

# Risk Modelling in Energy Markets

A Value at Risk and Expected Shortfall Approach

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# **Problem Description**

The master thesis aims to compare the predictive performance of different models for Value at Risk and Expected Shortfall for energy markets (electricity, oil, oil products, gas, coal and carbon). Primary markets are NASDAQ OMX, European Energy Exchange, Intercontinental Exchange and New York Mercantile Exchange.

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# Preface

This master thesis was written at the Department of Industrial Economics and Technology Management at the Norwegian University of Science and Technology (NTNU) between January 2011 and June 2011.

The authors would like to thank Simone Manganelli and Kevin Sheppard, for their public MATLAB program codes for CAViaR and GARCH models respectively, Roland Füss and Zeno Adams, for providing their EViews code, and especially thanks to Sjur Westgaard, associate professor at NTNU, for guidance and helpful comments in the process of writing this paper.

We hereby declare that this master thesis has been carried out in accordance with the examination regulations of NTNU.

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# Abstract

Value at risk (VaR) and Expected Shortfall (ES) are commonly used risk measures in the financial literature. They have however not been applied to a great extent on energy derivatives. This paper compares the performance of several VaR and ES models for energy commodity futures on some of the world's largest commodity exchanges. In total 14 different VaR models and nine ES models are evaluated; GARCH and GJR-GARCH with normal, student t, GED and skewed student t distributions and EWQR are used to obtain both VaR and ES forecasts. In addition, five CAViaR models are used in the VaR analysis.

EWQR is by far the best ES model. It has very good test results for all markets and quantiles considered. The VaR results vary greatly, and there does not appear to be any clear pattern in which some models are better suited for certain markets or commodities. The VaR models with best performance overall are however EWQR, the adaptive CAViaR and GARCH and GJR-GARCH models with student t and skewed student t distributions.

Keywords: Risk Modelling, Value at Risk, VaR, Expected Shortfall, ES, Expected Tail Loss, ETL, Conditional Value at Risk, CVaR, Quantile Regression, Exponentially Weighted Quantile Regression, EWQR, Conditional Autoregressive Value at Risk, CAViaR, Generalized AutoRegressive Conditional Heteroskedasticity, GARCH,GJR-GARCH, Normal Distribution, Student t, GED, Skewed Student t, Energy Markets, Energy Commodity Futures, Carbon, Electricity, Oil, Oil Products, Natural Gas, Coal,

# **1. Introduction**

Risk management in energy markets is becoming increasingly relevant. A growing number of the world's power markets have been liberalized and multinational power exchanges have emerged. Markets are becoming more integrated, and the trading of forward and futures contracts is increasing. Energy markets differ from traditional financial markets due to the nature of production and consumption (Pilipovic 2007); the volatility of energy commodities is higher, and return distributions tend to be more leptokurtic and skewed. This makes risk modelling a challenging and important task. Risk management is not only relevant for participants in financial trading; suppliers and consumers of energy commodities also have a need for hedging of their operations and investments.

In this paper both Value at Risk (VaR) and Expected Shortfall (ES) will be used to quantify risk. VaR is a popular tool in risk management today. It assists in setting position limits and allocating resources to meet capital requirements needed to cover market risk. ES is a risk measure which has been introduced as a coherent supplement to VaR.

We apply several different models to obtain VaR and ES estimates for the 90%, 95% and 99% quantiles of the loss distribution for both long and short trading positions: Exponentially Weighted Quantile Regression (EWQR), eight Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) models and five models based on the Conditional Autoregressive Value at Risk (CAViaR) framework. The GARCH models are well-established in risk management, but quantile regression based models such as CAViaR and EWQR are valid alternatives.

We consider monthly, quarterly and yearly first position energy futures from four different markets. These markets have been chosen because of their strong position in futures contracts trading of energy commodities.

