_{CC} is then given by:

$$LR_{CC} = -2ln\frac{(1-P_{UC})^{\alpha_{00}+\alpha_{10}}(P_{UC})^{\alpha_{01}+\alpha_{11}}}{(1-P_{01})^{\alpha_{00}}(P_{01})^{\alpha_{01}}(1-P_{11})^{\alpha_{10}}(P_{11})^{\alpha_{11}}} \tag{2.3.41}$$

which is, assuming a true null hypothesis, asymptotically distributed as a chi-square distribution with one degree of freedom and where F is its cumulative distribution. The result of the test is to not reject H_0 if F(LR_{CC}) < F(CLevel) or reject otherwise.

5. Results

The results for the models previously outlined in subsections 4.3 to 4.7 will be discussed and contrasted throughout this fifth section. The VaR obtained for each of these models is illustrated in the Figures appendix. For illustration purposes, Apple's stock was once again chosen. The backtesting findings are also displayed in the Tables appendix.

5.1. Historical Simulation

The Historical Simulation model, described in subsection 4.4, is the simplest and most straightforward VaR model, and as such, it will be used as the standard for comparison with all other models.

Figure 2.5 shows the HS results obtained for Apple(AAPL). The dark blue line represents the fitted VaR for a confidence level of 99% and an out-of-sample window of 500 trading days. The red dots represent the days where the return was more negative than what the VaR forecasted whereas the blue dots represent the exact opposite. A close look at the Figure, allows us to uncover the several shortcomings of the HS model. As depicted by the dark blue line's nearly horizontal aspect, the model is very slow to make any sort of adjustments, whether positive or negative. Given the persistence of financial asset returns, the model's linear nature and its slowness to adapt to new market conditions, VaR exceedances are likely to cluster. The independence property for this model will theoretically not hold, and given that there is an exception today, there will be a greater likelihood that there will be one tomorrow.

The results of the model's unconditional and conditional backtests are outlined in Tables 2.4 and 2.12 respectively. Table 2.4 demonstrates that only six out of 85 times is the null hypothesis of correct exceedances not rejected, indicating that the model misjudges the true number of exceptions for almost all of the stocks. For a 95% confidence interval, only 7% of the models present the correct number of exceptions.

Table 2.12 additionally shows that the null hypothesis is only not rejected three times in the conditional coverage test of correct and independent exceedances. For a 95% confidence interval only 3.5% of the models present the correct number of independent VaR exceptions. Therefore, only half of the six initial correct models had independent VaR exceptions. As expected, the Historical Simulation method produced only a very small number of high-quality models.

5.2. Weighted Historical Simulation

In theory, the WHS model should outperform the more simple HS model. Since we are now giving more weight to more recent observations, the model should be much more reactive to the extreme negative returns that affect the VaR making the clustering of VaR exceedances a much less significant issue.

Figure 2.6 outlines Apple's VaR obtained with the WHS model using the same 500-day out-of-sample window and 0.01 alpha, and a 0.98 lambda parameter. When compared to 2.5, the VaR, represented by the dark blue line, is much more reactive. This is ought to result in a lower number of actual exceptions when compared to the previous models.

Tables 2.5 and 2.13, present the backtesting results for the WHS model. Despite the model's increased responsiveness, Table 2.3 shows that not only are there significantly more actual exceptions than in the HS model, but there are also more exceptions during earnings. Tables 2.5 and 2.13 present the unconditional and conditional coverage backtesting results respectively. The null hypothesis for both the unconditional and conditional coverage tests are rejected for each and every equity for the WHS model.

Although the results may seem nonsensical at first, during the period between 2010 and 2020 there is an almost straight horizontal line at around -0.05 for the HS model. In the WHS model, during the same timeframe, the model sometimes seems to adjust but it creates more exceptions. Due to pure chance, this resulted in fewer exceptions for the HS model.

5.3. GARCH(1,1)

Parametric models promise to deliver results that are better than the ones obtained by their non-parametric counterparts. This subsection will go over the results obtained for the parametric model of choice for this dissertation and will contrast the various statistical distributions.

The VaR for a GARCH(1,1) model is shown in Figure 2.7 under the assumptions of a normal distribution, a 500-day out-of-sample estimation window, and an alpha of 0.01. The VaR appears to be even more responsive and assumes even more negative values when compared to Figure 2.6, which may help to lower the overall number of exceptions. In 5.1, when comparing the non-parametric models, we saw that increased responsiveness does not always translate into a more accurate number of exceptions (i.e., a better model). Table 2.3 confirms this once again. The number of total exceptions increased by around 22.6% and exceptions during earnings increased by 18%.

Tables 2.6 and 2.14 present unconditional and conditional backtest results respectively. For the greater majority of the stocks considered, the actual number of exceptions is roughly double the amount of expected exceedances. Consequently, the null hypothesis for both the unconditional and conditional coverage tests are rejected for all equities.

The assumption of a normal distribution for the returns, which in practice hardly ever seems to hold true, could be the reason why the GARCH model presents more VaR exceptions. Since an incorrect specification of the underlying statistical distribution may be causing the GARCH model to perform worse than the HS model, it is only logical to run the same model for other statistical distributions.

The t-student distribution shares many of the properties of the normal distribution such as the bell-shaped curve but they have a greater chance for extreme values creating heavier tails. Due to stock returns' excess kurtosis, T-distributions are a more sound distribution to use when modeling the VaR than its Gaussian counterpart.

Figure 2.8 presents the fitted VaR and respective VaR exceptions for a GARCH(1,1) model where the innovations are assumed to follow a t-student distribution. When compared to Figure 2.7, the VaR seems to be more appropriately fitted, resulting in fewer exceptions overall. Table 2.3 shows that the total number of exceptions was reduced by almost 34% whereas the number of exceptions during earnings announcement days was reduced by 30%.

Once more, the results of the conditional and unconditional backtesting for the GARCH(1,1) model that makes use of a t-student distribution are respectively provided in Figures 2.7 and 2.15. When comparing these results with the normal distribution model - Tables 2.6 and 2.14 - we observe that the null hypothesis for both the unconditional and conditional backtests are not rejected for more than 50% of all equities.

Table 2.2 shows that almost all stocks considered in this study present excess skewness on top of excess kurtosis. Thus, if the results are significantly better for a distribution with excess kurtosis, what about the same distribution that allows for some excess skewness?

Figure 2.9 presents the fitted VaR for the GARCH(1,1) model assuming skewed t-student distribution. There don't seem to be many differences from the prior model, shown in Figure 2.8. Table 2.3 shows this exactly. The number of rejected null hypotheses is reduced for the unconditional backtest but increases for the conditional backtest. The total number of exceptions rises by about 0.5%, but the proportion of exceptions that take place on days when earnings announcements are made stays the same. There seems to be a slight tradeoff between

correct exception count and independence of exceptions. Overall, the t-student distribution's improvement as a result of skewness inclusion is not statistically significant.

The generalized error distribution has been used to model the VaR in situations where the tail behavior and concentration of values around the mean are particularly important. That being the case in this specific research, Figure 2.10 presents the fitted VaR for a GARCH model assuming a generalized error distribution. There are some changes when compared to Figures 2.8 and 2.9 particularly a less volatile VaR at the beginning of the time frame. Apart from that, again, the Figures are similar.

Tables 2.9 and 2.17 present the results for the backtesting models for the unconditional and conditional coverage tests respectively. The Generalized Error Distribution provides even better results for the unconditional and conditional coverage tests with 54/85 = 63.5% and 53/85 = 62.35% rejection ratios. Table 2.3 also shows that the total number of VaR exceedances is the smallest out of all the models considered thus far. The number of exceptions during earnings announcement days also decreases by around 6%.

5.4. Filtered Historical Simulation

Figure 2.11 presents the fitted VaR for the FHS model assuming a generalised error distribution. The VaR seems to be more volatile than the previous GARCH models which may be a good sign, especially for the independence property of VaR exceedances.

Tables 2.10 and 2.18 present the conditional and unconditional backtesting results for the FHS model respectively. The semi-parametric model falls short when compared to the GARCH(1,1) - GED model as the null hypothesis for the unconditional and conditional coverage tests is rejected for 52 and 50 models versus 54 and 53 of its parametric counterpart. The number of total VaR exceptions and those that occur during earnings announcement days also increase by 2% and 5% respectively.

5.5. GARCHX - Adding an exogenous regressor

So far, I found that the GARCH(1,1) model whose innovations assumed a generalised error distribution was the model that best forecasted the VaR having the highest number of equities with correct and independent VaR exceedances, and the lowest amount of exceptions on earnings announcement days and overall.

None of the models that were explored took earnings announcements into account when forecasting the VaR and it remains to determine whether their inclusion as an indicator variable

in the model will improve VaR estimates, reducing exceedances and improving backtesting results. This will be achieved by extending the GARCH(1,1) - GED model to include the earnings announcements indicator variable; the GARCHX(1,1)-GED model.

Figure 2.12 presents the VaR fitted with the GARCHX(1,1) model. When compared to all the previous models it is clear that there are days where the forecasted VaR is much lower than in the previous day. It is very apparent that the inclusion of the earnings announcements variable plays a significant role at predicting the VaR when there is a sudden negative return on announcement days which could reduce the number of VaR exceptions.

Along with Table 2.3, Tables 2.11 and 2.19 summarise the unconditional and conditional coverage tests for the expanded GARCH(1,1) model. The total VaR exceedances are very slightly reduced by the GARCHX(1,1) model, but neither the number of exceptions on earnings announcement days nor the outcomes of the unconditional backtests are improved. Moreover the number of rejected null hypotheses for the conditional backtest increases by 8%.

As a result, although adding the earnings announcement variable to the model slightly decreased the number of exceedances, it weakened the independence property for some of the stocks. This could imply that there is still data to be extracted from the model in the period surrounding the announcements and that one VaR exception can predict the next one.

6. Conclusions, limitations and future work

The two objectives of this thesis were to investigate the various VaR models based on various statistical distributions and, more importantly, to ascertain whether a VaR model would benefit from the inclusion of an external regressor, in this case, an indicator variable for earnings announcement days.

This chapter summarizes the findings, provides answers to the research questions and describes what this work contributes to the field. It later illustrates the limitations of the work presented in this dissertation are discussed in the section that follows and how these issues can be further investigated in future research.

6.1. Conclusions

Scholars have extensively researched macroeconomic events and the information that can be gained from them from a market volatility and risk perspective. Other events, like corporate ones, haven't undergone the same thorough investigation. Given the importance of earnings announcements to a public firm and the increased volatility surrounding them, VaR estimates may be under/overstated if they do not take these stock price movements into account.

To assess this, I first tested a number of VaR models to determine which one forecasted the VaR most accurately for all S&P100 components as of December 1, 2022 - apart from those equities which didn't have data for the entire timeframe in consideration. Apart from the model that assumed a Gaussian distribution for its innovations, the parametric models outperformed the non-parametric ones. For the same distribution, the generalised error distribution, the parametric (GARCH(1,1)) model, outperformed its semi-parametric (FHS) sibling.

Posterior to determining that the GARCH(1,1) - GED model was the one that best predicted the VaR - resulting in a smaller number of VaR exceptions occurring during earnings announcement days and overall, I extended it by including an exogenous regressor and introduced the GARCHX(1,1)-GED model. The two were then compared and, although the GARCHX model reduced the overall number of VaR exceedances, it failed at improving the unconditional backtest results and at reducing the number of VaR exceptions that occurred during earnings announcement days. It also worsened the conditional backtest results meaning that it impaired the independence property of the VaR. Therefore, the information of earnings announcements didn't cause a statistically significant improvement in the original model.

6.2. Limitations and future work

A number of limitations were present in this study. Firstly, data quality issues were encountered. Only 85 out of the original 100 stocks had data for the entire time period chosen going back to the 1st of December of 2002. In addition, alternative GARCH specifications besides (1,1) might have been used. It's possible that these other attributes with lags superior to one would be superior.

On top of that, the models could've been expanded to include more indicator variables. A number of other additional factors, such as dividends changes, stock splits, mergers and acquisitions, could've been used as well to improve VaR forecasts. Finally, the models could've been run for larger estimation windows. Larger estimation windows would allow for the inclusion of more earnings days in the GARCHX model resulting in a more accurate estimation of the indicator variable.

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Figures

Figure I - Apple's returns

The following Figure plots Apple's returns from the 2nd of December 2022 up to and including the 1st of December 2022.

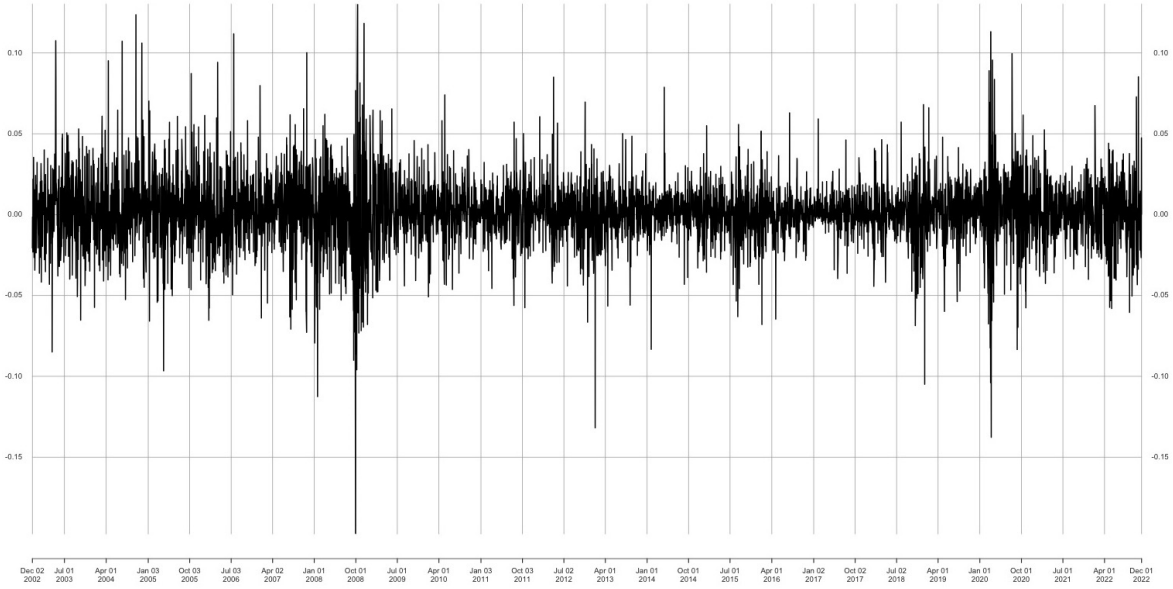

Figure 2.2: Apple's 20Y log returns

Figure II - Gaussian vs APPLE's returns empirical distribution

The following Figure outlines the difference between a normal distribution (blue) and Apple's returns empirical distribution (red).

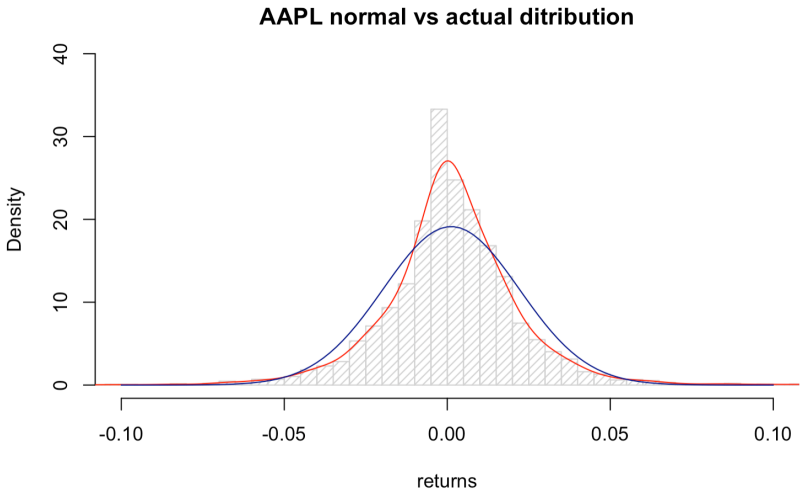

Figure 2.3: Normal distribution in blue vs Apple's actual return distribution in red

Figure III - Apple's returns QQ plot

The following Figure outlines a QQ plot with sample and theoretical Gaussian quantiles and allows for a quick observation on if the returns follow a normal distribution.

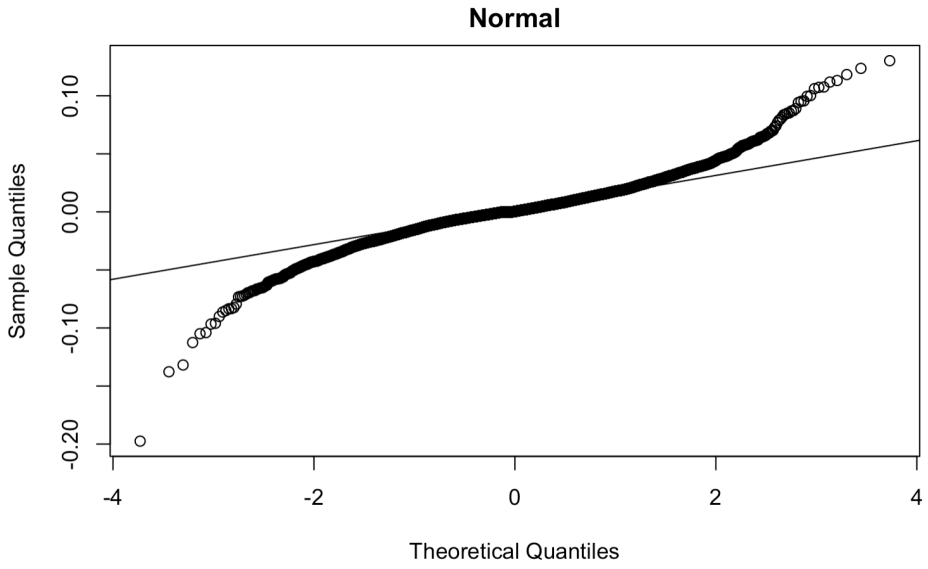

Figure 2.4: Apple's QQ plot

Figure IV - Apple's HS VaR

The Figure below presents Apple's returns and the VaR measured by an Historical Simulation model with $\alpha = 0.01$. The blue dots are represent the days where the return was bigger or equal to the VaR. Those in red represent the VaR exceptions - days where the return was smaller/more negative than the VaR.

Figure 2.5: Apple HS VaR α=0.01

Figure V - Apple's WHS VaR

The Figure below presents Apple's returns and the VaR measured by a Weighted Historical Simulation model with $\alpha = 0.01$.