New York Mercantile Exchange (NYMEX) is the largest energy and metals exchange in the world. In 2008 they became a part of the world's largest futures market, CME Group Inc. (CME Group 2008).Nord Pool was the world's largest power derivatives exchange when it was acquired by the NASDAQ OMX Group. In November 2010 it changed trade name to NASDAQ OMX Commodities Europe (Nasdaq OMX 2011). ICE Futures Europe is one of three futures exchanges operated by Intercontinental Exchange (NYSE: ICE), and hosts trading in half of the world's crude and refined oil futures contracts traded each day (ICE 2011). European Energy Exchange (EEX) is one of the leading trading markets in European energy trading, and the volume of power derivatives traded is about five times higher than the volume traded on the spot market for power (European Energy Exchange AG 2009).

We share the view of Angelidis et al. (2004) that it is better to use risk models that have good out-of-sample forecasts than models that are correctly specified for the in-sample period. Hence, the focus when evaluating the models will be on the out-of-sample performance.

Our analysis shows that the performance of the VaR models differs great between the 14 return series considered. EWQR, the adaptive CAViaR and the GARCH and GJR-GARCH models with student t and skewed student t distributions are the most accurate. EWQR is the best ES model, clearly outperforming the other models at the two-sided tests.

The rest of the paper is organized as follows. Section two provides a review of relevant studies conducted on VaR and ES, and how our approach will complement the existing literature. The third section describes the methodology of estimating VaR and ES with GARCH, EWQR and CAViaR, and section four and five methods of testing the VaR and ES forecasts, respectively. In section six a description of the data samples is given, while section seven contains an analysis of the empirical results. Concluding remarks follow in the last section.

# **2. Review of Existing Literature**

### 2.1 Models for Value at Risk

There are several different approaches to estimating VaR from time series. Manganelli and Engle (2001) distinguish between three categories of VaR methods: parametric, semiparametric and nonparametric.

A simple way to estimate VaR is through historical simulation (HS), which is a *nonparametric* approach where historic data is used to make sample quantile estimates. Kuester et al. (2006) describes two kinds of historical simulation, naive HS, which is the most used, and filtered historical simulation (FHS). A problem with the HS approach is that it assumes that the next return will be the same as one of the observed returns in the chosen sample, with equal probability of occurrence. A future return cannot deviate from the already observed returns.

Boudoukh, Richardson and Whitlaw (1998) introduce what they call a hybrid approach, which estimates VaR of a portfolio by applying exponentially declining weights to past returns and then finds the appropriate percentile of the time-weighted empirical distribution. This allows the VaR forecasts to deviate from the observed returns, and to emphasize recent returns.

Parametric VaR-methods, such as GARCH, use parameterization of the time-varying stochastic behavior of financial prices. GARCH was introduced by Bollerslev (1986), who based his work on the ARCH model by Engle (1982). In order to estimate the parameters in this model framework, an error distribution must be assumed. Originally the normal distribution was suggested (Bollerslev 1986). This is the easiest distribution to implement, and it is very often used at least as a benchmark. Even though the normal distribution assumption is easy and popular, it has been shown empirically that it is often unsuitable for real world applications (Kuester, Mittnik et al. 2006; Hung, Lee et al. 2008). The distribution of financial returns tend to be leptokurtic; it has heavier tails than predicted by the normal distribution, as well as more returns close to zero (McNeil and Frey 2000). In addition a lot of return series show an asymmetry that the normal distribution is unable to register (Harvey and Siddique 1999; Verhoeven and McAleer 2004). Therefore, other distributions may fit better with reality. The student t distribution (Bollerslev 1987), GED (Subbotin 1923; Nelson 1991) and heavy tails (Hung, Lee et al. 2008), all allow the distribution to be leptokurtic. Hansen's skewed Student t distribution accounts for asymmetry in addition to leptokurtosis (Hansen 1994; Giot and Laurent 2003).

There exist a lot of extensions to the ARCH/GARCH framework. In fact there are so many of them that Bollerslev, Russell et al. (2010) published a reference guide to ease the navigation

through the "alphabet-soup of acronyms and abbreviations". Many of the different GARCH models have been used in VaR studies, such as EGARCH (Bertsimas, Lauprete et al. 2004; Chan and Gray 2006), APARCH (Giot and Laurent 2003; Huang and Lin 2004) and GJR-GARCH (Bertsimas, Lauprete et al. 2004), all of which account for asymmetry, AR-GARCH (Byström 2005; Kuester, Mittnik et al. 2006), which includes an autoregressive term for the conditional mean, and FIGARCH (Beine, Bénassy-Quéré et al. 2002; Härdle and Mungo 2008) which includes volatility shock persistence.

The *semiparametric* VaR models include extreme value theory (EVT) and quantile regression (QR). Both EVT and QR model the quantile directly instead of modelling the whole distribution. The problem with EVT is that it assumes that the returns are independent and identically distributed, which is normally not the case. To solve this, some kind of filter, for example a GARCH model, is applied to the returns prior to the EVT (Kuester, Mittnik et al. 2006). Having to apply a filter removes some of the advantage of modelling the quantile directly. We refer to Embrechts, Klüppelberg and Mikosch (1996) and Mapa and Suaiso (2009) for a more comprehensive analysis on this subject.

An example of a QR based model is CAViaR, introduced by Engle and Manganelli (2004). It suggests that the quantiles for the different periods are autoregressive. The parameters in the CAViaR models are estimated using quantile regression minimization. Some studies suggest that CAViaR performs well both for stock markets (Engle and Manganelli 2004) and commodities indices (Füss, Adams et al. 2010).

EWQR, developed by Taylor (2008), is another QR based VaR model, in which a weighting parameter has been included to the quantile regression expression. Even though the EWQR formula generally include regressors, Taylor (2008) argues that an EWQR with an intercept and no regressors is reasonable and should perform well. The version without regressors is basically equivalent to the hybrid model by Boudoukh, Richardson and Whitlaw mentioned above, but perhaps with better a theoretical framework.

Regardless of the popularity and extensive use of VaR, it has also been criticized. Beder (1995) declared VaR to be "seductive, but dangerous", as results are very dependent on the method applied, the assumptions made and data considered. Acerbi and Tasche (2002) claim that VaR should be interpreted as "[...] the minimum loss incurred in the  $\alpha$ % worst cases of our portfolio", and that it therefore is a strange risk measure to consider.

A risk measure needs to meet four axioms; it must be monotonous, sub-additive, positively homogenous and translation invariant (Acerbi and Tasche 2002). With a portfolio made up of sub-portfolios, the risk calculated by VaR will be the sum of the risks of the sub-portfolios. In reality the risk will be lower or at most the sum of each risk because of diversification. Because our study only concerns univariate cases, this doesn't affect our result. However, it is an important weakness of a risk measure.

### 2.2 Models for Expected Shortfall

In order to avoid the shortcomings of VaR, Expected Shortfall (ES) was introduced. Expected Tail loss (ETL), Conditional Value at Risk (CVaR), Average Value at Risk (AVaR), Tail Mean (TM), Average Multiple of Tail Event to Risk Measure (AMTERM), Tail Conditional Expectation (TCE) and Worst Conditional Expectation (WCE) are other terms which are used interchangeably for ES, even though there is a theoretical difference between some of them

(Acerbi and Tasche 2002; Rockafellar and Uryasev 2002; Alexander 2008; Härdle and Mungo 2008).

Compared with VaR less research is done on ES, but in the last decade the number of published articles about ES has increased rapidly. The articles concerning ES can be divided into three groups: The first group compares VaR and ES, the second one uses ES as a measure of VaR performance, while the last group considers ES models individually, as complements or extensions to the VaR models.

Most of the articles comparing VaR and ES focus on the differences in theoretical framework, and how ES is a better and coherent risk measure (Beder 1995; Acerbi and Tasche 2002; Bertsimas, Lauprete et al. 2004; Inui and Kijima 2005; Cai and Wang 2008; Lan, Nelson et al. 2010). Yamai and Yoshiba (2005), on the other hand, try to decide which risk measure is best empirically, by comparing their performance in currency markets. They conclude that VaR and ES should be used together, since VaR has the problem that it ignores everything above the VaR, while ES has much greater estimation errors than VaR and is therefore more difficult to model accurately.