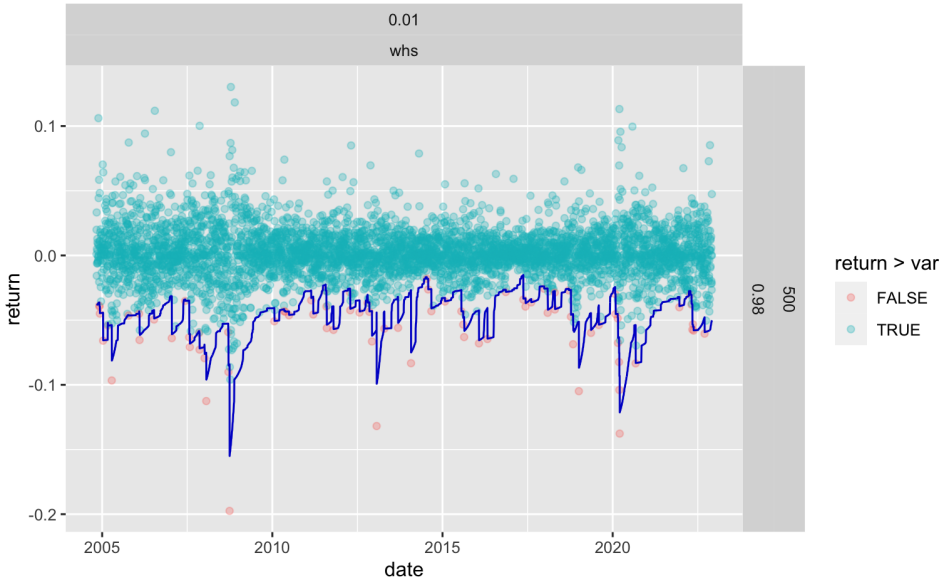

Figure 2.6: Apple WHS VaR α=0.01

Figure VI - Apple's GARCH VaR (Normal)

The Figure below presents Apple's returns and the VaR measured by a GARCH(1,1) model with $\alpha = 0.01$ assuming a normal distribution.

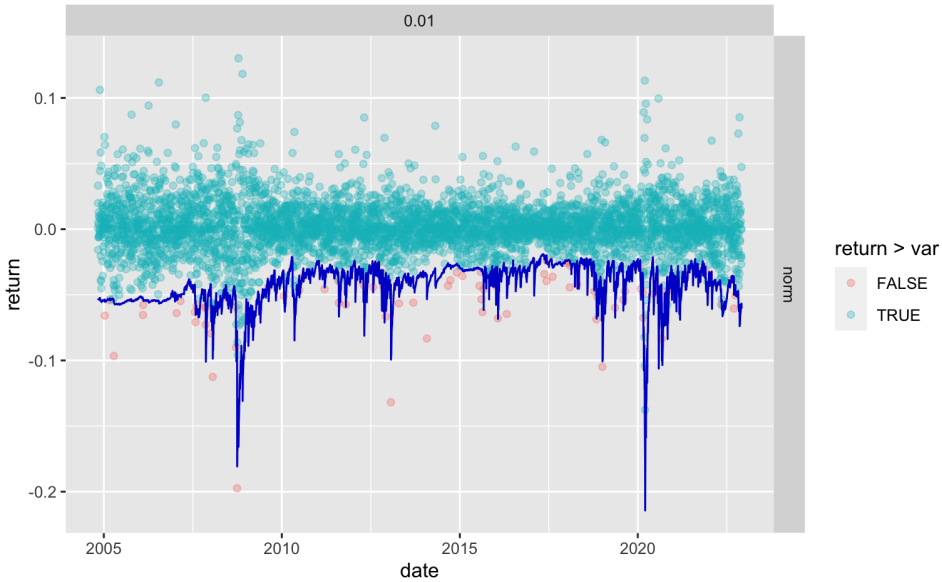

Figure 2.7: Apple GARCH VaR α=0.01

Figure VII - Apple's GARCH VaR (t-student)

The Figure below presents Apple's returns and the VaR measured by a GARCH(1,1) model with $\alpha = 0.01$ assuming a t-student distribution.

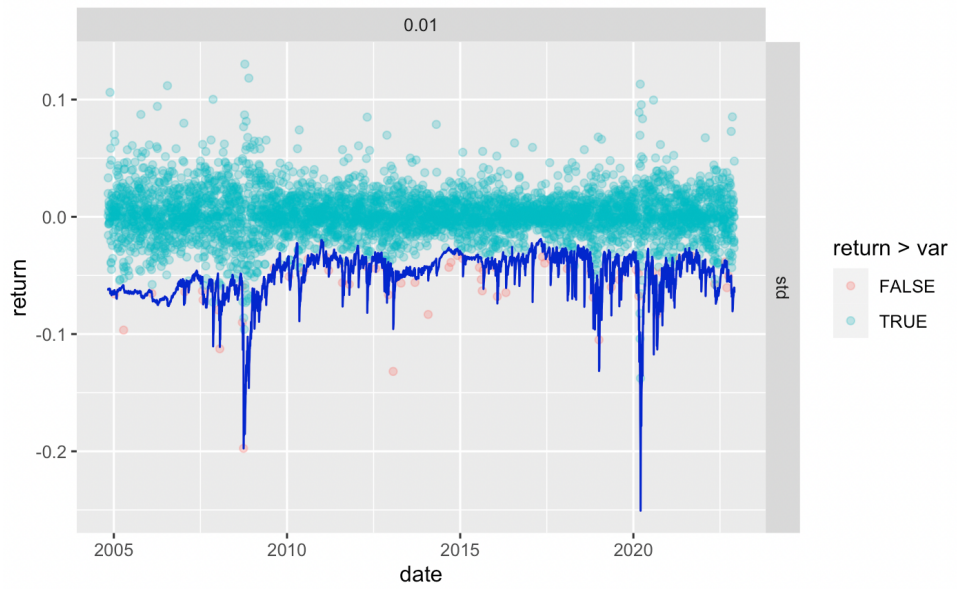

Figure 2.8: Apple GARCH VaR - Student-t distribution α=0.01

Figure VIII - Apple's GARCH VaR (Normal)

The Figure below presents Apple's returns and the VaR measured by a GARCH(1,1) model with $\alpha = 0.01$ assuming a skewed t-student distribution.

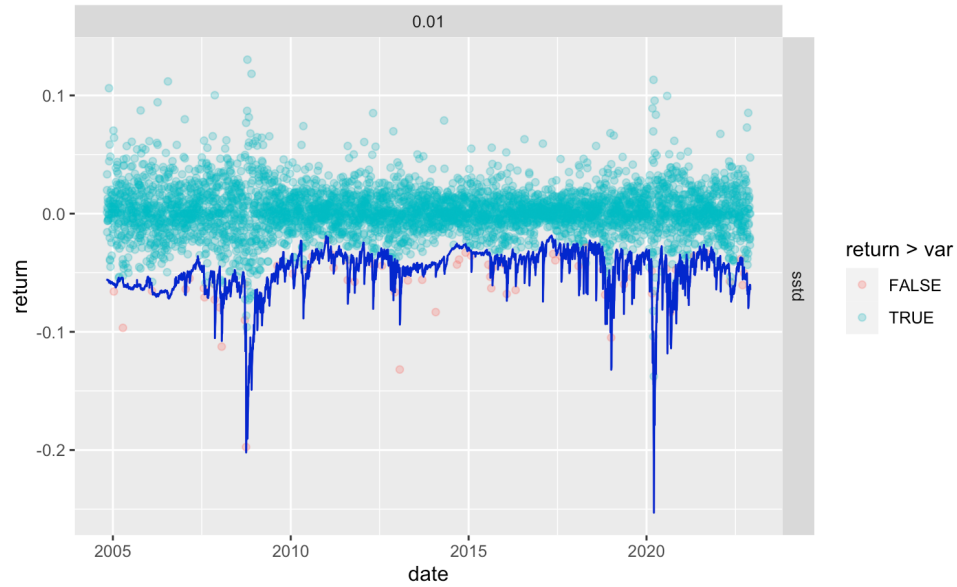

Figure 2.9: Apple GARCH VaR - Skewed student-t distribution α=0.01

Figure IX - Apple's GARCH VaR (GED)

The Figure below presents Apple's returns and the VaR measured by a GARCH(1,1) model with $\alpha = 0.01$ assuming a generalised error distribution.

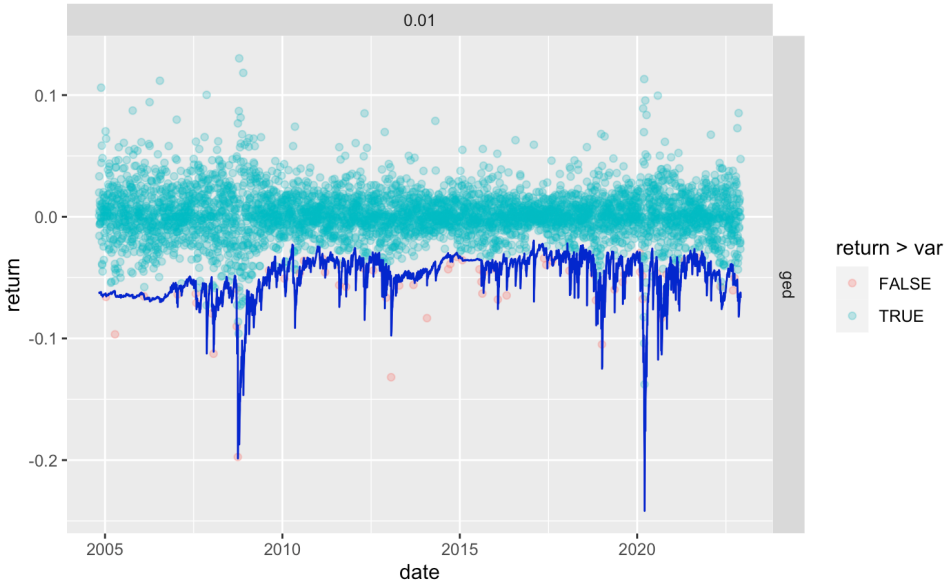

Figure 2.10: Apple GARCH VaR - Skewed student-t distribution α=0.01

Figure X - Apple's FHS VaR (Normal)

The Figure below presents Apple's returns and the VaR measured by a Filtered Historical Simulation model with $\alpha = 0.01$.

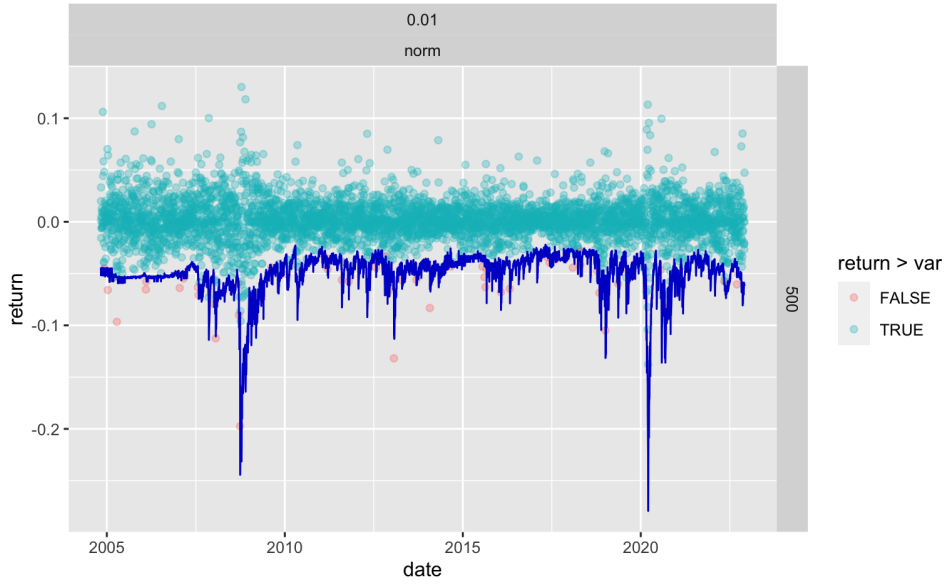

Figure 2.11: Apple FHS VaR α=0.01

Figure XI - Apple's GARCHX VaR (Normal)

The Figure below presents Apple's returns and the VaR measured by a GARCHX(1,1) model with $\alpha = 0.01$ assuming a generalised error distribution.

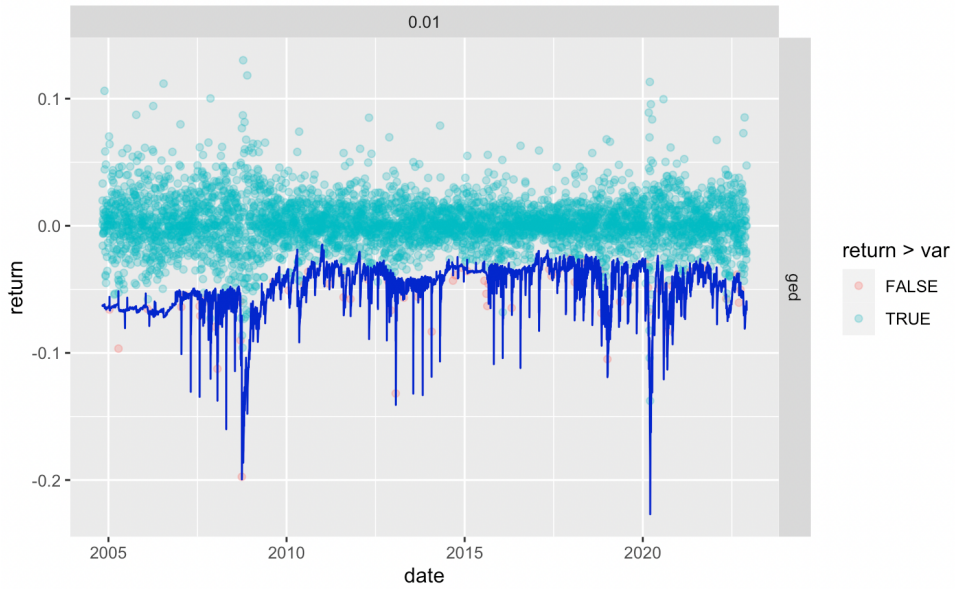

Figure 2.12: Apple GARCHX(1,1) GED VaR α=0.01

Tables

Table I - S\&P 100 constituents

This table contains the constituents of the S&P 100 - as of the 1st of December 2022 - used in this dissertation. Some of the equities didn't have data for the entire period considered for this study and where removed.

Ticker	Name	Sector
AAPL	Apple	Information Technology
ABBV	AbbVie	Health Care
ABT	Abbott	Health Care
ACN	Accenture	Information Technology
ADBE	Adobe	Information Technology
AIG	American International Group	Financials
AMD	AMD	Information Technology
AMGN	Amgen	Health Care
AMT	American Tower	Real Estate
AMZN	Amazon	Consumer Discretionary
AVGO	Broadcom	Information Technology
AXP	American Express	Financials
BA	Boeing	Industrials
BAC	Bank of America	Financials
BK	BNY Mellon	Financials
BKNG	Booking Holdings	Consumer Discretionary
BLK	BlackRock	Financials
BMY	Bristol Myers Squibb	Health Care
BRK.B	Berkshire Hathaway	Financials
C	Citigroup	Financials
CAT	Caterpillar	Industrials
CHTR	Charter Communications	Communication Services
CL	Colgate-Palmolive	Consumer Staples
CMCSA	Comcast	Communication Services
COF	Capital One	Financials
COP	ConocoPhillips	Energy
COST	Costco	Consumer Staples
CRM	Salesforce	Information Technology
CSCO	Cisco	Information Technology
CVS	CVS Health	Health Care
CVX	Chevron	Energy
DHR	Danaher	Health Care
DIS	Disney	Communication Services
DOW	Dow	Materials
DUK	Duke Energy	Utilities
EMR	Emerson	Industrials
EXC	Exelon	Utilities
F	Ford	Consumer Discretionary
FDX	FedEx	Industrials
GD	General Dynamics	Industrials

GE	GE	Industrials
GILD	Gilead	Health Care
GM	GM	Consumer Discretionary
GOOG	Alphabet (Class C)	Communication Services
GOOGL	Alphabet (Class A)	Communication Services
GS	Goldman Sachs	Financials
HD	Home Depot	Consumer Discretionary
HON	Honeywell	Industrials
IBM	IBM	Information Technology
INTC	Intel	Information Technology
JNJ	Johnson	Johnson&Health Care
JPM	JPMorgan Chase	Financials
KHC	Kraft Heinz	Consumer Staples
KO	Coca-Cola	Consumer Staples
LIN	Linde	Materials
LLY	Lilly	Health Care
LMT	Lockheed Martin	Industrials
LOW	Lowe's	Consumer Discretionary
MA	Mastercard	Information Technology
MCD	McDonald's	Consumer Discretionary
MDLZ	Mondelēz International	Consumer Staples
MDT	Medtronic	Health Care
MET	MetLife	Financials
META	Meta	Communication Services
MMM	3M	Industrials
MO	Altria	Consumer Staples
MRK	Merck	Health Care
MS	Morgan Stanley	Financials
MSFT	Microsoft	Information Technology
NEE	NextEra Energy	Utilities
NFLX	Netflix	Communication Services
NKE	Nike	Consumer Discretionary
NVDA	Nvidia	Information Technology
ORCL	Oracle	Information Technology
PEP	PepsiCo	Consumer Staples
PFE	Pfizer	Health Care
PG	Procter & Gamble	Consumer Staples
PM	Philip Morris International	Consumer Staples
PYPL	PayPal	Information Technology
QCOM	Qualcomm	Information Technology
RTX	Raytheon Technologies	Industrials
SBUX	Starbucks	Consumer Discretionary
SCHW	Charles Schwab	Financials
SO	Southern Company	Utilities
SPG	Simon	Real Estate
T	AT&T	Communication Services
TGT	Target	Consumer Discretionary
TMO	Thermo Fisher Scientific	Health Care
TMUS	T-Mobile	Communication Services
TSLA	Tesla	Consumer Discretionary

TXN	Texas Instruments	Information Technology
UNH	UnitedHealth Group	Health Care
UNP	Union Pacific	Industrials
United Parcel Service	United Parcel Service	Industrials
USB	U.S. Bank	Financials
V	Visa	Information Technology
VZ	Verizon	Communication Services
WBA	Walgreens Boots Alliance	Consumer Staples
WFC	Wells Fargo	Financials
WMT	Walmart	Consumer Staples
XOM	ExxonMobil	Energy

Table 2.1: Constituents of the S&P100 as of December 1st, 2022

Table II - Descriptive statistics of the returns for all stocks

The table below outlines the descriptive statistics for all stocks considered in this dissertation. These include the mean, minimum, maximum and the difference between both (range), the skewness and kurtosis of the returns distributions.