ES can be used as a measure of VaR performance in at least two ways. First, as a comparable value, against which for example the average VaR forecast is compared, to verify whether the risk beyond VaR is great for a given market (Gupta and Liang 2005; Härdle and Mungo 2008). Secondly, an ES based loss function can be used to choose the best VaR model (Angelidis and Degiannakis 2006). The problem with using ES in this way is that the accuracy of the ES models is not tested. Therefore more attention should be focused on the third group of ES articles.

Among the ES models that are widely applied in stock or currency markets are EVT, the Stable Paretian Approach, historical simulation, and the normal distribution (McNeil and Frey 2000; Embrechts, Kaufmann et al. 2005; Yamai and Yoshiba 2005; Harmantzis, Miao et al. 2006; Marinelli, D'Addona et al. 2007; Alexander 2008; Chen 2008). These models have many of the same advantages and disadvantages as their corresponding VaR models, and alternative models are therefore still emerging.

Some GARCH specifications have been considered as well with several different error distributions, as the normal distribution, student t, GED and skewed student t (Angelidis, Benos et al. 2004; Embrechts, Kaufmann et al. 2005; Härdle and Mungo 2008; Caillault and Guégan 2009). These are however either calculated numerically (Embrechts, Kaufmann et al. 2005) or by following Dowd's approach of slicing the distribution's tail in many slices, estimating the corresponding VaR of each slice and then estimate ES as the average of these "tail VaRs" (Dowd 2002).

Conditional AutoRegressive Expectiles (CARE) is inspired by CAViaR, but it is constructed in a way that it is possible to obtain ES forecasts as well as VaR forecasts. (Taylor 2008; Kuan, Yeh et al. 2009). EWQR is also a model that can be used both for VaR and ES forecasting. It have had promising ES results so far, and is therefore an interesting model for further research (Lin 2008; Taylor 2008).

### **2.3 Our Contribution to the Existing Literature**

Not much literature has been written on risk management by VaR or ES for energy commodity futures. Füss et al. (2010) investigated how different VaR models succeeded for futures indices based on commodities, one of which was an energy index. Others have estimated VaR for energy commodities, in particular oil, gas and oil products, but the focus has been on spot prices and not on futures (David Cabedo and Moya 2003; Giot and Laurent 2003; Chan and Gray 2006; Sadeghi and Shavvalpour 2006; Costello, Asem et al. 2008; Hung, Lee et al. 2008; Aloui and Mabrouk 2010). Even less has work has been done on ES models for energy commodities; to our knowledge there has not been published such an article yet.

The scope of this paper is to apply several VaR and ES models to a wide range of energy commodity futures. In this way our study will make an attribution to the existing literature, both in the variety of models used and the type of markets and financial instruments investigated.

In the existing literature, the quantile regression based VaR models, CAViaR and EWQR, and models in the GARCH framework seem the most promising. They have mainly been applied to stock or currency markets. We therefore wish to compare their performance for energy commodity futures as well. Since there exist too many GARCH based models to consider in this paper, we will focus our attention on the standard GARCH(1,1) model as well as one model which take asymmetry into account; the GJR-GARCH(1,1,1) model. Both GARCH models will be implemented with four different error distributions; the normal, student t, GED and skewed student t distributions.

We will use the same models to predict ES as VaR, except CAViaR, from which it is not clear how to obtain ES. It is straightforward to calculate ES with EWQR, using the expression derived by Taylor (2008). With GARCH, ES has so far been calculated numerically or as an average of many VaRs. We wish to expand the existing literature by finding analytical expressions for GARCH based ES models using the four mentioned error distributions. Yamai and Yoshiba (2005) have already derived from the standard normal distribution an ES expression which depends on the standard deviation. We will use the same approach to derive similar expressions for the other distributions and then use GARCH models to estimate the standard deviation in order to forecast ES.

# **3.** Value at Risk and Expected Shortfall Models

14 different models are considered in this paper: GARCH(1,1) and GJR-GARCH (1,1,1) with four different error distributions each, five CAViaR specifications and EWQR. These models are used to produce day-ahead forecasts for both VaR and ES, with the exception of the CAViaR models, from which ES forecasts are not easily obtained. The expected value of the conditional mean is, for simplicity, assumed to be zero unless otherwise stated. Details regarding parameter estimation and derivations are left in appendix A.