Asset	Mean	Standard Deviation	Minimum	Maximum	Range	Skewness	Kurtosis
3M	0	0.01	-0.14	0.12	0.26	-0.54	8.77
Abbott	0	0.01	-0.10	0.10	0.21	-0.27	6.59
Accenture	0	0.02	-0.14	0.15	0.30	-0.09	7.74
Adobe	0	0.02	-0.21	0.16	0.37	-0.27	8.59
Altria	0	0.01	-0.13	0.15	0.28	-0.54	11.48
Amazon	0	0.02	-0.25	0.24	0.48	0.32	12.45
AMD	0	0.04	-0.30	0.42	0.72	0.02	8.68
American Express	0	0.02	-0.19	0.20	0.39	0.21	15.31
American International Group	0	0.04	-0.94	0.51	1.44	-3.34	115.65
American Tower	0	0.02	-0.16	0.18	0.35	0.14	9.30
Amgen	0	0.02	-0.10	0.14	0.24	0.44	7.38
Apple	0	0.02	-0.20	0.13	0.33	-0.09	5.62
AT&T	0	0.01	-0.10	0.15	0.25	0.08	9.15
Bank of America	0	0.03	-0.34	0.30	0.64	-0.34	28.77
Berkshire Hathaway	0	0.01	-0.13	0.15	0.28	0.53	17.41
BlackRock	0	0.02	-0.17	0.18	0.35	0.08	9.25
BNY Mellon	0	0.02	-0.32	0.22	0.54	-0.26	22.67
Boeing	0	0.02	-0.27	0.22	0.49	-0.35	18.56
Booking Holdings	0	0.03	-0.30	0.28	0.58	0.76	16.70
Bristol Myers Squibb	0	0.02	-0.17	0.10	0.27	-0.741	0.29
Capital One	0	0.03	-0.29	0.23	0.52	-0.46	16.44
Caterpillar	0	0.02	-0.16	0.14	0.29	-0.26	5.71
Charles Schwab	0	0.02	-0.16	0.18	0.34	0.09	6.05
Chevron	0	0.02	-0.25	0.20	0.45	-0.51	23.33
Cisco	0	0.02	-0.18	0.15	0.32	-0.44	10.78
Citigroup	0	0.03	-0.49	0.46	0.95	-0.57	43.89
Coca Cola	0	0.01	-0.10	0.13	0.23	-0.22	11.91
Colgate-Palmolive	0	0.01	-0.12	0.12	0.24	-0.10	11.53
Comcast	0	0.018	-0.16	0.22	0.38	-0.044	11.02
ConocoPhillips	0	0.02	-0.29	0.22	0.51	-0.53	14.74
Costco	0	0.01	-0.21	0.10	0.31	-0.79	15.36
CVS	0	0.02	-0.22	0.13	0.36	-0.88	14.65

Danaher	0	0.01	-0.11	0.10	0.21	0.02	5.12
Disney	0	0.02	-0.14	0.15	0.29	0.23	9.97
Duke Energy	0	0.01	-0.16	0.12	0.29	-0.41	15.60
Emerson	0	0.02	-0.21	0.15	0.36	-0.40	13.43
Exelon	0	0.02	-0.18	0.17	0.34	-0.03	14.80
ExxonMobil	0	0.02	-0.15	0.16	0.31	-0.09	10.82
Fedex	0	0.02	-0.24	0.13	0.38	-0.71	12.10
Ford	0	0.03	-0.29	0.26	0.55	0.00	15.90
General Dynamics	0	0.01	-0.13	0.11	0.24	-0.35	6.42
General Electric	0	0.02	-0.16	0.18	0.34	-0.07	9.46
Gilead	0	0.02	-0.15	0.13	0.28	-0.19	7.11
Goldman Sachs	0	0.02	-0.21	0.23	0.45	0.19	16.39
Home Depot	0	0.02	-0.22	0.13	0.35	-0.44	13.11
Honeywell	0	0.02	-0.13	0.14	0.27	-0.12	6.74
IBM	0	0.01	-0.14	0.11	0.25	-0.44	8.68
Intel	0	0.02	-0.20	0.18	0.38	-0.44	9.25
Johnson	0	0.01	-0.11	0.12	0.22	-0.01	10.77
JPMorgan Chase	0	0.02	-0.23	0.22	0.46	0.28	18.08
Lilly	0	0.02	-0.13	0.15	0.28	0.30	10.47
Linde	0	0.02	-0.13	0.14	0.27	0.08	8.78
Lockheed Martin	0	0.01	-0.14	0.10	0.24	-0.53	10.25
Lowe's	0	0.02	-0.28	0.15	0.44	-0.59	15.76
McDonald's	0	0.01	-0.17	0.17	0.34	0.07	16.41
Medtronic	0	0.01	-0.14	0.10	0.24	-0.75	11.22
Merck	0	0.02	-0.31	0.12	0.43	-1.76	37.52
Metlife	0	0.03	-0.31	0.25	0.56	-0.50	24.13
Microsoft	0	0.02	-0.16	0.17	0.33	-0.09	9.93
Mondelēz International	0	0.01	-0.15	0.11	0.25	-0.35	10.21
Morgan Stanley	0	0.03	-0.30	0.63	0.93	1.53	62.74
Netflix	0	0.03	-0.53	0.35	0.88	-1.46	29.35
NextEra Energy	0	0.01	-0.14	0.13	0.27	0.14	13.30
Nike	0	0.02	-0.14	0.14	0.28	0.21	9.31
Nvidia	0	0.03	-0.43	0.29	0.72	-0.67	16.57
Oracle	0	0.02	-0.12	0.19	0.31	0.22	8.72
Pepsi	0	0.01	-0.13	0.12	0.25	-0.42	17.98
Pfizer	0	0.01	-0.12	0.10	0.22	-0.15	6.98
Procter & Gamble	0	0.01	-0.09	0.11	0.20	-0.10	10.41
Qualcomm	0	0.02	-0.17	0.21	0.37	0.00	8.86
Raytheon Technologies	0	0.02	-0.16	0.15	0.30	-0.04	11.93
Simon	0	0.02	-0.31	0.25	0.56	-0.30	23.19
Southern Company	0	0.01	-0.13	0.17	0.30	0.34	21.40
Starbucks	0	0.02	-0.18	0.17	0.35	0.20	8.60
Target	0	0.02	-0.29	0.19	0.47	-0.64	19.13
Texas Instruments	0	0.02	-0.16	0.13	0.28	-0.12	4.66
Thermo Fisher Scientific	0	0.02	-0.11	0.16	0.27	-0.19	6.64
Union Pacific	0	0.02	-0.15	0.12	0.27	-0.38	6.86
United Parcel Service	0	0.01	-0.11	0.13	0.24	0.12	10.09
UnitedHealth Group	0	0.02	-0.21	0.30	0.50	0.19	24.44
US Bancorp	0	0.02	-0.20	0.21	0.41	-0.08	18.18
Verizon	0	0.01	-0.08	0.14	0.22	0.17	7.20
Walgreens Boots Alliance	0	0.02	-0.16	0.15	0.32	-0.34	9.37
Walmart	0	0.01	-0.12	0.11	0.23	-0.01	12.00
Wells Fargo	0	0.02	-0.27	0.28	0.56	0.68	25.50

Table 2.2: Data summary

Table III - Backtests summary

The following table outlines a high level summary of the results of the backtests done in this dissertation. It also outlines the total number of exceptions, if these occured during earnings announcement days and the respective ratio.

Model	Distribution	Unconditional backtest		Conditional backtest		Nº of VaR Exceptions		
		Non-rejected H_0	Ratio	Non-rejected H_0	Ratio	Earnings	Total	Ratio
HS	N/A	6	0.07	6	0.07	138	6218	0.0222
WHS	N/A	0	0	0	0	168	6709	0.0250
GARCH(1,1)	Normal	0	0	0	0	189	7727	0.0241
	T-student	47	0.58	48	0.54	133	5117	0.0213
	Skewed T-student	51	0.54	46	0.54	133	5141	0.0204
	GED	54	0.64	53	0.62	125	5007	0.0267
FHS	GED	52	0.63	50	0.61	131	5110	0.0256
GARCHX(1,1)	GED	54	0.66	49	0.60	125	4991	0.0240

Table 2.3: Summary of backtests

Table IV - Historical Simulation - Unconditional Coverage

Results for the unconditional coverage test for an Historical Simulation model with a window size of 500 days and an alpha of 0.01.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Abbott	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Accenture	47	82	Correct Exceedances	21.256	3.841	0	Reject H0
Adobe	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Altria	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Amazon	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
AMD	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
American Express	47	87	Correct Exceedances	27.161	3.841	0	Reject H0
American International Group	47	77	Correct Exceedances	15.973	3.841	0	Reject H0
American Tower	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
Amgen	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Apple	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
AT&T	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
Bank of America	47	95	Correct Exceedances	37.813	3.841	0	Reject H0
Berkshire Hathaway	47	74	Correct Exceedances	13.117	3.841	0	Reject H0
BlackRock	47	85	Correct Exceedances	24.727	3.841	0	Reject H0
BNY Mellon	47	78	Correct Exceedances	16.978	3.841	0	Reject H0
Boeing	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
Booking Holdings	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
Bristol Myers Squibb	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Capital One	47	81	Correct Exceedances	20.149	3.841	0	Reject H0
Caterpillar	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
Charles Schwab	47	81	Correct Exceedances	20.149	3.841	0	Reject H0
Chevron	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
Cisco	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Citigroup	47	92	Correct Exceedances	33.651	3.841	0	Reject H0
Coca Cola	47	70	Correct Exceedances	9.695	3.841	0.002	Reject H0
Colgate-Palmolive	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Comcast	47	70	Correct Exceedances	9.695	3.841	0.002	Reject H0
ConocoPhillips	47	90	Correct Exceedances	30.986	3.841	0	Reject H0
Costco	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
CSV Health	47	74	Correct Exceedances	13.117	3.841	0	Reject H0
Danaher	47	77	Correct Exceedances	15.973	3.841	0	Reject H0
Disney	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
Duke Energy	47	76	Correct Exceedances	14.994	3.841	0	Reject H0
Emerson	47	79	Correct Exceedances	18.009	3.841	0	Reject H0
Exelon	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
ExxonMobil	47	79	Correct Exceedances	18.009	3.841	0	Reject H0
Fedex	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Ford	47	76	Correct Exceedances	14.994	3.841	0	Reject H0
General Dynamics	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0

General Electric	47	78	Correct Exceedances	16.978	3.841	0	Reject H0
Gilead	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Goldman Sachs	47	94	Correct Exceedances	36.404	3.841	0	Reject H0
Home Depot	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Honeywell	47	70	Correct Exceedances	9.695	3.841	0.002	Reject H0
IBM	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Intel	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Johnson	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
JPMorgan Chase	47	85	Correct Exceedances	24.727	3.841	0	Reject H0
Lilly	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Linde	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
Lockheed Martin	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
Lowe's	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
McDonald's	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Medtronic	47	77	Correct Exceedances	15.973	3.841	0	Reject H0
Merck	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Metlife	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Microsoft	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
Mondelēz International	47	75	Correct Exceedances	14.042	3.841	0	Reject H0
Morgan Stanley	47	84	Correct Exceedances	23.545	3.841	0	Reject H0
Netflix	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
NextEra Energy	47	84	Correct Exceedances	23.545	3.841	0	Reject H0
Nike	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
Nvidia	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Oracle	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
Pepsi	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Pfizer	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Procter & Gamble	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
Qualcomm	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Raytheon Technologies	47	76	Correct Exceedances	14.994	3.841	0	Reject H0
Simon	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Southern Company	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Starbucks	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
Target	47	78	Correct Exceedances	16.978	3.841	0	Reject H0
Texas Instruments	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
Thermo Fisher Scientific	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
Union Pacific	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
United Parcel Service	47	75	Correct Exceedances	14.042	3.841	0	Reject H0
UnitedHealth Group	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
US Bancorp	47	89	Correct Exceedances	29.688	3.841	0	Reject H0
Verizon	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Walgreens Boots Alliance	47	74	Correct Exceedances	13.117	3.841	0	Reject H0
Walmart	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Wells Fargo	47	89	Correct Exceedances	29.688	3.841	0	Reject H0

Table 2.4: HS unconditional coverage for a window size of 500 days and $\alpha = 0.01$

Table V - Weighted Historical Simulation - Unconditional Coverage

Results for the unconditional coverage test for a Weighted Historical Simulation model with a lambda of 0.98, a window size of 500 days and an alpha of 0.01.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
Abbott	47	77	Correct Exceedances	15.973	3.841	0	Reject H0
Accenture	47	81	Correct Exceedances	20.149	3.841	0	Reject H0
Adobe	47	74	Correct Exceedances	13.117	3.841	0	Reject H0
Altria	47	70	Correct Exceedances	9.695	3.841	0.002	Reject H0
Amazon	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
AMD	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
American Express	47	85	Correct Exceedances	24.727	3.841	0	Reject H0
American International Group	47	78	Correct Exceedances	16.978	3.841	0	Reject H0
American Tower	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
Amgen	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
Apple	47	79	Correct Exceedances	18.009	3.841	0	Reject H0
AT&T	47	78	Correct Exceedances	16.978	3.841	0	Reject H0
Bank of America	47	82	Correct Exceedances	21.256	3.841	0	Reject H0
Berkshire Hathaway	47	77	Correct Exceedances	15.973	3.841	0	Reject H0
BlackRock	47	85	Correct Exceedances	24.727	3.841	0	Reject H0
BNY Mellon	47	76	Correct Exceedances	14.994	3.841	0	Reject H0
Boeing	47	83	Correct Exceedances	22.389	3.841	0	Reject H0
Booking Holdings	47	87	Correct Exceedances	27.161	3.841	0	Reject H0
Bristol Myers Squibb	47	85	Correct Exceedances	24.727	3.841	0	Reject H0
Capital One	47	77	Correct Exceedances	15.973	3.841	0	Reject H0
Caterpillar	47	79	Correct Exceedances	18.009	3.841	0	Reject H0
Charles Schwab	47	84	Correct Exceedances	23.545	3.841	0	Reject H0
Chevron	47	79	Correct Exceedances	18.009	3.841	0	Reject H0
Cisco	47	76	Correct Exceedances	14.994	3.841	0	Reject H0
Citigroup	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
Coca Cola	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Colgate-Palmolive	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
Comcast	47	74	Correct Exceedances	13.117	3.841	0	Reject H0
ConocoPhillips	47	78	Correct Exceedances	16.978	3.841	0	Reject H0
Costco	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
CSV Health	47	88	Correct Exceedances	28.413	3.841	0	Reject H0
Danaher	47	77	Correct Exceedances	15.973	3.841	0	Reject H0
Disney	47	75	Correct Exceedances	14.042	3.841	0	Reject H0
Duke Energy	47	78	Correct Exceedances	16.978	3.841	0	Reject H0
Emerson	47	75	Correct Exceedances	14.042	3.841	0	Reject H0
Exelon	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
ExxonMobil	47	76	Correct Exceedances	14.994	3.841	0	Reject H0
Fedex	47	92	Correct Exceedances	33.651	3.841	0	Reject H0
Ford	47	82	Correct Exceedances	21.256	3.841	0	Reject H0
General Dynamics	47	70	Correct Exceedances	9.695	3.841	0.002	Reject H0

General Electric	47	87	Correct Exceedances	27.161	3.841	0	Reject H0
Gilead	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Goldman Sachs	47	85	Correct Exceedances	24.727	3.841	0	Reject H0
Home Depot	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Honeywell	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
IBM	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
Intel	47	81	Correct Exceedances	20.149	3.841	0	Reject H0
Johnson	47	79	Correct Exceedances	18.009	3.841	0	Reject H0
JPMorgan Chase	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
Lilly	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Linde	47	83	Correct Exceedances	22.389	3.841	0	Reject H0
Lockheed Martin	47	87	Correct Exceedances	27.161	3.841	0	Reject H0
Lowe's	47	83	Correct Exceedances	22.389	3.841	0	Reject H0
McDonald's	47	81	Correct Exceedances	20.149	3.841	0	Reject H0
Medtronic	47	81	Correct Exceedances	20.149	3.841	0	Reject H0
Merck	47	74	Correct Exceedances	13.117	3.841	0	Reject H0
Metlife	47	75	Correct Exceedances	14.042	3.841	0	Reject H0
Microsoft	47	86	Correct Exceedances	25.932	3.841	0	Reject H0
Mondelēz International	47	77	Correct Exceedances	15.973	3.841	0	Reject H0
Morgan Stanley	47	81	Correct Exceedances	20.149	3.841	0	Reject H0
Netflix	47	82	Correct Exceedances	21.256	3.841	0	Reject H0
NextEra Energy	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
Nike	47	90	Correct Exceedances	30.986	3.841	0	Reject H0
Nvidia	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
Oracle	47	81	Correct Exceedances	20.149	3.841	0	Reject H0
Pepsi	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
Pfizer	47	70	Correct Exceedances	9.695	3.841	0.002	Reject H0
Procter & Gamble	47	76	Correct Exceedances	14.994	3.841	0	Reject H0
Qualcomm	47	78	Correct Exceedances	16.978	3.841	0	Reject H0
Raytheon Technologies	47	82	Correct Exceedances	21.256	3.841	0	Reject H0
Simon	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Southern Company	47	83	Correct Exceedances	22.389	3.841	0	Reject H0
Starbucks	47	82	Correct Exceedances	21.256	3.841	0	Reject H0
Target	47	92	Correct Exceedances	33.651	3.841	0	Reject H0
Texas Instruments	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Thermo Fisher Scientific	47	93	Correct Exceedances	35.016	3.841	0	Reject H0
Union Pacific	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
United Parcel Service	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
UnitedHealth Group	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
US Bancorp	47	84	Correct Exceedances	23.545	3.841	0	Reject H0
Verizon	47	76	Correct Exceedances	14.994	3.841	0	Reject H0
Walgreens Boots Alliance	47	77	Correct Exceedances	15.973	3.841	0	Reject H0
Walmart	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
Wells Fargo	47	91	Correct Exceedances	32.307	3.841	0	Reject H0

Table 2.5: WHS unconditional coverage for a window size of 500 days and $\alpha = 0.01$