#### **3.1 Definitions**

The probability of experiencing a loss higher than  $VaR_{\alpha}$  is  $\alpha$  percent. ES is defined as the expected value of the loss, given that it is greater than  $VaR_{\alpha}$ . Mathematically, this can be expressed as:

$$VaR_{\alpha} = \sup_{x_t} \{x_t | P(X \ge x_t) \ge \alpha\}$$
$$ES_{\alpha} = E[x_t | X > VaR_{\alpha}(X)]$$

Here  $x_t$  represent the  $(1-\alpha)$ th quantile of the distribution of the loss function X. For short positions the loss function is given by the return itself, while for long positions it equals the negative of the return.

#### **3.2 GARCH and GJR-GARCH**

Both GARCH(1,1) and GJR-GARCH(1,1,1) are autoregressive models for conditional variance that take volatility clustering into account. VaR and ES are expected to increase as the volatility in a market increases and vice versa. These models should therefore in theory provide a good basis for VaR and ES estimation. Their conditional variance expressions follow:

$$GARCH(1,1): \qquad \sigma_t^2 = \beta_0 + \beta_1 r_{t-1}^2 + \beta_2 \sigma_{t-1}^2$$
  

$$GJR\text{-}GARCH(1,1,1): \qquad \sigma_t^2 = \beta_0 + \beta_1 r_{t-1}^2 + \beta_2 r_{t-1}^2 I(r_{t-1} < 0) + \beta_3 \sigma_{t-1}^2$$

The difference between the regular GARCH and the GJR-GARCH is that the latter allows the conditional variance to respond asymmetrically for positive and negative returns. In order to estimate the parameters in the expressions above, an error distribution needs to be assumed. Initially the normal distribution was suggested (Bollerslev 1986) but later more heavy tailed or asymmetrical distributions have been more popular, since they tend to fit empirical results better. In this paper four different error distributions are investigated; normal distribution, student t distribution, generalized error distribution (GED) and Hansen's skew student t distribution.

VaR is found from the following expressions, in which  $q_{1-\alpha}$  is the  $(1 - \alpha)$ th-quantile of the assumed error distribution, or in other words the inverse cumulative error distribution at  $(1 - \alpha)$ :

$$\widehat{VaR}_{\alpha,t} = q_{1-\alpha}\widehat{\sigma}_t$$

ES is then calculated from the following formulas:

Normal distribution:

$$\widehat{ES}_{\alpha,t} = \frac{\widehat{\sigma}_t}{\alpha\sqrt{2\pi}} e^{-\frac{q_{1-\alpha}^2}{2}}$$

Student t distribution:

$$\widehat{ES}_{\alpha,t} = \frac{\widehat{\sigma}_t \Gamma\left(\frac{v+1}{2}\right) \sqrt{v-2}}{\alpha \sqrt{\pi} (v-1) \Gamma\left(\frac{v}{2}\right)} \left( \left(1 + \frac{q_{1-\alpha}^2}{\widehat{\sigma}_t^2 (v-2)}\right)^{\frac{1}{2}(1-v)} \right)$$

Generalized error distribution:

$$\widehat{ES}_{\alpha,t} = \frac{\widehat{\sigma}_t \omega 2^{\frac{1}{\nu-1}}}{\alpha \Gamma\left(\frac{1}{\nu}\right)} \Gamma\left(\frac{2}{\nu}, \frac{1}{2}\left(\frac{\widehat{VaR}_{\alpha,t}}{|\lambda \widehat{\sigma}_t|}\right)^{\nu}\right)$$

Skew student t distribution:

$$\begin{split} \widehat{ES}_{\alpha,t} &= \frac{\sigma_t}{ab} \Biggl( I \left( \overline{VaR}_{\alpha,t} < -\frac{a\hat{\sigma}_t}{b} \right) \Biggl( c(1-\lambda)^2 \frac{v-2}{v-1} \Biggl( \left( 1 + \frac{\overline{VaR}_u^2}{(v-2)} \right)^{\frac{1-v}{2}} - 1 \Biggr) + a(1-\lambda) * \\ &\left( F_{SST} (\overline{VaR}_u) - 0.5 \right) + c(1+\lambda)^2 \frac{v-2}{v-1} - \frac{a}{2} (1+\lambda) \Biggr) + I \left( \overline{VaR}_{\alpha,t} \ge -\frac{a\hat{\sigma}_t}{b} \right) \Biggl( c(1+\lambda)^2 * \\ &\frac{v-2}{v-1} \Biggl( 1 + \frac{\overline{VaR}_w^2}{(v-2)} \Biggr)^{\frac{1-v}{2}} - a(1+\lambda) \Biggl( 1 - F_{SST} (\overline{VaR}_w) \Biggr) \Biggr) \Biggr) \end{split}$$

In the previous expressions  $\Gamma(\cdot)$  is the gamma function,  $\Gamma(\cdot, \cdot)$  is the incomplete gamma function,  $I(\cdot)$  is the indicator function,  $F_{SST}(\cdot)$  is the scale family of the cumulative standardized student t distribution,  $\lambda$  and v are parameters that are estimated with maximum likelihood estimation, and

$$\omega = 2^{-\frac{1}{\nu}} \sqrt{\frac{\Gamma(\frac{1}{\nu})}{\Gamma(\frac{3}{\nu})}}, \quad VaR_u = \frac{\frac{bVaR_{\alpha,t}}{\sigma_t} + a}{1 - \lambda}, \\ VaR_w = \frac{\frac{bVaR_{\alpha,t}}{\sigma_t} + a}{1 + \lambda}, \quad a = 4\lambda c \frac{\nu - 2}{\nu - 1}, \quad b^2 = 1 + 3\lambda^2 - a^2 \quad \text{and} \quad c = \frac{\Gamma(\frac{\nu + 1}{2})}{\sqrt{\pi(\nu - 2)}\Gamma(\frac{\nu}{2})}$$

### 3.3 CAViaR

Instead of assuming an error distribution, CAViaR estimates the relevant quantile directly by a form for quantile regression. The intuition of the CAViaR models is that VaR is autoregressive, and that it also depends on the realized losses in one way or another. The five specifications considered are all first-order autoregressive VaR models.

In the Symmetric Absolute Value CAViaR model, VaR depends on the absolute value of the last period's return. This means that positive and negative losses will have the same impact; hence, the specification is symmetric. The Asymmetric Slope CAViaR model, on the other hand, allows positive and negative losses to be weighted differently.

*Symmetric Absolute Value:*  $VaR_{\alpha,t} = \beta_0 + \beta_1 VaR_{\alpha,t-1} + \beta_2 |x_{t-1}|$ 

Asymmetric Slope:

$$VaR_{\alpha,t} = \beta_0 + \beta_1 VaR_{\alpha,t-1} + \beta_2 max[x_{t-1}, 0] - \beta_3 min[x_{t-1}, 0]$$

The Adaptive CAViaR model increases the VaR when a loss in the last period exceeds the corresponding VaR; otherwise it decreases the VaR slightly.

Adaptive: 
$$VaR_{\alpha,t} = VaR_{\alpha,t-1} + \beta_1 [I(x_{t-1} > VaR_{\alpha,t-1}) - \alpha]$$

The Indirect GARCH(1,1) CAViaR model works just like a GARCH(1,1) model, except that an error distribution is not needed to estimate the parameters. The Indirect AR(1)-GARCH(1,1) CAViaR model, which is an extension of the indirect GARCH(1,1) CAViaR model, includes a first-order autoregressive term for the mean equation.