Table VI - GARCH(1,1) Normal - Unconditional Coverage

Results for the unconditional coverage test for a GARCH(1,1) model with a window size of 500 days, an alpha of 0.01 assuming a normal distribution.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	107	Correct Exceedances	56.339	3.841	0	Reject H0
Abbott	47	85	Correct Exceedances	24.727	3.841	0	Reject H0
Accenture	47	83	Correct Exceedances	22.389	3.841	0	Reject H0
Adobe	47	93	Correct Exceedances	35.016	3.841	0	Reject H0
Altria	47	116	Correct Exceedances	72.061	3.841	0	Reject H0
Amazon	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
AMD	47	78	Correct Exceedances	16.978	3.841	0	Reject H0
American Express	47	93	Correct Exceedances	35.016	3.841	0	Reject H0
American International Group	47	92	Correct Exceedances	33.651	3.841	0	Reject H0
American Tower	47	84	Correct Exceedances	23.545	3.841	0	Reject H0
Amgen	47	90	Correct Exceedances	30.986	3.841	0	Reject H0
Apple	47	84	Correct Exceedances	23.545	3.841	0	Reject H0
AT&T	47	109	Correct Exceedances	59.704	3.841	0	Reject H0
Bank of America	47	100	Correct Exceedances	45.177	3.841	0	Reject H0
BNY Mellon	47	104	Correct Exceedances	51.437	3.841	0	Reject H0
Berkshire Hathaway	47	74	Correct Exceedances	13.117	3.841	0	Reject H0
BlackRock	47	94	Correct Exceedances	36.404	3.841	0	Reject H0
Boeing	47	96	Correct Exceedances	39.244	3.841	0	Reject H0
Booking Holdings	47	81	Correct Exceedances	20.149	3.841	0	Reject H0
Bristol Myers Squibb	47	84	Correct Exceedances	23.545	3.841	0	Reject H0
Capital One	47	91	Correct Exceedances	32.307	3.841	0	Reject H0
Caterpillar	47	102	Correct Exceedances	48.267	3.841	0	Reject H0
Charles Schwab	47	90	Correct Exceedances	30.986	3.841	0	Reject H0
Chevron	47	111	Correct Exceedances	63.143	3.841	0	Reject H0
Cisco	47	88	Correct Exceedances	28.413	3.841	0	Reject H0
Citigroup	47	113	Correct Exceedances	66.656	3.841	0	Reject H0
Coca Cola	47	90	Correct Exceedances	30.986	3.841	0	Reject H0
Colgate-Palmolive	47	83	Correct Exceedances	22.389	3.841	0	Reject H0
Comcast	47	87	Correct Exceedances	27.161	3.841	0	Reject H0
ConocoPhillips	47	94	Correct Exceedances	36.404	3.841	0	Reject H0
Costco	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
CSV Health	47	82	Correct Exceedances	21.256	3.841	0	Reject H0
Danaher	47	94	Correct Exceedances	36.404	3.841	0	Reject H0
Disney	47	82	Correct Exceedances	21.256	3.841	0	Reject H0
Duke Energy	47	98	Correct Exceedances	42.169	3.841	0	Reject H0
Emerson	47	111	Correct Exceedances	63.143	3.841	0	Reject H0
Exelon	47	86	Correct Exceedances	25.932	3.841	0	Reject H0
ExxonMobil	47	106	Correct Exceedances	54.686	3.841	0	Reject H0
Fedex	47	94	Correct Exceedances	36.404	3.841	0	Reject H0
Ford	47	94	Correct Exceedances	36.404	3.841	0	Reject H0
General Dynamics	47	104	Correct Exceedances	51.437	3.841	0	Reject H0

General Electric	47	81	Correct Exceedances	20.149	3.841	0	Reject H0
Gilead	47	79	Correct Exceedances	18.009	3.841	0	Reject H0
Goldman Sachs	47	97	Correct Exceedances	40.696	3.841	0	Reject H0
Home Depot	47	92	Correct Exceedances	33.651	3.841	0	Reject H0
Honeywell	47	97	Correct Exceedances	40.696	3.841	0	Reject H0
IBM	47	83	Correct Exceedances	22.389	3.841	0	Reject H0
Intel	47	85	Correct Exceedances	24.727	3.841	0	Reject H0
Johnson	47	98	Correct Exceedances	42.169	3.841	0	Reject H0
JPMorgan Chase	47	87	Correct Exceedances	27.161	3.841	0	Reject H0
Linde	47	104	Correct Exceedances	51.437	3.841	0	Reject H0
Lilly	47	89	Correct Exceedances	29.688	3.841	0	Reject H0
Lockheed Martin	47	100	Correct Exceedances	45.177	3.841	0	Reject H0
Lowe's	47	86	Correct Exceedances	25.932	3.841	0	Reject H0
McDonald's	47	79	Correct Exceedances	18.009	3.841	0	Reject H0
Medtronic	47	93	Correct Exceedances	35.016	3.841	0	Reject H0
Metlife	47	104	Correct Exceedances	51.437	3.841	0	Reject H0
Merck	47	93	Correct Exceedances	35.016	3.841	0	Reject H0
Microsoft	47	93	Correct Exceedances	35.016	3.841	0	Reject H0
Mondelēz International	47	94	Correct Exceedances	36.404	3.841	0	Reject H0
Morgan Stanley	47	93	Correct Exceedances	35.016	3.841	0	Reject H0
Netflix	47	74	Correct Exceedances	13.117	3.841	0	Reject H0
NextEra Energy	47	86	Correct Exceedances	25.932	3.841	0	Reject H0
Nike	47	81	Correct Exceedances	20.149	3.841	0	Reject H0
Nvidia	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
Oracle	47	88	Correct Exceedances	28.413	3.841	0	Reject H0
Pepsi	47	97	Correct Exceedances	40.696	3.841	0	Reject H0
Pfizer	47	76	Correct Exceedances	14.994	3.841	0	Reject H0
Procter & Gamble	47	102	Correct Exceedances	48.267	3.841	0	Reject H0
Qualcomm	47	89	Correct Exceedances	29.688	3.841	0	Reject H0
Raytheon Technologies	47	97	Correct Exceedances	40.696	3.841	0	Reject H0
Simon	47	86	Correct Exceedances	25.932	3.841	0	Reject H0
Southern Company	47	100	Correct Exceedances	45.177	3.841	0	Reject H0
Starbucks	47	90	Correct Exceedances	30.986	3.841	0	Reject H0
Target	47	94	Correct Exceedances	36.404	3.841	0	Reject H0
Texas Instruments	47	79	Correct Exceedances	18.009	3.841	0	Reject H0
Thermo Fisher Scientific	47	87	Correct Exceedances	27.161	3.841	0	Reject H0
Union Pacific	47	96	Correct Exceedances	39.244	3.841	0	Reject H0
United Parcel Service	47	78	Correct Exceedances	16.978	3.841	0	Reject H0
UnitedHealth Group	47	83	Correct Exceedances	22.389	3.841	0	Reject H0
US Bancorp	47	95	Correct Exceedances	37.813	3.841	0	Reject H0
Verizon	47	92	Correct Exceedances	33.651	3.841	0	Reject H0
Walgreens Boots Alliance	47	91	Correct Exceedances	32.307	3.841	0	Reject H0
Walmart	47	80	Correct Exceedances	19.066	3.841	0	Reject H0
Wells Fargo	47	95	Correct Exceedances	37.813	3.841	0	Reject H0

Table 2.6: GARCH(1,1) unconditional coverage for normal distribution, a window size of 500 days and a $\alpha = 0.01$

Table VII - GARCH(1,1) t-student - Unconditional Coverage

Results for the unconditional coverage test for a GARCH(1,1) model with a window size of 500 days, an alpha of 0.01 assuming a t-student distribution.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Abbott	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Accenture	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Adobe	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Altria	47	78	Correct Exceedances	16.978	3.841	0	Reject H0
Amazon	47	49	Correct Exceedances	0.069	3.841	0.792	Fail to Reject H0
AMD	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
American Express	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
American International Group	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
American Tower	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Amgen	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Apple	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
AT&T	47	75	Correct Exceedances	14.042	3.841	0	Reject H0
Bank of America	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Berkshire Hathaway	47	42	Correct Exceedances	0.599	3.841	0.439	Fail to Reject H0
BlackRock	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
BNY Mellon	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Boeing	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Booking Holdings	47	49	Correct Exceedances	0.069	3.841	0.792	Fail to Reject H0
Bristol Myers Squibb	47	53	Correct Exceedances	0.695	3.841	0.405	Fail to Reject H0
Capital One	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Caterpillar	47	76	Correct Exceedances	14.994	3.841	0	Reject H0
Charles Schwab	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Chevron	47	82	Correct Exceedances	21.256	3.841	0	Reject H0
Cisco	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Citigroup	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Coca Cola	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Colgate-Palmolive	47	53	Correct Exceedances	0.695	3.841	0.405	Fail to Reject H0
Comcast	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
ConocoPhillips	47	70	Correct Exceedances	9.695	3.841	0.002	Reject H0
Costco	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
CSV Health	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Danaher	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
Disney	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Duke Energy	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
Emerson	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
Exelon	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
ExxonMobil	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Fedex	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Ford	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
General Dynamics	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0

General Electric	47	51	Correct Exceedances	0.303	3.841	0.582	Fail to Reject H0
Gilead	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Goldman Sachs	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Home Depot	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Honeywell	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
IBM	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Intel	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Johnson	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
JPMorgan Chase	47	49	Correct Exceedances	0.069	3.841	0.792	Fail to Reject H0
Lilly	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Linde	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Lockheed Martin	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Lowe's	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
McDonald's	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Medtronic	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Merck	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Metlife	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Microsoft	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Mondelēz International	47	48	Correct Exceedances	0.014	3.841	0.906	Fail to Reject H0
Morgan Stanley	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Netflix	47	49	Correct Exceedances	0.069	3.841	0.792	Fail to Reject H0
NextEra Energy	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Nike	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Nvidia	47	51	Correct Exceedances	0.303	3.841	0.582	Fail to Reject H0
Oracle	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
Pepsi	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Pfizer	47	46	Correct Exceedances	0.031	3.841	0.861	Fail to Reject H0
Procter & Gamble	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Qualcomm	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
Southern Company	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Raytheon Technologies	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Simon	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Starbucks	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Target	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
Texas Instruments	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Thermo Fisher Scientific	47	51	Correct Exceedances	0.303	3.841	0.582	Fail to Reject H0
United Parcel Service	47	50	Correct Exceedances	0.166	3.841	0.684	Fail to Reject H0
UnitedHealth Group	47	51	Correct Exceedances	0.303	3.841	0.582	Fail to Reject H0
Union Pacific	47	74	Correct Exceedances	13.117	3.841	0	Reject H0
US Bancorp	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
Verizon	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Walgreens Boots Alliance	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Walmart	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Wells Fargo	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0

Table 2.7: GARCH(1,1) unconditional coverage for t-student distribution, a window size of 500 days and a $\alpha = 0.01$

Table VIII - GARCH(1,1) skewed t-student - Unconditional Coverage

Results for the unconditional coverage test for a GARCH(1,1) model with a window size of 500 days, an alpha of 0.01 assuming a skewed t-student distribution.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Abbott	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Accenture	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Adobe	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Altria	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
Amazon	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
AMD	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
American Express	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
American International Group	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
American Tower	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Amgen	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Apple	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
AT&T	47	70	Correct Exceedances	9.695	3.841	0.002	Reject H0
Bank of America	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
Berkshire Hathaway	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
BlackRock	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
BNY Mellon	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Boeing	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Booking Holdings	47	51	Correct Exceedances	0.303	3.841	0.582	Fail to Reject H0
Bristol Myers Squibb	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Capital One	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Caterpillar	47	76	Correct Exceedances	14.994	3.841	0	Reject H0
Charles Schwab	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Chevron	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Cisco	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
Citigroup	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
Coca Cola	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Colgate-Palmolive	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Comcast	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
ConocoPhillips	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
Costco	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
CSV Health	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Danaher	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Disney	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Duke Energy	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
Emerson	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
Exelon	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
ExxonMobil	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Fedex	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Ford	47	70	Correct Exceedances	9.695	3.841	0.002	Reject H0
General Dynamics	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0

General Electric	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Gilead	47	49	Correct Exceedances	0.069	3.841	0.792	Fail to Reject H0
Goldman Sachs	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Home Depot	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Honeywell	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Intel	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
IBM	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Johnson	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
JPMorgan Chase	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Lilly	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Linde	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
Lockheed Martin	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Lowe's	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
McDonald's	47	53	Correct Exceedances	0.695	3.841	0.405	Fail to Reject H0
Medtronic	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Merck	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Metlife	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Microsoft	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Mondelēz International	47	51	Correct Exceedances	0.303	3.841	0.582	Fail to Reject H0
Morgan Stanley	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Netflix	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
NextEra Energy	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Nike	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Nvidia	47	47	Correct Exceedances	0.001	3.841	0.978	Fail to Reject H0
Oracle	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
Pepsi	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
Pfizer	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Procter & Gamble	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Qualcomm	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Raytheon Technologies	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Simon	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Southern Company	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Starbucks	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Target	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Texas Instruments	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Thermo Fisher Scientific	47	53	Correct Exceedances	0.695	3.841	0.405	Fail to Reject H0
Union Pacific	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
United Parcel Service	47	48	Correct Exceedances	0.014	3.841	0.906	Fail to Reject H0
UnitedHealth Group	47	51	Correct Exceedances	0.303	3.841	0.582	Fail to Reject H0
US Bancorp	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Verizon	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
Walgreens Boots Alliance	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Walmart	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Wells Fargo	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0

Table 2.8: GARCH(1,1) unconditional coverage for a skewed t-student distribution, a window size of 500 days and a $\alpha = 0.01$

Table IX - GARCH(1,1) GED - Unconditional Coverage

Results for the unconditional coverage test for a GARCH(1,1) model with a window size of 500 days, an alpha of 0.01 assuming a generalised error distribution.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Abbott	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Accenture	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Adobe	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Altria	47	81	Correct Exceedances	20.149	3.841	0	Reject H0
Amazon	47	42	Correct Exceedances	0.599	3.841	0.439	Fail to Reject H0
AMD	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
American Express	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
American International Group	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
American Tower	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Amgen	47	48	Correct Exceedances	0.014	3.841	0.906	Fail to Reject H0
Apple	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
AT&T	47	78	Correct Exceedances	16.978	3.841	0	Reject H0
Bank of America	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Berkshire Hathaway	47	41	Correct Exceedances	0.858	3.841	0.354	Fail to Reject H0
BlackRock	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
BNY Mellon	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Boeing	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Booking Holdings	47	48	Correct Exceedances	0.014	3.841	0.906	Fail to Reject H0
Bristol Myers Squibb	47	50	Correct Exceedances	0.166	3.841	0.684	Fail to Reject H0
Capital One	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Caterpillar	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
Charles Schwab	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Chevron	47	82	Correct Exceedances	21.256	3.841	0	Reject H0
Cisco	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
Citigroup	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
Coca Cola	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Colgate-Palmolive	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
Comcast	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
ConocoPhillips	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
Costco	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
CVS	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Danaher	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Disney	47	53	Correct Exceedances	0.695	3.841	0.405	Fail to Reject H0
Duke Energy	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Emerson	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
Exelon	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
ExxonMobil	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Fedex	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Ford	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
General Dynamics	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0

General Electric	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Gilead	47	50	Correct Exceedances	0.166	3.841	0.684	Fail to Reject H0
Goldman Sachs	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Home Depot	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Honeywell	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
IBM	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Intel	47	50	Correct Exceedances	0.166	3.841	0.684	Fail to Reject H0
Johnson	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
JPMorgan Chase	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Lilly	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Linde	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Lockheed Martin	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
Lowe's	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
McDonald's	47	53	Correct Exceedances	0.695	3.841	0.405	Fail to Reject H0
Medtronic	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Merck	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Metlife	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Microsoft	47	48	Correct Exceedances	0.014	3.841	0.906	Fail to Reject H0
Mondelēz International	47	51	Correct Exceedances	0.303	3.841	0.582	Fail to Reject H0
Morgan Stanley	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Netflix	47	41	Correct Exceedances	0.858	3.841	0.354	Fail to Reject H0
NextEra Energy	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
Nike	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Nvidia	47	47	Correct Exceedances	0.001	3.841	0.978	Fail to Reject H0
Oracle	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
Pepsi	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Pfizer	47	48	Correct Exceedances	0.014	3.841	0.906	Fail to Reject H0
Procter & Gamble	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Qualcomm	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Raytheon Technologies	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Simon	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Southern Company	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Starbucks	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Target	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Texas Instruments	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Thermo Fisher Scientific	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Union Pacific	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
United Parcel Service	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
UnitedHealth Group	47	49	Correct Exceedances	0.069	3.841	0.792	Fail to Reject H0
US Bancorp	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Verizon	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Walgreens Boots Alliance	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Walmart	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Wells Fargo	47	53	Correct Exceedances	0.695	3.841	0.405	Fail to Reject H0

Table 2.9: GARCH(1,1) unconditional coverage for a GED distribution, a window size of 500 days and a $\alpha = 0.01$

Table X - FHS GED - Unconditional Coverage

Results for the unconditional coverage test for a GARCH(1,1) model with a window size of 500 days, an alpha of 0.01 assuming a generalised error distribution.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Abbott	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
Accenture	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Adobe	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Altria	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Amazon	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
AMD	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
American Express	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
American International Group	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
American Tower	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Amgen	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Apple	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
AT&T	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Bank of America	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
Berkshire Hathaway	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
BlackRock	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
BNY Mellon	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Boeing	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Booking Holdings	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
Bristol Myers Squibb	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
Capital One	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
Caterpillar	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Charles Schwab	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Chevron	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Citigroup	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
Cisco	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Coca Cola	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Colgate-Palmolive	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Comcast	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
ConocoPhillips	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Costco	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
CSV Health	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Danaher	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Disney	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Duke Energy	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Emerson	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Exelon	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
ExxonMobil	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
Fedex	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Ford	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
General Dynamics	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0

General Electric	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Gilead	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Goldman Sachs	47	67	Correct Exceedances	7.433	3.841	0.006	Reject H0
Home Depot	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Honeywell	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
IBM	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Intel	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Johnson	47	47	Correct Exceedances	0.001	3.841	0.978	Fail to Reject H0
JPMorgan Chase	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Lilly	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Linde	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Lockheed Martin	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Lowe's	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
McDonald's	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Medtronic	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Merck	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Metlife	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Microsoft	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Mondelēz International	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
Morgan Stanley	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Netflix	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
NextEra Energy	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
Nike	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Nvidia	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
Oracle	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Pepsi	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Pfizer	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Procter & Gamble	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Qualcomm	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Raytheon Technologies	47	53	Correct Exceedances	0.695	3.841	0.405	Fail to Reject H0
Simon	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Southern Company	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Starbucks	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
Target	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Texas Instruments	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
Thermo Fisher Scientific	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Union Pacific	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
United Parcel Service	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
UnitedHealth Group	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
US Bancorp	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Verizon	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Walgreens Boots Alliance	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Walmart	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Wells Fargo	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0

Table 2.10: FHS unconditional coverage for GED distribution, a window size of 500 days and a $\alpha = 0.01$

Table XI - GARCHX(1,1) GED - Unconditional Coverage

Results for the unconditional coverage test for a GARCH(1,1) model with a window size of 500 days, an alpha of 0.01 assuming a generalised error distribution.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
Abbott	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Accenture	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Adobe	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Altria	47	82	Correct Exceedances	21.256	3.841	0	Reject H0
Amazon	47	44	Correct Exceedances	0.223	3.841	0.637	Fail to Reject H0
AMD	47	45	Correct Exceedances	0.104	3.841	0.747	Fail to Reject H0
American Express	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
American International Group	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
American Tower	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Amgen	47	48	Correct Exceedances	0.014	3.841	0.906	Fail to Reject H0
Apple	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
AT&T	47	77	Correct Exceedances	15.973	3.841	0	Reject H0
Bank of America	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Berkshire Hathaway	47	39	Correct Exceedances	1.526	3.841	0.217	Fail to Reject H0
BNY Mellon	47	55	Correct Exceedances	1.24	3.841	0.266	Fail to Reject H0
Boeing	47	64	Correct Exceedances	5.442	3.841	0.02	Reject H0
Booking Holdings	47	49	Correct Exceedances	0.069	3.841	0.792	Fail to Reject H0
Bristol Myers Squibb	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Capital One	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Caterpillar	47	76	Correct Exceedances	14.994	3.841	0	Reject H0
Charles Schwab	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
Chevron	47	83	Correct Exceedances	22.389	3.841	0	Reject H0
Cisco	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Citigroup	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Coca Cola	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Colgate-Palmolive	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Comcast	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
ConocoPhillips	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Costco	47	50	Correct Exceedances	0.166	3.841	0.684	Fail to Reject H0
CSV Health	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Danaher	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
Disney	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Duke Energy	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Emerson	47	71	Correct Exceedances	10.508	3.841	0.001	Reject H0
Exelon	47	70	Correct Exceedances	9.695	3.841	0.002	Reject H0
ExxonMobil	47	74	Correct Exceedances	13.117	3.841	0	Reject H0
Fedex	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Ford	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
General Dynamics	47	65	Correct Exceedances	6.075	3.841	0.014	Reject H0
General Electric	47	51	Correct Exceedances	0.303	3.841	0.582	Fail to Reject H0

Gilead	47	49	Correct Exceedances	0.069	3.841	0.792	Fail to Reject H0
Goldman Sachs	47	61	Correct Exceedances	3.737	3.841	0.053	Fail to Reject H0
Home Depot	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Honeywell	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
IBM	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Intel	47	50	Correct Exceedances	0.166	3.841	0.684	Fail to Reject H0
Johnson	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
JPMorgan Chase	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Lilly	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Linde	47	73	Correct Exceedances	12.219	3.841	0	Reject H0
Lockheed Martin	47	66	Correct Exceedances	6.738	3.841	0.009	Reject H0
Lowe's	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
McDonald's	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Medtronic	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
Merck	47	74	Correct Exceedances	13.117	3.841	0	Reject H0
Metlife	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Microsoft	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Mondelēz International	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
Morgan Stanley	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Netflix	47	39	Correct Exceedances	1.526	3.841	0.217	Fail to Reject H0
NextEra Energy	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
Nike	47	54	Correct Exceedances	0.949	3.841	0.33	Fail to Reject H0
Oracle	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Pepsi	47	62	Correct Exceedances	4.273	3.841	0.039	Reject H0
Pfizer	47	48	Correct Exceedances	0.014	3.841	0.906	Fail to Reject H0
Procter & Gamble	47	60	Correct Exceedances	3.235	3.841	0.072	Fail to Reject H0
Qualcomm	47	63	Correct Exceedances	4.842	3.841	0.028	Reject H0
Raytheon Technologies	47	58	Correct Exceedances	2.331	3.841	0.127	Fail to Reject H0
Simon	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Southern Company	47	70	Correct Exceedances	9.695	3.841	0.002	Reject H0
Starbucks	47	59	Correct Exceedances	2.766	3.841	0.096	Fail to Reject H0
Target	47	57	Correct Exceedances	1.932	3.841	0.165	Fail to Reject H0
Thermo Fisher Scientific	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Union Pacific	47	69	Correct Exceedances	8.912	3.841	0.003	Reject H0
United Parcel Service	47	53	Correct Exceedances	0.695	3.841	0.405	Fail to Reject H0
UnitedHealth Group	47	50	Correct Exceedances	0.166	3.841	0.684	Fail to Reject H0
US Bancorp	47	72	Correct Exceedances	11.35	3.841	0.001	Reject H0
Verizon	47	68	Correct Exceedances	8.157	3.841	0.004	Reject H0
Walgreens Boots Alliance	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0
Walmart	47	56	Correct Exceedances	1.568	3.841	0.211	Fail to Reject H0
Wells Fargo	47	52	Correct Exceedances	0.479	3.841	0.489	Fail to Reject H0

Table 2.11: GARCH unconditional coverage w/ added dummy for GED distribution, a window size of 500 days and a $\alpha = 0.01$

Table XII - Historical Simulation - Conditional Coverage

Results for the conditional coverage test for an Historical Simulation model with a window size of 500 days, an alpha of 0.01.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	66	Correct Exceedances & Independent	12.611	5.991	0.002	Reject H0
Abbott	47	71	Correct Exceedances & Independent	34.888	5.991	0	Reject H0
Accenture	47	82	Correct Exceedances & Independent	29.89	5.991	0	Reject H0
Adobe	47	71	Correct Exceedances & Independent	22.069	5.991	0	Reject H0
Altria	47	68	Correct Exceedances & Independent	13.647	5.991	0.001	Reject H0
Amazon	47	67	Correct Exceedances & Independent	16.438	5.991	0	Reject H0
AMD	47	68	Correct Exceedances & Independent	10.954	5.991	0.004	Reject H0
American Express	47	87	Correct Exceedances & Independent	29.815	5.991	0	Reject H0
American International Group	47	77	Correct Exceedances & Independent	37.577	5.991	0	Reject H0
American Tower	47	69	Correct Exceedances & Independent	11.586	5.991	0.003	Reject H0
Amgen	47	64	Correct Exceedances & Independent	11.718	5.991	0.003	Reject H0
Apple	47	67	Correct Exceedances & Independent	13.112	5.991	0.001	Reject H0
AT&T	47	67	Correct Exceedances & Independent	8.341	5.991	0.015	Reject H0
Bank of America	47	95	Correct Exceedances & Independent	56.18	5.991	0	Reject H0
Berkshire Hathaway	47	74	Correct Exceedances & Independent	40.765	5.991	0	Reject H0
BlackRock	47	85	Correct Exceedances & Independent	39.281	5.991	0	Reject H0
BNY Mellon	47	78	Correct Exceedances & Independent	30.119	5.991	0	Reject H0
Boeing	47	80	Correct Exceedances & Independent	31.59	5.991	0	Reject H0
Booking Holdings	47	67	Correct Exceedances & Independent	8.341	5.991	0.015	Reject H0
Bristol Myers Squibb	47	60	Correct Exceedances & Independent	4.667	5.991	0.097	Fail to Reject H0
Capital One	47	81	Correct Exceedances & Independent	26.062	5.991	0	Reject H0
Caterpillar	47	69	Correct Exceedances & Independent	9.695	5.991	0.008	Reject H0
Charles Schwab	47	81	Correct Exceedances & Independent	32.373	5.991	0	Reject H0
Chevron	47	80	Correct Exceedances & Independent	28.185	5.991	0	Reject H0
Cisco	47	72	Correct Exceedances & Independent	16.127	5.991	0	Reject H0
Citigroup	47	92	Correct Exceedances & Independent	40.129	5.991	0	Reject H0
Coca Cola	47	70	Correct Exceedances & Independent	29.904	5.991	0	Reject H0
Colgate-Palmolive	47	68	Correct Exceedances & Independent	29.246	5.991	0	Reject H0
Comcast	47	70	Correct Exceedances & Independent	11.804	5.991	0.003	Reject H0
ConocoPhillips	47	90	Correct Exceedances & Independent	55.327	5.991	0	Reject H0
Costco	47	69	Correct Exceedances & Independent	11.586	5.991	0.003	Reject H0
CSV Health	47	74	Correct Exceedances & Independent	17.563	5.991	0	Reject H0
Danaher	47	77	Correct Exceedances & Independent	19.951	5.991	0	Reject H0
Disney	47	73	Correct Exceedances & Independent	23.199	5.991	0	Reject H0
Duke Energy	47	76	Correct Exceedances & Independent	46.441	5.991	0	Reject H0
Emerson	47	79	Correct Exceedances & Independent	24.308	5.991	0	Reject H0
Exelon	47	80	Correct Exceedances & Independent	28.185	5.991	0	Reject H0
ExxonMobil	47	79	Correct Exceedances & Independent	30.839	5.991	0	Reject H0
Fedex	47	72	Correct Exceedances & Independent	19.14	5.991	0	Reject H0
Ford	47	76	Correct Exceedances & Independent	19.124	5.991	0	Reject H0
General Dynamics	47	71	Correct Exceedances & Independent	15.457	5.991	0	Reject H0

General Electric	47	78	Correct Exceedances & Independent	30.119	5.991	0	Reject H0
Gilead	47	61	Correct Exceedances & Independent	5.335	5.991	0.069	Fail to Reject H0
Goldman Sachs	47	94	Correct Exceedances & Independent	48.223	5.991	0	Reject H0
Home Depot	47	62	Correct Exceedances & Independent	10.972	5.991	0.004	Reject H0
Honeywell	47	70	Correct Exceedances & Independent	21.557	5.991	0	Reject H0
IBM	47	72	Correct Exceedances & Independent	19.14	5.991	0	Reject H0
Intel	47	64	Correct Exceedances & Independent	8.765	5.991	0.012	Reject H0
Johnson	47	69	Correct Exceedances & Independent	34.287	5.991	0	Reject H0
JPMorgan Chase	47	85	Correct Exceedances & Independent	47.113	5.991	0	Reject H0
Lilly	47	56	Correct Exceedances & Independent	13.778	5.991	0.001	Reject H0
Linde	47	80	Correct Exceedances & Independent	86.518	5.991	0	Reject H0
Lockheed Martin	47	69	Correct Exceedances & Independent	14.217	5.991	0.001	Reject H0
Lowe's	47	69	Correct Exceedances & Independent	11.586	5.991	0.003	Reject H0
McDonald's	47	60	Correct Exceedances & Independent	10.377	5.991	0.006	Reject H0
Medtronic	47	77	Correct Exceedances & Independent	25.857	5.991	0	Reject H0
Merck	47	60	Correct Exceedances & Independent	18.657	5.991	0	Reject H0
Metlife	47	63	Correct Exceedances & Independent	18.986	5.991	0	Reject H0
Microsoft	47	73	Correct Exceedances & Independent	16.829	5.991	0	Reject H0
Mondelēz International	47	75	Correct Exceedances & Independent	24.463	5.991	0	Reject H0
Morgan Stanley	47	84	Correct Exceedances & Independent	55.335	5.991	0	Reject H0
Netflix	47	64	Correct Exceedances & Independent	15.244	5.991	0	Reject H0
NextEra Energy	47	84	Correct Exceedances & Independent	42.263	5.991	0	Reject H0
Nike	47	80	Correct Exceedances & Independent	28.185	5.991	0	Reject H0
Nvidia	47	63	Correct Exceedances & Independent	6.032	5.991	0.049	Reject H0
Oracle	47	73	Correct Exceedances & Independent	23.199	5.991	0	Reject H0
Pepsi	47	72	Correct Exceedances & Independent	22.617	5.991	0	Reject H0
Pfizer	47	63	Correct Exceedances & Independent	11.326	5.991	0.003	Reject H0
Procter & Gamble	47	67	Correct Exceedances & Independent	13.112	5.991	0.001	Reject H0
Qualcomm	47	66	Correct Exceedances & Independent	12.611	5.991	0.002	Reject H0
Raytheon Technologies	47	76	Correct Exceedances & Independent	25.144	5.991	0	Reject H0
Simon	47	72	Correct Exceedances & Independent	22.617	5.991	0	Reject H0
Southern Company	47	72	Correct Exceedances & Independent	35.246	5.991	0	Reject H0
Starbucks	47	69	Correct Exceedances & Independent	14.217	5.991	0.001	Reject H0
Target	47	78	Correct Exceedances & Independent	17.326	5.991	0	Reject H0
Texas Instruments	47	59	Correct Exceedances & Independent	4.286	5.991	0.117	Fail to Reject H0
Thermo Fisher Scientific	47	73	Correct Exceedances & Independent	19.783	5.991	0	Reject H0
Union Pacific	47	80	Correct Exceedances & Independent	25.17	5.991	0	Reject H0
United Parcel Service	47	75	Correct Exceedances & Independent	21.165	5.991	0	Reject H0
UnitedHealth Group	47	67	Correct Exceedances & Independent	24.426	5.991	0	Reject H0
US Bancorp	47	89	Correct Exceedances & Independent	32.117	5.991	0	Reject H0
Verizon	47	66	Correct Exceedances & Independent	12.611	5.991	0.002	Reject H0
Walgreens Boots Alliance	47	74	Correct Exceedances & Independent	23.814	5.991	0	Reject H0
Walmart	47	64	Correct Exceedances & Independent	19.24	5.991	0	Reject H0
Wells Fargo	47	89	Correct Exceedances & Independent	39.703	5.991	0	Reject H0

Table 2.12: HS conditional coverage for a window size of 500 days and $\alpha = 0.01$

Table XIII - Weighted Historical Simulation - Conditional Coverage

Results for the conditional coverage test for an Weighted Historical Simulation model with a window size of 500 days, an alpha of 0.01.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	80	Correct Exceedances & Independent	19.173	5.991	0	Reject H0
Abbott	47	77	Correct Exceedances & Independent	22.675	5.991	0	Reject H0
Accenture	47	81	Correct Exceedances & Independent	23.557	5.991	0	Reject H0
Adobe	47	74	Correct Exceedances & Independent	17.563	5.991	0	Reject H0
Altria	47	70	Correct Exceedances & Independent	9.697	5.991	0.008	Reject H0
Amazon	47	80	Correct Exceedances & Independent	22.611	5.991	0	Reject H0
AMD	47	80	Correct Exceedances & Independent	20.611	5.991	0	Reject H0
American Express	47	85	Correct Exceedances & Independent	27.619	5.991	0	Reject H0
American International Group	47	78	Correct Exceedances & Independent	20.808	5.991	0	Reject H0
American Tower	47	73	Correct Exceedances & Independent	12.235	5.991	0.002	Reject H0
Amgen	47	73	Correct Exceedances & Independent	16.829	5.991	0	Reject H0
Apple	47	79	Correct Exceedances & Independent	19.641	5.991	0	Reject H0
AT&T	47	78	Correct Exceedances & Independent	17.051	5.991	0	Reject H0
Bank of America	47	82	Correct Exceedances & Independent	26.983	5.991	0	Reject H0
Berkshire Hathaway	47	77	Correct Exceedances & Independent	16.359	5.991	0	Reject H0
BlackRock	47	85	Correct Exceedances & Independent	24.863	5.991	0	Reject H0
BNY Mellon	47	76	Correct Exceedances & Independent	19.124	5.991	0	Reject H0
Boeing	47	83	Correct Exceedances & Independent	23.688	5.991	0	Reject H0
Booking Holdings	47	87	Correct Exceedances & Independent	29.815	5.991	0	Reject H0
Bristol Myers Squibb	47	85	Correct Exceedances & Independent	25.877	5.991	0	Reject H0
Capital One	47	77	Correct Exceedances & Independent	17.788	5.991	0	Reject H0
Caterpillar	47	79	Correct Exceedances & Independent	18.32	5.991	0	Reject H0
Charles Schwab	47	84	Correct Exceedances & Independent	28.911	5.991	0	Reject H0
Chevron	47	79	Correct Exceedances & Independent	18.32	5.991	0	Reject H0
Cisco	47	76	Correct Exceedances & Independent	25.144	5.991	0	Reject H0
Citigroup	47	80	Correct Exceedances & Independent	28.185	5.991	0	Reject H0
Coca Cola	47	71	Correct Exceedances & Independent	11.178	5.991	0.004	Reject H0
Colgate-Palmolive	47	73	Correct Exceedances & Independent	16.829	5.991	0	Reject H0
Comcast	47	74	Correct Exceedances & Independent	15.475	5.991	0	Reject H0
ConocoPhillips	47	78	Correct Exceedances & Independent	26.602	5.991	0	Reject H0
Costco	47	80	Correct Exceedances & Independent	22.611	5.991	0	Reject H0
CSV Health	47	88	Correct Exceedances & Independent	29.357	5.991	0	Reject H0
Danaher	47	77	Correct Exceedances & Independent	16.359	5.991	0	Reject H0
Disney	47	75	Correct Exceedances & Independent	14.076	5.991	0.001	Reject H0
Duke Energy	47	78	Correct Exceedances & Independent	18.7	5.991	0	Reject H0
Emerson	47	75	Correct Exceedances & Independent	21.165	5.991	0	Reject H0
Exelon	47	66	Correct Exceedances & Independent	16.003	5.991	0	Reject H0
ExxonMobil	47	76	Correct Exceedances & Independent	15.039	5.991	0.001	Reject H0
Fedex	47	92	Correct Exceedances & Independent	37.722	5.991	0	Reject H0
Ford	47	82	Correct Exceedances & Independent	21.402	5.991	0	Reject H0
General Dynamics	47	70	Correct Exceedances & Independent	11.804	5.991	0.003	Reject H0