Indirect GARCH(1,1): 
$$VaR_{\alpha,t} = \sqrt{\beta_0 + \beta_1 (VaR_{\alpha,t-1})^2 + \beta_2 x_{t-1}^2}$$

*Indirect* AR(1)-GARCH(1,1):

$$VaR_{\alpha,t} = ax_{t-1} + \sqrt{\beta_0 + \beta_1 (ax_{t-2} - x_{t-1})^2 + \beta_2 (VaR_{\alpha,t-1} - ax_{t-2})^2}$$

#### **3.4 EWQR**

EWQR is another quantile regression based model. The main idea is that past observations influence the future, and that the most resent observations are more relevant than distant ones. Therefore a weighting parameter  $\lambda$  is included in the quantile regression minimization formula, which can be expressed as:

$$\min_{\widehat{VaR}_{\alpha,T+1}} \sum_{t=1}^{T} \lambda^{T-t} (\widehat{VaR}_{\alpha,T+1} - x_t) \left( \alpha - I(x_t > \widehat{VaR}_{\alpha,T+1}) \right)$$

From this expression the VaR forecast follows directly and ES can easily be obtained:

$$\widehat{ES}_{\alpha,T+1} = \frac{1}{\alpha \sum_{t=1}^{T} \lambda^{T-t}} \sum_{t=1}^{T} \lambda^{T-t} \left( \widehat{VaR}_{\alpha,T+1} - x_t \right) \left( \alpha - I(x_t > \widehat{VaR}_{\alpha,T+1}) \right)$$

### 4. Backtesting Value at Risk Forecasts

To assess the accuracy and appropriateness of VaR models, we consider three different tests. The *test for unconditional coverage*, also known as the Kupiec test, checks whether the proportion of losses that are higher than their corresponding VaR is as expected or not (Kupiec 1995). This test rejects models that either overestimate or underestimate VaR (Hung, Lee et al. 2008).

It does not, however, consider whether the extreme returns are randomly distributed or if they appear in clusters (Hung, Lee et al. 2008). This is of particular interest since it is far worse for an investor if the VaR estimates are exceeded many times in a row (Alexander 2008). The problem is addressed by the *test for conditional coverage*, which is a joint test of correct coverage and independence of the violations (Christoffersen 1998). This test rejects models

that either overestimate or underestimate VaR or that generate either too many or too few clustered violations (Hung, Lee et al. 2008).

The third test considered in this paper is the *dynamic quantile* (DQ) *test*. For good VaR models, a VaR violation should be independent of the VaR estimate, as well as earlier VaR violations (Engle and Manganelli 2004). The DQ test checks whether or not this is the case by performing an artificial regression. The form of artificial regression that appears to be used most frequently, is the one that include four lags of VaR violations and the VaR estimate (Engle and Manganelli 1999; Kuester, Mittnik et al. 2006).

Details regarding these tests can be found in appendix B

# **5. Backtesting Expected Shortfall Forecasts**

### 5.1 An Expected Shortfall Test Dependent on VaR Forecasts (DV)

McNeil and Frey (2000) developed a test, in which the difference between the ES forecasts and the realized losses is calculated for observations where the loss is greater than the VaR forecast. These residuals are then standardized. If the ES forecasts are appropriate, the residuals should now have a zero mean, be independent and identically distributed. A bootstrap test, which is explained in appendix B, checks whether or not the mean of the residuals is statistically different from zero. The test can be either one-sided or two-sided; we have considered both cases after following the reasoning of appendix B.

McNeil and Frey (2000) standardize the residuals by the corresponding forecasts of the conditional volatility. Taylor (2008), on the other hand, chooses to use the conditional quantile estimate (the forecasted Value at Risk), since not all models estimate volatility. We follow Taylor's example, and standardize with the VaR forecasts. The standardized residuals,  $z_{\alpha,t}$ , can thus be calculated from the following expression:

$$z_{\alpha,t} = \left\{ \frac{x_t - \widehat{ES}_{\alpha,t}}{\widehat{VaR}_{\alpha,t}} | x_t > \widehat{VaR}_{\alpha,t} \right\}$$

Even though this test has an attractive intuitiveness, it has a weakness; the test results have a strong dependence of the VaR forecasts (Embrechts, Kaufmann et al. 2005). If a model gives terrible VaR forecasts, the ES test results will be poor since only losses greater than the *forecasted* VaR are considered. A test that considers the ES forecasts separately would therefore be more appropriate.

Another problem with this test rises whenever there are few VaR violations. This may be the case for extreme quantiles if the out-of-sample period is not large enough, or if the VaR forecasts are too conservative. Then there are few data to bootstrap, which makes the test results less reliable. In some cases a bootstrap test does not make sense at all, for example when the number of observations is less than two.