General Electric	47	87	Correct Exceedances & Independent	34.663	5.991	0	Reject H0
Gilead	47	68	Correct Exceedances & Independent	8.158	5.991	0.017	Reject H0
Goldman Sachs	47	85	Correct Exceedances & Independent	29.917	5.991	0	Reject H0
Home Depot	47	71	Correct Exceedances & Independent	11.178	5.991	0.004	Reject H0
Honeywell	47	80	Correct Exceedances & Independent	20.611	5.991	0	Reject H0
IBM	47	80	Correct Exceedances & Independent	19.173	5.991	0	Reject H0
Intel	47	81	Correct Exceedances & Independent	20.393	5.991	0	Reject H0
Johnson	47	79	Correct Exceedances & Independent	18.098	5.991	0	Reject H0
JPMorgan Chase	47	80	Correct Exceedances & Independent	31.59	5.991	0	Reject H0
Lilly	47	71	Correct Exceedances & Independent	11.178	5.991	0.004	Reject H0
Linde	47	83	Correct Exceedances & Independent	41.497	5.991	0	Reject H0
Lockheed Martin	47	87	Correct Exceedances & Independent	29.815	5.991	0	Reject H0
Lowe's	47	83	Correct Exceedances & Independent	25.532	5.991	0	Reject H0
McDonald's	47	81	Correct Exceedances & Independent	23.557	5.991	0	Reject H0
Medtronic	47	81	Correct Exceedances & Independent	20.393	5.991	0	Reject H0
Merck	47	74	Correct Exceedances & Independent	17.563	5.991	0	Reject H0
Metlife	47	75	Correct Exceedances & Independent	16.053	5.991	0	Reject H0
Microsoft	47	86	Correct Exceedances & Independent	26.046	5.991	0	Reject H0
Mondelēz International	47	77	Correct Exceedances & Independent	17.788	5.991	0	Reject H0
Morgan Stanley	47	81	Correct Exceedances & Independent	23.557	5.991	0	Reject H0
Netflix	47	82	Correct Exceedances & Independent	22.635	5.991	0	Reject H0
NextEra Energy	47	80	Correct Exceedances & Independent	22.611	5.991	0	Reject H0
Nike	47	90	Correct Exceedances & Independent	37.862	5.991	0	Reject H0
Nvidia	47	80	Correct Exceedances & Independent	19.173	5.991	0	Reject H0
Oracle	47	81	Correct Exceedances & Independent	20.393	5.991	0	Reject H0
Pepsi	47	80	Correct Exceedances & Independent	19.343	5.991	0	Reject H0
Pfizer	47	70	Correct Exceedances & Independent	25.555	5.991	0	Reject H0
Procter & Gamble	47	76	Correct Exceedances & Independent	15.422	5.991	0	Reject H0
Qualcomm	47	78	Correct Exceedances & Independent	17.326	5.991	0	Reject H0
Raytheon Technologies	47	82	Correct Exceedances & Independent	26.983	5.991	0	Reject H0
Simon	47	71	Correct Exceedances & Independent	12.948	5.991	0.002	Reject H0
Southern Company	47	83	Correct Exceedances & Independent	22.574	5.991	0	Reject H0
Starbucks	47	82	Correct Exceedances & Independent	22.635	5.991	0	Reject H0
Target	47	92	Correct Exceedances & Independent	35.763	5.991	0	Reject H0
Texas Instruments	47	72	Correct Exceedances & Independent	13.581	5.991	0.001	Reject H0
Thermo Fisher Scientific	47	93	Correct Exceedances & Independent	37.029	5.991	0	Reject H0
Union Pacific	47	73	Correct Exceedances & Independent	12.235	5.991	0.002	Reject H0
United Parcel Service	47	71	Correct Exceedances & Independent	12.678	5.991	0.002	Reject H0
UnitedHealth Group	47	69	Correct Exceedances & Independent	9.695	5.991	0.008	Reject H0
US Bancorp	47	84	Correct Exceedances & Independent	23.705	5.991	0	Reject H0
Verizon	47	76	Correct Exceedances & Independent	15.422	5.991	0	Reject H0
Walgreens Boots Alliance	47	77	Correct Exceedances & Independent	16.359	5.991	0	Reject H0
Walmart	47	73	Correct Exceedances & Independent	12.235	5.991	0.002	Reject H0
Wells Fargo	47	91	Correct Exceedances & Independent	33.069	5.991	0	Reject H0

Table 2.13: WHS conditional coverage for a window size of 500 days and $\alpha = 0.01$

Table XIV - GARCH(1,1) Normal - Conditional Coverage

Results for the conditional coverage test for a GARCH(1,1) model with a window size of 500 days, an alpha of 0.01 assuming a normal distribution.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	107	Correct Exceedances & Independent	60.306	5.991	0	Reject H0
Abbott	47	85	Correct Exceedances & Independent	29.917	5.991	0	Reject H0
Accenture	47	83	Correct Exceedances & Independent	22.557	5.991	0	Reject H0
Adobe	47	93	Correct Exceedances & Independent	37.029	5.991	0	Reject H0
Altria	47	116	Correct Exceedances & Independent	73.462	5.991	0	Reject H0
Amazon	47	72	Correct Exceedances & Independent	11.359	5.991	0.003	Reject H0
AMD	47	78	Correct Exceedances & Independent	17.326	5.991	0	Reject H0
American Express	47	93	Correct Exceedances & Independent	35.668	5.991	0	Reject H0
American International Group	47	92	Correct Exceedances & Independent	49.464	5.991	0	Reject H0
American Tower	47	84	Correct Exceedances & Independent	23.705	5.991	0	Reject H0
Amgen	47	90	Correct Exceedances & Independent	35.359	5.991	0	Reject H0
Apple	47	84	Correct Exceedances & Independent	28.911	5.991	0	Reject H0
AT&T	47	109	Correct Exceedances & Independent	59.823	5.991	0	Reject H0
Bank of America	47	100	Correct Exceedances & Independent	52.642	5.991	0	Reject H0
Berkshire Hathaway	47	74	Correct Exceedances & Independent	15.23	5.991	0	Reject H0
BlackRock	47	94	Correct Exceedances & Independent	37.004	5.991	0	Reject H0
BNY Mellon	47	104	Correct Exceedances & Independent	53.967	5.991	0	Reject H0
Boeing	47	96	Correct Exceedances & Independent	40.975	5.991	0	Reject H0
Booking Holdings	47	81	Correct Exceedances & Independent	21.609	5.991	0	Reject H0
Bristol Myers Squibb	47	84	Correct Exceedances & Independent	24.769	5.991	0	Reject H0
Capital One	47	91	Correct Exceedances & Independent	34.523	5.991	0	Reject H0
Caterpillar	47	102	Correct Exceedances & Independent	49.507	5.991	0	Reject H0
Charles Schwab	47	90	Correct Exceedances & Independent	31.807	5.991	0	Reject H0
Chevron	47	111	Correct Exceedances & Independent	64.968	5.991	0	Reject H0
Cisco	47	88	Correct Exceedances & Independent	28.489	5.991	0	Reject H0
Citigroup	47	113	Correct Exceedances & Independent	76.439	5.991	0	Reject H0
Coca Cola	47	90	Correct Exceedances & Independent	31.807	5.991	0	Reject H0
Colgate-Palmolive	47	83	Correct Exceedances & Independent	27.932	5.991	0	Reject H0
Comcast	47	87	Correct Exceedances & Independent	27.255	5.991	0	Reject H0
ConocoPhillips	47	94	Correct Exceedances & Independent	51.549	5.991	0	Reject H0
Costco	47	72	Correct Exceedances & Independent	11.966	5.991	0.003	Reject H0
CSV Health	47	82	Correct Exceedances & Independent	21.47	5.991	0	Reject H0
Danaher	47	94	Correct Exceedances & Independent	36.413	5.991	0	Reject H0
Disney	47	82	Correct Exceedances & Independent	21.47	5.991	0	Reject H0
Duke Energy	47	98	Correct Exceedances & Independent	43.726	5.991	0	Reject H0
Emerson	47	111	Correct Exceedances & Independent	64.968	5.991	0	Reject H0
Exelon	47	86	Correct Exceedances & Independent	30.951	5.991	0	Reject H0
ExxonMobil	47	106	Correct Exceedances & Independent	55.649	5.991	0	Reject H0
Fedex	47	94	Correct Exceedances & Independent	45.195	5.991	0	Reject H0
Ford	47	94	Correct Exceedances & Independent	37.004	5.991	0	Reject H0
General Dynamics	47	104	Correct Exceedances & Independent	51.646	5.991	0	Reject H0

General Electric	47	81	Correct Exceedances & Independent	20.393	5.991	0	Reject H0
Gilead	47	79	Correct Exceedances & Independent	18.32	5.991	0	Reject H0
Goldman Sachs	47	97	Correct Exceedances & Independent	42.338	5.991	0	Reject H0
Home Depot	47	92	Correct Exceedances & Independent	35.763	5.991	0	Reject H0
Honeywell	47	97	Correct Exceedances & Independent	44.07	5.991	0	Reject H0
IBM	47	83	Correct Exceedances & Independent	22.574	5.991	0	Reject H0
Intel	47	85	Correct Exceedances & Independent	24.944	5.991	0	Reject H0
Johnson	47	98	Correct Exceedances & Independent	42.841	5.991	0	Reject H0
JPMorgan Chase	47	87	Correct Exceedances & Independent	57.327	5.991	0	Reject H0
Lilly	47	89	Correct Exceedances & Independent	30.569	5.991	0	Reject H0
Linde	47	104	Correct Exceedances & Independent	63.553	5.991	0	Reject H0
Lockheed Martin	47	100	Correct Exceedances & Independent	45.184	5.991	0	Reject H0
Lowe's	47	86	Correct Exceedances & Independent	27.011	5.991	0	Reject H0
McDonald's	47	79	Correct Exceedances & Independent	21.695	5.991	0	Reject H0
Medtronic	47	93	Correct Exceedances & Independent	38.941	5.991	0	Reject H0
Metlife	47	104	Correct Exceedances & Independent	52.534	5.991	0	Reject H0
Merck	47	93	Correct Exceedances&Independent	39.014	5.99	0	Reject H0
Microsoft	47	93	Correct Exceedances & Independent	35.032	5.991	0	Reject H0
Mondelēz International	47	94	Correct Exceedances & Independent	38.32	5.991	0	Reject H0
Morgan Stanley	47	93	Correct Exceedances & Independent	38.941	5.991	0	Reject H0
Netflix	47	74	Correct Exceedances & Independent	40.765	5.991	0	Reject H0
NextEra Energy	47	86	Correct Exceedances & Independent	27.011	5.991	0	Reject H0
Nike	47	81	Correct Exceedances & Independent	29.023	5.991	0	Reject H0
Nvidia	47	73	Correct Exceedances & Independent	12.235	5.991	0.002	Reject H0
Oracle	47	88	Correct Exceedances & Independent	30.953	5.991	0	Reject H0
Pepsi	47	97	Correct Exceedances & Independent	41.156	5.991	0	Reject H0
Pfizer	47	76	Correct Exceedances & Independent	25.144	5.991	0	Reject H0
Procter & Gamble	47	102	Correct Exceedances & Independent	49.507	5.991	0	Reject H0
Qualcomm	47	89	Correct Exceedances & Independent	30.569	5.991	0	Reject H0
Raytheon Technologies	47	97	Correct Exceedances & Independent	48.805	5.991	0	Reject H0
Simon	47	86	Correct Exceedances & Independent	28.704	5.991	0	Reject H0
Southern Company	47	100	Correct Exceedances & Independent	45.184	5.991	0	Reject H0
Starbucks	47	90	Correct Exceedances & Independent	33.307	5.991	0	Reject H0
Target	47	94	Correct Exceedances & Independent	38.32	5.991	0	Reject H0
Texas Instruments	47	79	Correct Exceedances & Independent	18.098	5.991	0	Reject H0
Thermo Fisher Scientific	47	87	Correct Exceedances & Independent	28.171	5.991	0	Reject H0
Union Pacific	47	96	Correct Exceedances & Independent	39.748	5.991	0	Reject H0
United Parcel Service	47	78	Correct Exceedances & Independent	18.7	5.991	0	Reject H0
UnitedHealth Group	47	83	Correct Exceedances & Independent	27.932	5.991	0	Reject H0
US Bancorp	47	95	Correct Exceedances & Independent	39.635	5.991	0	Reject H0
Verizon	47	92	Correct Exceedances & Independent	34.084	5.991	0	Reject H0
Walgreens Boots Alliance	47	91	Correct Exceedances & Independent	32.341	5.991	0	Reject H0
Walmart	47	80	Correct Exceedances & Independent	20.611	5.991	0	Reject H0
Wells Fargo	47	95	Correct Exceedances & Independent	39.635	5.991	0	Reject H0

Table 2.14: GARCH(1,1) conditional coverage for normal distribution, a window size of 500 days and a $\alpha = 0.01$

Table XV - GARCH(1,1) t-student - Conditional Coverage

Results for the conditional coverage test for a GARCH(1,1) model with a window size of 500 days, an alpha of 0.01 assuming a t-student distribution.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	66	Correct Exceedances & Independent	8.611	5.991	0.013	Reject H0
Abbott	47	52	Correct Exceedances & Independent	2.705	5.991	0.259	Fail to Reject H0
Accenture	47	56	Correct Exceedances & Independent	1.718	5.991	0.424	Fail to Reject H0
Adobe	47	60	Correct Exceedances & Independent	4.667	5.991	0.097	Fail to Reject H0
Altria	47	78	Correct Exceedances & Independent	17.326	5.991	0	Reject H0
Amazon	47	49	Correct Exceedances & Independent	0.448	5.991	0.799	Fail to Reject H0
AMD	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
American Express	47	61	Correct Exceedances & Independent	5.086	5.991	0.079	Fail to Reject H0
American International Group	47	65	Correct Exceedances & Independent	9.26	5.991	0.01	Reject H0
American Tower	47	57	Correct Exceedances & Independent	2.059	5.991	0.357	Fail to Reject H0
Amgen	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
Apple	47	63	Correct Exceedances & Independent	6.547	5.991	0.038	Reject H0
AT&T	47	75	Correct Exceedances & Independent	16.465	5.991	0	Reject H0
Bank of America	47	55	Correct Exceedances & Independent	5.989	5.991	0.05	Fail to Reject H0
BNY Mellon	47	58	Correct Exceedances & Independent	3.775	5.991	0.151	Fail to Reject H0
Berkshire Hathaway	47	42	Correct Exceedances & Independent	1.333	5.991	0.513	Fail to Reject H0
BlackRock	47	65	Correct Exceedances & Independent	7.891	5.991	0.019	Reject H0
Boeing	47	64	Correct Exceedances & Independent	8.765	5.991	0.012	Reject H0
Booking Holdings	47	49	Correct Exceedances & Independent	1.098	5.991	0.578	Fail to Reject H0
Bristol Myers Squibb	47	53	Correct Exceedances & Independent	0.929	5.991	0.628	Fail to Reject H0
Capital One	47	63	Correct Exceedances & Independent	6.032	5.991	0.049	Reject H0
Caterpillar	47	76	Correct Exceedances & Independent	15.422	5.991	0	Reject H0
Charles Schwab	47	60	Correct Exceedances & Independent	4.667	5.991	0.097	Fail to Reject H0
Chevron	47	82	Correct Exceedances & Independent	22.635	5.991	0	Reject H0
Cisco	47	57	Correct Exceedances & Independent	2.059	5.991	0.357	Fail to Reject H0
Citigroup	47	64	Correct Exceedances & Independent	6.558	5.991	0.038	Reject H0
Coca Cola	47	64	Correct Exceedances & Independent	7.203	5.991	0.027	Reject H0
Colgate-Palmolive	47	53	Correct Exceedances & Independent	5.814	5.991	0.055	Fail to Reject H0
Comcast	47	64	Correct Exceedances & Independent	7.203	5.991	0.027	Reject H0
ConocoPhillips	47	70	Correct Exceedances & Independent	12.251	5.991	0.002	Reject H0
Costco	47	54	Correct Exceedances & Independent	1.153	5.991	0.562	Fail to Reject H0
CSV Health	47	63	Correct Exceedances & Independent	6.032	5.991	0.049	Reject H0
Danaher	47	59	Correct Exceedances & Independent	2.852	5.991	0.24	Fail to Reject H0
Disney	47	55	Correct Exceedances & Independent	2.537	5.991	0.281	Fail to Reject H0
Duke Energy	47	65	Correct Exceedances & Independent	6.087	5.991	0.048	Reject H0
Emerson	47	67	Correct Exceedances & Independent	10.355	5.991	0.006	Reject H0
Exelon	47	71	Correct Exceedances & Independent	15.457	5.991	0	Reject H0
ExxonMobil	47	72	Correct Exceedances & Independent	11.966	5.991	0.003	Reject H0
Fedex	47	62	Correct Exceedances & Independent	5.541	5.991	0.063	Fail to Reject H0
Ford	47	65	Correct Exceedances & Independent	6.087	5.991	0.048	Reject H0
General Dynamics	47	68	Correct Exceedances & Independent	10.146	5.991	0.006	Reject H0

General Electric	47	51	Correct Exceedances & Independent	1.417	5.991	0.492	Fail to Reject H0
Gilead	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
Goldman Sachs	47	62	Correct Exceedances & Independent	5.541	5.991	0.063	Fail to Reject H0
Home Depot	47	56	Correct Exceedances & Independent	3.369	5.991	0.186	Fail to Reject H0
Honeywell	47	65	Correct Exceedances & Independent	7.118	5.991	0.028	Reject H0
IBM	47	58	Correct Exceedances & Independent	3.942	5.991	0.139	Fail to Reject H0
Intel	47	56	Correct Exceedances & Independent	2.913	5.991	0.233	Fail to Reject H0
Johnson	47	62	Correct Exceedances & Independent	4.313	5.991	0.116	Fail to Reject H0
JPMorgan Chase	47	49	Correct Exceedances & Independent	2.655	5.991	0.265	Fail to Reject H0
Lilly	47	56	Correct Exceedances & Independent	1.718	5.991	0.424	Fail to Reject H0
Linde	47	71	Correct Exceedances & Independent	15.457	5.991	0	Reject H0
Lockheed Martin	47	68	Correct Exceedances & Independent	8.158	5.991	0.017	Reject H0
Lowe's	47	61	Correct Exceedances & Independent	3.791	5.991	0.15	Fail to Reject H0
McDonald's	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
Medtronic	47	66	Correct Exceedances & Independent	6.745	5.991	0.034	Reject H0
Metlife	47	64	Correct Exceedances & Independent	6.558	5.991	0.038	Reject H0
Merck	47	62	Correct Exceedances & Independent	11.081	5.991	0.004	Reject H0
Microsoft	47	52	Correct Exceedances & Independent	1.638	5.991	0.441	Fail to Reject H0
Mondelēz International	47	48	Correct Exceedances & Independent	1.001	5.991	0.606	Fail to Reject H0
Morgan Stanley	47	66	Correct Exceedances & Independent	12.611	5.991	0.002	Reject H0
Netflix	47	49	Correct Exceedances & Independent	5.994	5.991	0.05	Reject H0
NextEra Energy	47	60	Correct Exceedances & Independent	4.667	5.991	0.097	Fail to Reject H0
Nike	47	58	Correct Exceedances & Independent	2.437	5.991	0.296	Fail to Reject H0
Nvidia	47	51	Correct Exceedances & Independent	0.604	5.991	0.739	Fail to Reject H0
Oracle	47	69	Correct Exceedances & Independent	9.695	5.991	0.008	Reject H0
Pepsi	47	64	Correct Exceedances & Independent	5.462	5.991	0.065	Fail to Reject H0
Pfizer	47	46	Correct Exceedances & Independent	6.623	5.991	0.036	Reject H0
Procter & Gamble	47	61	Correct Exceedances & Independent	5.086	5.991	0.079	Fail to Reject H0
Qualcomm	47	67	Correct Exceedances & Independent	8.341	5.991	0.015	Reject H0
Raytheon Technologies	47	56	Correct Exceedances & Independent	9.668	5.991	0.008	Reject H0
Simon	47	60	Correct Exceedances & Independent	4.667	5.991	0.097	Fail to Reject H0
Southern Company	47	72	Correct Exceedances & Independent	11.966	5.991	0.003	Reject H0
Starbucks	47	55	Correct Exceedances & Independent	1.416	5.991	0.493	Fail to Reject H0
Target	47	59	Correct Exceedances & Independent	4.286	5.991	0.117	Fail to Reject H0
Texas Instruments	47	55	Correct Exceedances & Independent	2.537	5.991	0.281	Fail to Reject H0
Thermo Fisher Scientific	47	51	Correct Exceedances & Independent	0.604	5.991	0.739	Fail to Reject H0
Union Pacific	47	74	Correct Exceedances & Independent	15.475	5.991	0	Reject H0
United Parcel Service	47	50	Correct Exceedances & Independent	0.505	5.991	0.777	Fail to Reject H0
UnitedHealth Group	47	51	Correct Exceedances & Independent	5.813	5.991	0.055	Fail to Reject H0
US Bancorp	47	69	Correct Exceedances & Independent	8.912	5.991	0.012	Reject H0
Verizon	47	62	Correct Exceedances & Independent	5.924	5.991	0.052	Fail to Reject H0
Walgreens Boots Alliance	47	60	Correct Exceedances & Independent	3.304	5.991	0.192	Fail to Reject H0
Walmart	47	56	Correct Exceedances & Independent	6.14	5.991	0.046	Reject H0
Wells Fargo	47	59	Correct Exceedances & Independent	2.852	5.991	0.24	Fail to Reject H0

Table 2.15: GARCH(1,1) conditional coverage for t-student distribution, a window size of 500 days and a $\alpha = 0.01$

Table XVI - GARCH(1,1) skewed t-student - Conditional Coverage

Results for the conditional coverage test for a GARCH(1,1) model with a window size of 500 days, an alpha of 0.01 assuming a skewed t-student distribution.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	61	Correct Exceedances & Independent	5.335	5.991	0.069	Fail to Reject H0
Abbott	47	55	Correct Exceedances & Independent	5.989	5.991	0.05	Fail to Reject H0
Accenture	47	58	Correct Exceedances & Independent	2.437	5.991	0.296	Fail to Reject H0
Adobe	47	58	Correct Exceedances & Independent	3.942	5.991	0.139	Fail to Reject H0
Altria	47	67	Correct Exceedances & Independent	7.435	5.991	0.024	Reject H0
Amazon	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
AMD	47	56	Correct Exceedances & Independent	1.718	5.991	0.424	Fail to Reject H0
American Express	47	62	Correct Exceedances & Independent	5.541	5.991	0.063	Fail to Reject H0
American International Group	47	61	Correct Exceedances & Independent	3.791	5.991	0.15	Fail to Reject H0
American Tower	47	57	Correct Exceedances & Independent	2.059	5.991	0.357	Fail to Reject H0
Amgen	47	56	Correct Exceedances & Independent	1.718	5.991	0.424	Fail to Reject H0
Apple	47	65	Correct Exceedances & Independent	7.891	5.991	0.019	Reject H0
AT&T	47	70	Correct Exceedances & Independent	11.804	5.991	0.003	Reject H0
Bank of America	47	54	Correct Exceedances & Independent	5.88	5.991	0.053	Fail to Reject H0
Berkshire Hathaway	47	61	Correct Exceedances & Independent	7.496	5.991	0.024	Reject H0
BlackRock	47	68	Correct Exceedances & Independent	9.002	5.991	0.011	Reject H0
BNY Mellon	47	60	Correct Exceedances & Independent	4.78	5.991	0.092	Fail to Reject H0
Boeing	47	68	Correct Exceedances & Independent	10.954	5.991	0.004	Reject H0
Booking Holdings	47	51	Correct Exceedances & Independent	1.417	5.991	0.492	Fail to Reject H0
Bristol Myers Squibb	47	55	Correct Exceedances & Independent	2.537	5.991	0.281	Fail to Reject H0
Capital One	47	61	Correct Exceedances & Independent	5.086	5.991	0.079	Fail to Reject H0
Caterpillar	47	76	Correct Exceedances & Independent	15.422	5.991	0	Reject H0
Charles Schwab	47	63	Correct Exceedances & Independent	6.032	5.991	0.049	Reject H0
Chevron	47	71	Correct Exceedances & Independent	12.948	5.991	0.002	Reject H0
Cisco	47	59	Correct Exceedances & Independent	4.286	5.991	0.117	Fail to Reject H0
Citigroup	47	65	Correct Exceedances & Independent	9.26	5.991	0.01	Reject H0
Coca Cola	47	60	Correct Exceedances & Independent	3.304	5.991	0.192	Fail to Reject H0
Colgate-Palmolive	47	57	Correct Exceedances & Independent	6.332	5.991	0.042	Reject H0
Comcast	47	62	Correct Exceedances & Independent	5.924	5.991	0.052	Fail to Reject H0
ConocoPhillips	47	65	Correct Exceedances & Independent	9.26	5.991	0.01	Reject H0
Costco	47	55	Correct Exceedances & Independent	1.416	5.991	0.493	Fail to Reject H0
CSV Health	47	66	Correct Exceedances & Independent	7.713	5.991	0.021	Reject H0
Danaher	47	60	Correct Exceedances & Independent	3.304	5.991	0.192	Fail to Reject H0
Disney	47	60	Correct Exceedances & Independent	4.667	5.991	0.097	Fail to Reject H0
Duke Energy	47	59	Correct Exceedances & Independent	4.26	5.991	0.119	Fail to Reject H0
Emerson	47	67	Correct Exceedances & Independent	10.355	5.991	0.006	Reject H0
Exelon	47	65	Correct Exceedances & Independent	9.26	5.991	0.01	Reject H0
ExxonMobil	47	66	Correct Exceedances & Independent	7.713	5.991	0.021	Reject H0
Fedex	47	66	Correct Exceedances & Independent	12.611	5.991	0.002	Reject H0
Ford	47	70	Correct Exceedances & Independent	10.421	5.991	0.005	Reject H0
General Dynamics	47	61	Correct Exceedances & Independent	5.335	5.991	0.069	Fail to Reject H0

General Electric	47	55	Correct Exceedances & Independent	2.537	5.991	0.281	Fail to Reject H0
Gilead	47	49	Correct Exceedances & Independent	0.448	5.991	0.799	Fail to Reject H0
Goldman Sachs	47	61	Correct Exceedances & Independent	7.496	5.991	0.024	Reject H0
Home Depot	47	60	Correct Exceedances & Independent	4.667	5.991	0.097	Fail to Reject H0
Honeywell	47	68	Correct Exceedances & Independent	8.158	5.991	0.017	Reject H0
IBM	47	55	Correct Exceedances & Independent	1.416	5.991	0.493	Fail to Reject H0
Intel	47	55	Correct Exceedances & Independent	2.537	5.991	0.281	Fail to Reject H0
Johnson	47	67	Correct Exceedances & Independent	7.435	5.991	0.024	Reject H0
JPMorgan Chase	47	56	Correct Exceedances & Independent	6.14	5.991	0.046	Reject H0
Lilly	47	55	Correct Exceedances & Independent	1.416	5.991	0.493	Fail to Reject H0
Linde	47	67	Correct Exceedances & Independent	13.112	5.991	0.001	Reject H0
Lockheed Martin	47	62	Correct Exceedances & Independent	5.924	5.991	0.052	Fail to Reject H0
Lowe's	47	61	Correct Exceedances & Independent	3.791	5.991	0.15	Fail to Reject H0
McDonald's	47	53	Correct Exceedances & Independent	0.929	5.991	0.628	Fail to Reject H0
Medtronic	47	61	Correct Exceedances & Independent	5.086	5.991	0.079	Fail to Reject H0
Merck	47	64	Correct Exceedances & Independent	11.822	5.991	0.003	Reject H0
Metlife	47	64	Correct Exceedances & Independent	6.558	5.991	0.038	Reject H0
Microsoft	47	57	Correct Exceedances & Independent	3.326	5.991	0.19	Fail to Reject H0
Mondelēz International	47	51	Correct Exceedances & Independent	0.604	5.991	0.739	Fail to Reject H0
Morgan Stanley	47	64	Correct Exceedances & Independent	11.718	5.991	0.003	Reject H0
Netflix	47	59	Correct Exceedances & Independent	10.139	5.991	0.006	Reject H0
NextEra Energy	47	58	Correct Exceedances & Independent	6.565	5.991	0.038	Reject H0
Nike	47	62	Correct Exceedances & Independent	7.883	5.991	0.019	Reject H0
Nvidia	47	47	Correct Exceedances & Independent	0.467	5.991	0.792	Fail to Reject H0
Oracle	47	65	Correct Exceedances & Independent	7.118	5.991	0.028	Reject H0
Pepsi	47	73	Correct Exceedances & Independent	12.785	5.991	0.002	Reject H0
Pfizer	47	55	Correct Exceedances & Independent	9.595	5.991	0.008	Reject H0
Procter & Gamble	47	63	Correct Exceedances & Independent	6.032	5.991	0.049	Reject H0
Qualcomm	47	71	Correct Exceedances & Independent	12.948	5.991	0.002	Reject H0
Raytheon Technologies	47	61	Correct Exceedances & Independent	14.39	5.991	0.001	Reject H0
Simon	47	57	Correct Exceedances & Independent	3.636	5.991	0.162	Fail to Reject H0
Southern Company	47	64	Correct Exceedances & Independent	6.558	5.991	0.038	Reject H0
Starbucks	47	57	Correct Exceedances & Independent	3.636	5.991	0.162	Fail to Reject H0
Target	47	57	Correct Exceedances & Independent	3.636	5.991	0.162	Fail to Reject H0
Texas Instruments	47	52	Correct Exceedances & Independent	1.638	5.991	0.441	Fail to Reject H0
Thermo Fisher Scientific	47	53	Correct Exceedances & Independent	0.929	5.991	0.628	Fail to Reject H0
Union Pacific	47	73	Correct Exceedances & Independent	14.514	5.991	0.001	Reject H0
United Parcel Service	47	48	Correct Exceedances & Independent	1.001	5.991	0.606	Fail to Reject H0
UnitedHealth Group	47	51	Correct Exceedances & Independent	5.813	5.991	0.055	Fail to Reject H0
US Bancorp	47	68	Correct Exceedances & Independent	8.158	5.991	0.017	Reject H0
Verizon	47	54	Correct Exceedances & Independent	2.199	5.991	0.333	Fail to Reject H0
Walgreens Boots Alliance	47	63	Correct Exceedances & Independent	6.032	5.991	0.049	Reject H0
Walmart	47	56	Correct Exceedances & Independent	3.369	5.991	0.186	Fail to Reject H0
Wells Fargo	47	60	Correct Exceedances & Independent	4.78	5.991	0.092	Fail to Reject H0

Table 2.16: GARCH(1,1) conditional coverage for a skewed t-student distribution, a window size of 500 days and a $\alpha = 0.01$

Table XVII - GARCH(1,1) GED - Conditional Coverage

Results for the conditional coverage test for a GARCH(1,1) model with a window size of 500 days, an alpha of 0.01 assuming a generalised error distribution.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	62	Correct Exceedances & Independent	5.924	5.991	0.052	Fail to Reject H0
Abbott	47	52	Correct Exceedances & Independent	2.705	5.991	0.259	Fail to Reject H0
Accenture	47	55	Correct Exceedances & Independent	1.416	5.991	0.493	Fail to Reject H0
Adobe	47	57	Correct Exceedances & Independent	6.332	5.991	0.042	Reject H0
Altria	47	81	Correct Exceedances & Independent	20.393	5.991	0	Reject H0
Amazon	47	42	Correct Exceedances & Independent	1.353	5.991	0.508	Fail to Reject H0
AMD	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
American Express	47	56	Correct Exceedances & Independent	3.369	5.991	0.186	Fail to Reject H0
American International Group	47	66	Correct Exceedances & Independent	9.79	5.991	0.007	Reject H0
American Tower	47	58	Correct Exceedances & Independent	2.437	5.991	0.296	Fail to Reject H0
Amgen	47	48	Correct Exceedances & Independent	0.435	5.991	0.804	Fail to Reject H0
Apple	47	62	Correct Exceedances & Independent	5.924	5.991	0.052	Fail to Reject H0
AT&T	47	78	Correct Exceedances & Independent	19.6	5.991	0	Reject H0
Bank of America	47	55	Correct Exceedances & Independent	5.989	5.991	0.05	Fail to Reject H0
Berkshire Hathaway	47	41	Correct Exceedances & Independent	8.708	5.991	0.013	Reject H0
BlackRock	47	61	Correct Exceedances & Independent	3.791	5.991	0.15	Fail to Reject H0
BNY Mellon	47	56	Correct Exceedances & Independent	2.913	5.991	0.233	Fail to Reject H0
Boeing	47	64	Correct Exceedances & Independent	8.765	5.991	0.012	Reject H0
Booking Holdings	47	48	Correct Exceedances & Independent	0.435	5.991	0.804	Fail to Reject H0
Bristol Myers Squibb	47	50	Correct Exceedances & Independent	0.505	5.991	0.777	Fail to Reject H0
Capital One	47	61	Correct Exceedances & Independent	3.791	5.991	0.15	Fail to Reject H0
Caterpillar	47	69	Correct Exceedances & Independent	8.912	5.991	0.012	Reject H0
Charles Schwab	47	58	Correct Exceedances & Independent	3.942	5.991	0.139	Fail to Reject H0
Chevron	47	82	Correct Exceedances & Independent	22.635	5.991	0	Reject H0
Cisco	47	54	Correct Exceedances & Independent	1.153	5.991	0.562	Fail to Reject H0
Citigroup	47	65	Correct Exceedances & Independent	9.26	5.991	0.01	Reject H0
Coca Cola	47	68	Correct Exceedances & Independent	8.158	5.991	0.017	Reject H0
Colgate-Palmolive	47	54	Correct Exceedances & Independent	9.565	5.991	0.008	Reject H0
Comcast	47	64	Correct Exceedances & Independent	5.462	5.991	0.065	Fail to Reject H0
ConocoPhillips	47	67	Correct Exceedances & Independent	10.355	5.991	0.006	Reject H0
Costco	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
CVS	47	58	Correct Exceedances & Independent	3.942	5.991	0.139	Fail to Reject H0
Danaher	47	56	Correct Exceedances & Independent	1.718	5.991	0.424	Fail to Reject H0
Disney	47	53	Correct Exceedances & Independent	1.899	5.991	0.387	Fail to Reject H0
Duke Energy	47	62	Correct Exceedances & Independent	4.313	5.991	0.116	Fail to Reject H0
Emerson	47	65	Correct Exceedances & Independent	9.26	5.991	0.01	Reject H0
Exelon	47	69	Correct Exceedances & Independent	11.586	5.991	0.003	Reject H0
ExxonMobil	47	72	Correct Exceedances & Independent	11.966	5.991	0.003	Reject H0
Fedex	47	62	Correct Exceedances & Independent	5.924	5.991	0.052	Fail to Reject H0
Ford	47	61	Correct Exceedances & Independent	3.791	5.991	0.15	Fail to Reject H0
General Dynamics	47	66	Correct Exceedances & Independent	8.611	5.991	0.013	Reject H0

General Electric	47	52	Correct Exceedances & Independent	1.638	5.991	0.441	Fail to Reject H0
Gilead	47	50	Correct Exceedances & Independent	0.505	5.991	0.777	Fail to Reject H0
Goldman Sachs	47	60	Correct Exceedances & Independent	4.667	5.991	0.097	Fail to Reject H0
Home Depot	47	52	Correct Exceedances & Independent	2.705	5.991	0.259	Fail to Reject H0
Honeywell	47	66	Correct Exceedances & Independent	7.713	5.991	0.021	Reject H0
IBM	47	62	Correct Exceedances & Independent	5.541	5.991	0.063	Fail to Reject H0
Intel	47	50	Correct Exceedances & Independent	1.237	5.991	0.539	Fail to Reject H0
Johnson	47	60	Correct Exceedances & Independent	3.304	5.991	0.192	Fail to Reject H0
JPMorgan Chase	47	52	Correct Exceedances & Independent	5.791	5.991	0.055	Fail to Reject H0
Lilly	47	60	Correct Exceedances & Independent	3.304	5.991	0.192	Fail to Reject H0
Linde	47	71	Correct Exceedances & Independent	15.457	5.991	0	Reject H0
Lockheed Martin	47	67	Correct Exceedances & Independent	7.435	5.991	0.024	Reject H0
Lowe's	47	60	Correct Exceedances & Independent	3.304	5.991	0.192	Fail to Reject H0
McDonald's	47	53	Correct Exceedances & Independent	0.929	5.991	0.628	Fail to Reject H0
Medtronic	47	60	Correct Exceedances & Independent	4.667	5.991	0.097	Fail to Reject H0
Merck	47	71	Correct Exceedances & Independent	18.65	5.991	0	Reject H0
Metlife	47	60	Correct Exceedances & Independent	3.304	5.991	0.192	Fail to Reject H0
Microsoft	47	48	Correct Exceedances & Independent	1.001	5.991	0.606	Fail to Reject H0
Mondelēz International	47	51	Correct Exceedances & Independent	0.604	5.991	0.739	Fail to Reject H0
Morgan Stanley	47	62	Correct Exceedances & Independent	10.972	5.991	0.004	Reject H0
Netflix	47	41	Correct Exceedances & Independent	8.708	5.991	0.013	Reject H0
NextEra Energy	47	59	Correct Exceedances & Independent	2.852	5.991	0.24	Fail to Reject H0
Nike	47	52	Correct Exceedances & Independent	2.705	5.991	0.259	Fail to Reject H0
Nvidia	47	47	Correct Exceedances & Independent	0.467	5.991	0.792	Fail to Reject H0
Oracle	47	67	Correct Exceedances & Independent	8.341	5.991	0.015	Reject H0
Pepsi	47	63	Correct Exceedances & Independent	6.032	5.991	0.049	Reject H0
Pfizer	47	48	Correct Exceedances & Independent	6.154	5.991	0.046	Reject H0
Procter & Gamble	47	63	Correct Exceedances & Independent	6.032	5.991	0.049	Reject H0
Qualcomm	47	60	Correct Exceedances & Independent	4.78	5.991	0.092	Fail to Reject H0
Raytheon Technologies	47	57	Correct Exceedances & Independent	9.783	5.991	0.008	Reject H0
Simon	47	58	Correct Exceedances & Independent	3.942	5.991	0.139	Fail to Reject H0
Southern Company	47	68	Correct Exceedances & Independent	8.158	5.991	0.017	Reject H0
Starbucks	47	60	Correct Exceedances & Independent	4.667	5.991	0.097	Fail to Reject H0
Target	47	60	Correct Exceedances & Independent	4.667	5.991	0.097	Fail to Reject H0
Texas Instruments	47	56	Correct Exceedances & Independent	2.913	5.991	0.233	Fail to Reject H0
Thermo Fisher Scientific	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
Union Pacific	47	68	Correct Exceedances & Independent	10.146	5.991	0.006	Reject H0
United Parcel Service	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
UnitedHealth Group	47	49	Correct Exceedances & Independent	5.994	5.991	0.05	Reject H0
US Bancorp	47	68	Correct Exceedances & Independent	8.158	5.991	0.017	Reject H0
Verizon	47	64	Correct Exceedances & Independent	7.203	5.991	0.027	Reject H0
Walgreens Boots Alliance	47	58	Correct Exceedances & Independent	3.942	5.991	0.139	Fail to Reject H0
Walmart	47	55	Correct Exceedances & Independent	3.141	5.991	0.208	Fail to Reject H0
Wells Fargo	47	53	Correct Exceedances & Independent	0.929	5.991	0.628	Fail to Reject H0

Table 2.17: GARCH(1,1) conditional coverage for a GED distribution, a window size of 500 days and a α = 0.01

Table XVIII - FHS GED - Conditional Coverage

Results for the conditional coverage test for a FHS model with a window size of 500 days, an alpha of 0.01 assuming a generalised error distribution.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
3M	47	63	Correct Exceedances & Independent	6.547	5.991	0.038	Reject H0
Abbott	47	65	Correct Exceedances & Independent	12.147	5.991	0.002	Reject H0
Accenture	47	58	Correct Exceedances & Independent	2.437	5.991	0.296	Fail to Reject H0
Adobe	47	58	Correct Exceedances & Independent	6.565	5.991	0.038	Reject H0
Altria	47	63	Correct Exceedances & Independent	4.871	5.991	0.088	Fail to Reject H0
Amazon	47	60	Correct Exceedances & Independent	3.304	5.991	0.192	Fail to Reject H0
AMD	47	54	Correct Exceedances & Independent	1.153	5.991	0.562	Fail to Reject H0
American Express	47	60	Correct Exceedances & Independent	4.667	5.991	0.097	Fail to Reject H0
American International Group	47	58	Correct Exceedances & Independent	3.942	5.991	0.139	Fail to Reject H0
American Tower	47	60	Correct Exceedances & Independent	4.78	5.991	0.092	Fail to Reject H0
Amgen	47	58	Correct Exceedances & Independent	3.942	5.991	0.139	Fail to Reject H0
Apple	47	54	Correct Exceedances & Independent	2.199	5.991	0.333	Fail to Reject H0
AT&T	47	57	Correct Exceedances & Independent	3.326	5.991	0.19	Fail to Reject H0
Bank of America	47	54	Correct Exceedances & Independent	5.88	5.991	0.053	Fail to Reject H0
Berkshire Hathaway	47	57	Correct Exceedances & Independent	6.332	5.991	0.042	Reject H0
BlackRock	47	62	Correct Exceedances & Independent	4.313	5.991	0.116	Fail to Reject H0
BNY Mellon	47	58	Correct Exceedances & Independent	3.775	5.991	0.151	Fail to Reject H0
Boeing	47	66	Correct Exceedances & Independent	12.611	5.991	0.002	Reject H0
Booking Holdings	47	69	Correct Exceedances & Independent	8.912	5.991	0.012	Reject H0
Bristol Myers Squibb	47	54	Correct Exceedances & Independent	1.153	5.991	0.562	Fail to Reject H0
Capital One	47	65	Correct Exceedances & Independent	9.26	5.991	0.01	Reject H0
Caterpillar	47	60	Correct Exceedances & Independent	3.304	5.991	0.192	Fail to Reject H0
Charles Schwab	47	66	Correct Exceedances & Independent	12.611	5.991	0.002	Reject H0
Chevron	47	64	Correct Exceedances & Independent	5.462	5.991	0.065	Fail to Reject H0
Cisco	47	63	Correct Exceedances & Independent	8.306	5.991	0.016	Reject H0
Citigroup	47	54	Correct Exceedances & Independent	2.955	5.991	0.228	Fail to Reject H0
Coca Cola	47	64	Correct Exceedances & Independent	5.462	5.991	0.065	Fail to Reject H0
Colgate-Palmolive	47	58	Correct Exceedances & Independent	6.565	5.991	0.038	Reject H0
Comcast	47	61	Correct Exceedances & Independent	3.791	5.991	0.15	Fail to Reject H0
ConocoPhillips	47	61	Correct Exceedances & Independent	3.791	5.991	0.15	Fail to Reject H0
Costco	47	55	Correct Exceedances & Independent	1.416	5.991	0.493	Fail to Reject H0
CSV Health	47	64	Correct Exceedances & Independent	6.558	5.991	0.038	Reject H0
Danaher	47	63	Correct Exceedances & Independent	6.032	5.991	0.049	Reject H0
Disney	47	55	Correct Exceedances & Independent	5.989	5.991	0.05	Fail to Reject H0
Duke Energy	47	60	Correct Exceedances & Independent	3.304	5.991	0.192	Fail to Reject H0
Emerson	47	64	Correct Exceedances & Independent	8.765	5.991	0.012	Reject H0
Exelon	47	61	Correct Exceedances & Independent	5.086	5.991	0.079	Fail to Reject H0
ExxonMobil	47	65	Correct Exceedances & Independent	7.118	5.991	0.028	Reject H0
Fedex	47	58	Correct Exceedances & Independent	3.942	5.991	0.139	Fail to Reject H0
Ford	47	61	Correct Exceedances & Independent	5.086	5.991	0.079	Fail to Reject H0
General Dynamics	47	65	Correct Exceedances & Independent	7.891	5.991	0.019	Reject H0

General Electric	47	64	Correct Exceedances & Independent	5.462	5.991	0.065	Fail to Reject H0
Gilead	47	61	Correct Exceedances & Independent	3.791	5.991	0.15	Fail to Reject H0
Goldman Sachs	47	67	Correct Exceedances & Independent	10.355	5.991	0.006	Reject H0
Home Depot	47	55	Correct Exceedances & Independent	3.141	5.991	0.208	Fail to Reject H0
Honeywell	47	64	Correct Exceedances & Independent	8.765	5.991	0.012	Reject H0
IBM	47	58	Correct Exceedances & Independent	3.942	5.991	0.139	Fail to Reject H0
Intel	47	56	Correct Exceedances & Independent	2.913	5.991	0.233	Fail to Reject H0
Johnson	47	47	Correct Exceedances & Independent	0.947	5.991	0.623	Fail to Reject H0
JPMorgan Chase	47	57	Correct Exceedances & Independent	6.332	5.991	0.042	Reject H0
Lilly	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
Linde	47	72	Correct Exceedances & Independent	19.14	5.991	0	Reject H0
Lockheed Martin	47	60	Correct Exceedances & Independent	4.78	5.991	0.092	Fail to Reject H0
Lowe's	47	63	Correct Exceedances & Independent	8.306	5.991	0.016	Reject H0
McDonald's	47	58	Correct Exceedances & Independent	6.565	5.991	0.038	Reject H0
Medtronic	47	71	Correct Exceedances & Independent	12.948	5.991	0.002	Reject H0
Merck	47	57	Correct Exceedances & Independent	6.418	5.991	0.04	Reject H0
Metlife	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
Microsoft	47	57	Correct Exceedances & Independent	2.059	5.991	0.357	Fail to Reject H0
Mondelēz International	47	59	Correct Exceedances & Independent	4.286	5.991	0.117	Fail to Reject H0
Morgan Stanley	47	60	Correct Exceedances & Independent	7.147	5.991	0.028	Reject H0
Netflix	47	63	Correct Exceedances & Independent	14.92	5.991	0.001	Reject H0
NextEra Energy	47	65	Correct Exceedances & Independent	12.147	5.991	0.002	Reject H0
Nike	47	72	Correct Exceedances & Independent	16.127	5.991	0	Reject H0
Nvidia	47	54	Correct Exceedances & Independent	1.153	5.991	0.562	Fail to Reject H0
Oracle	47	66	Correct Exceedances & Independent	7.713	5.991	0.021	Reject H0
Pepsi	47	57	Correct Exceedances & Independent	3.636	5.991	0.162	Fail to Reject H0
Pfizer	47	55	Correct Exceedances & Independent	9.595	5.991	0.008	Reject H0
Procter & Gamble	47	52	Correct Exceedances & Independent	2.705	5.991	0.259	Fail to Reject H0
Qualcomm	47	57	Correct Exceedances & Independent	2.059	5.991	0.357	Fail to Reject H0
Raytheon Technologies	47	53	Correct Exceedances & Independent	13.932	5.991	0.001	Reject H0
Simon	47	56	Correct Exceedances & Independent	2.913	5.991	0.233	Fail to Reject H0
Southern Company	47	61	Correct Exceedances & Independent	3.791	5.991	0.15	Fail to Reject H0
Starbucks	47	65	Correct Exceedances & Independent	9.26	5.991	0.01	Reject H0
Target	47	66	Correct Exceedances & Independent	6.745	5.991	0.034	Reject H0
Texas Instruments	47	54	Correct Exceedances & Independent	2.199	5.991	0.333	Fail to Reject H0
Thermo Fisher Scientific	47	60	Correct Exceedances & Independent	3.304	5.991	0.192	Fail to Reject H0
Union Pacific	47	65	Correct Exceedances & Independent	7.891	5.991	0.019	Reject H0
United Parcel Service	47	64	Correct Exceedances & Independent	5.462	5.991	0.065	Fail to Reject H0
UnitedHealth Group	47	64	Correct Exceedances & Independent	11.718	5.991	0.003	Reject H0
US Bancorp	47	57	Correct Exceedances & Independent	3.326	5.991	0.19	Fail to Reject H0
Verizon	47	57	Correct Exceedances & Independent	2.059	5.991	0.357	Fail to Reject H0
Walgreens Boots Alliance	47	63	Correct Exceedances & Independent	6.032	5.991	0.049	Reject H0
Walmart	47	62	Correct Exceedances & Independent	4.313	5.991	0.116	Fail to Reject H0
Wells Fargo	47	57	Correct Exceedances & Independent	3.326	5.991	0.19	Fail to Reject H0

Table 2.18: FHS conditional coverage for GED distribution, a window size of 500 days and a $\alpha = 0.01$

Table XIX - GARCHX(1,1) GED - Conditional Coverage

Results for the conditional coverage test for a GARCH(1,1) model with a window size of 500 days, an alpha of 0.01 assuming a generalised error distribution with earnings announcements dummy.

Name	Expected	Actual	H0	LRstat	crit	LRp	Decision
Apple	47	69	Correct Exceedances & Independent	8.912	5.991	0.012	Reject H0
3M	47	59	Correct Exceedances & Independent	4.26	5.991	0.119	Fail to Reject H0
Abbott	47	55	Correct Exceedances & Independent	5.989	5.991	0.05	Fail to Reject H0
Accenture	47	58	Correct Exceedances & Independent	3.942	5.991	0.139	Fail to Reject H0
Adobe	47	61	Correct Exceedances & Independent	7.496	5.991	0.024	Reject H0
Altria	47	82	Correct Exceedances & Independent	21.47	5.991	0	Reject H0
Amazon	47	44	Correct Exceedances & Independent	1.051	5.991	0.591	Fail to Reject H0
AMD	47	45	Correct Exceedances & Independent	0.669	5.991	0.716	Fail to Reject H0
American Express	47	56	Correct Exceedances & Independent	6.14	5.991	0.046	Reject H0
American International Group	47	58	Correct Exceedances & Independent	9.941	5.991	0.007	Reject H0
American Tower	47	62	Correct Exceedances & Independent	4.313	5.991	0.116	Fail to Reject H0
Amgen	47	48	Correct Exceedances & Independent	0.435	5.991	0.804	Fail to Reject H0
AT&T	47	77	Correct Exceedances & Independent	18.528	5.991	0	Reject H0
Bank of America	47	55	Correct Exceedances & Independent	9.595	5.991	0.008	Reject H0
BNY Mellon	47	55	Correct Exceedances & Independent	1.416	5.991	0.493	Fail to Reject H0
Berkshire Hathaway	47	39	Correct Exceedances & Independent	5.62	5.991	0.06	Fail to Reject H0
Boeing	47	64	Correct Exceedances & Independent	11.718	5.991	0.003	Reject H0
Booking Holdings	47	49	Correct Exceedances & Independent	0.448	5.991	0.799	Fail to Reject H0
Bristol Myers Squibb	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
Capital One	47	58	Correct Exceedances & Independent	2.437	5.991	0.296	Fail to Reject H0
Caterpillar	47	76	Correct Exceedances & Independent	15.422	5.991	0	Reject H0
Charles Schwab	47	59	Correct Exceedances & Independent	4.286	5.991	0.117	Fail to Reject H0
Chevron	47	83	Correct Exceedances & Independent	23.688	5.991	0	Reject H0
Cisco	47	58	Correct Exceedances & Independent	2.437	5.991	0.296	Fail to Reject H0
Citigroup	47	61	Correct Exceedances & Independent	7.496	5.991	0.024	Reject H0
Coca Cola	47	66	Correct Exceedances & Independent	6.745	5.991	0.034	Reject H0
Colgate-Palmolive	47	57	Correct Exceedances & Independent	9.783	5.991	0.008	Reject H0
Comcast	47	59	Correct Exceedances & Independent	4.26	5.991	0.119	Fail to Reject H0
ConocoPhillips	47	68	Correct Exceedances & Independent	10.954	5.991	0.004	Reject H0
Costco	47	50	Correct Exceedances & Independent	0.505	5.991	0.777	Fail to Reject H0
CSV Health	47	62	Correct Exceedances & Independent	5.541	5.991	0.063	Fail to Reject H0
Danaher	47	54	Correct Exceedances & Independent	1.153	5.991	0.562	Fail to Reject H0
Disney	47	57	Correct Exceedances & Independent	3.636	5.991	0.162	Fail to Reject H0
Duke Energy	47	61	Correct Exceedances & Independent	3.791	5.991	0.15	Fail to Reject H0
Emerson	47	71	Correct Exceedances & Independent	18.531	5.991	0	Reject H0
Exelon	47	70	Correct Exceedances & Independent	14.82	5.991	0.001	Reject H0
ExxonMobil	47	74	Correct Exceedances & Independent	13.634	5.991	0.001	Reject H0
Fedex	47	63	Correct Exceedances & Independent	4.871	5.991	0.088	Fail to Reject H0
Ford	47	59	Correct Exceedances & Independent	2.852	5.991	0.24	Fail to Reject H0
General Dynamics	47	65	Correct Exceedances & Independent	7.891	5.991	0.019	Reject H0

General Electric	47	51	Correct Exceedances & Independent	1.417	5.991	0.492	Fail to Reject H0
Gilead	47	49	Correct Exceedances & Independent	0.448	5.991	0.799	Fail to Reject H0
Goldman Sachs	47	61	Correct Exceedances & Independent	7.496	5.991	0.024	Reject H0
Home Depot	47	52	Correct Exceedances & Independent	2.705	5.991	0.259	Fail to Reject H0
Honeywell	47	63	Correct Exceedances & Independent	4.871	5.991	0.088	Fail to Reject H0
Intel	47	50	Correct Exceedances & Independent	1.237	5.991	0.539	Fail to Reject H0
IBM	47	63	Correct Exceedances & Independent	6.032	5.991	0.049	Reject H0
Johnson	47	59	Correct Exceedances & Independent	4.26	5.991	0.119	Fail to Reject H0
JPMorgan Chase	47	52	Correct Exceedances & Independent	5.791	5.991	0.055	Fail to Reject H0
Lilly	47	58	Correct Exceedances & Independent	2.437	5.991	0.296	Fail to Reject H0
Linde	47	73	Correct Exceedances & Independent	16.829	5.991	0	Reject H0
Lockheed Martin	47	66	Correct Exceedances & Independent	6.745	5.991	0.034	Reject H0
Lowe's	47	60	Correct Exceedances & Independent	3.304	5.991	0.192	Fail to Reject H0
McDonald's	47	58	Correct Exceedances & Independent	2.437	5.991	0.296	Fail to Reject H0
Medtronic	47	59	Correct Exceedances & Independent	4.286	5.991	0.117	Fail to Reject H0
Merck	47	74	Correct Exceedances & Independent	20.569	5.991	0	Reject H0
Metlife	47	60	Correct Exceedances & Independent	4.78	5.991	0.092	Fail to Reject H0
Microsoft	47	58	Correct Exceedances & Independent	2.437	5.991	0.296	Fail to Reject H0
Mondelēz International	47	54	Correct Exceedances & Independent	1.153	5.991	0.562	Fail to Reject H0
Morgan Stanley	47	68	Correct Exceedances & Independent	13.647	5.991	0.001	Reject H0
Netflix	47	39	Correct Exceedances & Independent	5.62	5.991	0.06	Fail to Reject H0
NextEra Energy	47	59	Correct Exceedances & Independent	4.286	5.991	0.117	Fail to Reject H0
Nike	47	54	Correct Exceedances & Independent	2.955	5.991	0.228	Fail to Reject H0
Oracle	47	63	Correct Exceedances & Independent	6.032	5.991	0.049	Reject H0
Pepsi	47	62	Correct Exceedances & Independent	5.541	5.991	0.063	Fail to Reject H0
Pfizer	47	48	Correct Exceedances & Independent	6.154	5.991	0.046	Reject H0
Procter & Gamble	47	60	Correct Exceedances & Independent	7.147	5.991	0.028	Reject H0
Qualcomm	47	63	Correct Exceedances & Independent	6.547	5.991	0.038	Reject H0
Raytheon Technologies	47	58	Correct Exceedances & Independent	9.941	5.991	0.007	Reject H0
Simon	47	57	Correct Exceedances & Independent	2.059	5.991	0.357	Fail to Reject H0
Southern Company	47	70	Correct Exceedances & Independent	10.421	5.991	0.005	Reject H0
Starbucks	47	59	Correct Exceedances & Independent	4.286	5.991	0.117	Fail to Reject H0
Target	47	57	Correct Exceedances & Independent	2.059	5.991	0.357	Fail to Reject H0
Thermo Fisher Scientific	47	52	Correct Exceedances & Independent	2.705	5.991	0.259	Fail to Reject H0
Union Pacific	47	69	Correct Exceedances & Independent	10.96	5.991	0.004	Reject H0
United Parcel Service	47	53	Correct Exceedances & Independent	1.899	5.991	0.387	Fail to Reject H0
UnitedHealth Group	47	50	Correct Exceedances & Independent	5.88	5.991	0.053	Fail to Reject H0
US Bancorp	47	72	Correct Exceedances & Independent	11.966	5.991	0.003	Reject H0
Verizon	47	68	Correct Exceedances & Independent	10.146	5.991	0.006	Reject H0
Walgreens Boots Alliance	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0
Walmart	47	56	Correct Exceedances & Independent	3.369	5.991	0.186	Fail to Reject H0
Wells Fargo	47	52	Correct Exceedances & Independent	0.746	5.991	0.689	Fail to Reject H0

Table 2.19: GARCHX conditional coverage for GED distribution, a window size of 500 days and a $\alpha = 0.01$