### 5.2 An Expected Shortfall Test Independent of VaR Forecasts (IV)

Embrechts, Kaufmann et al. (2005) introduced an ES measure that is independent of the VaR forecasts. They considered the  $\alpha$  % cases in which the difference between the loss and the ES

forecast is the greatest, and calculate the average difference. Ideally the number should be zero, so it should be close to zero for good ES forecasts. Embrechts, Kaufmann et al. do not however state how small the measure should be for the forecasts to be considered adequate.

We propose a test that follows the same intuition of looking at the  $\alpha$  % worst cases, but instead of calculating the average difference, it performs a bootstrap hypothesis test for the differences alone. Since this test evaluates ES forecasts independent of VaR forecasts, we choose to keep it that way by not standardizing by the VaR forecasts as in the previous ES test. Another measure could be used to standardize the residuals, but the results of a bootstrap test will have similar results whether or not the residuals are standardized (McNeil and Frey 2000). We therefore use the following variable as a basis for a bootstrap test.

 $z_{\alpha,t} = \{x_t - \widehat{ES}_{\alpha,t} | x_t - \widehat{ES}_{\alpha,t} > D_{\alpha}\}, \text{ where } D_{\alpha} \text{ is the } \alpha \text{-th quantile of } x_t - \widehat{ES}_{\alpha,t}.$ 

# 6. Data and Descriptive Statistics

The data considered in this paper are prices of monthly, quarterly and yearly first position energy futures from EEX, NASDAQ OMX (Nord Pool), ICE and NYMEX; monthly peak electricity, brent crude oil, light crude oil, heating oil, gasoline, coal and gas futures, quarterly carbon futures and yearly peak electricity and carbon futures. In total this yields 14 different futures. The prices are gathered from the Reuters EcoWin Pro database.

The focus has been on the returns  $r_t$ , which can be defined as the logarithmic difference of the price from one day to another (Taylor 2005);  $r_t=ln(P_t/P_{t-1})$ . Since daily returns are generally small in monetary units, they have been multiplied by 100 to avoid numerical errors in computer programs. Each price change between the last trading day of a futures contract and the first trading day of the subsequent contract has been excluded from the data set. This is because such price changes are not genuine returns; no trader will ever experience them. Each futures contract has its own rule for when the last trading day occur. The specific rules for the contracts considered in this paper are left in appendix C.

The length of the return series varies between 927 and 3500 data points. In appendix D a table with the length, start date and end date of each series is given, together with a table with descriptive statistics for all series. The last 500 observations are left as an out-of-sample period, against which the models' forecasting performance is backtested.

The means of all the return series are close to zero and the standard deviations are high compared to the means. This indicates that the returns are very volatile. Typical standard deviations for stocks and stock indices are between 0.7% and 2% for daily returns (Taylor 2005). In this study the standard deviations vary between 0.9% and 5.7%. 13 of the 14 commodity futures contracts in this paper have a standard deviation greater than 2%, which suggests that they are more volatile than stocks. The contract with lowest standard deviation is the yearly electricity futures. This makes sense, since the length of the contract makes it less sensitive to short term price variations. The most volatile contract, on the other hand, is the monthly electricity futures on NYMEX.

The kurtosis of the series ranges in value from 4.6 to 40.5. This is significantly higher than the kurtosis of a standard normal distribution, which is 3. A distribution which has a kurtosis higher than 3 is called leptokurtic, which implies a high peak around the mean and fat tails. In

other words, there are many returns close to zero as well as numerous extreme returns. All of the series considered are leptokurtic, which contributes to making forecasting a more challenging task.

Comparing the maximum and minimum values with the median supports the notion of having a leptokurtic distribution of the returns. With the exception of yearly electricity futures, all the contracts have some returns with absolute value above 10%. A few of them also display returns well above 30%. The median, on the other hand is very close to zero.

The skewness of the returns varies between -1.4 and 1.9, which means that some of the series are skewed to the right and others to the left. With exception of the electricity futures, all futures for the same commodity are skewed to the same side regardless of which market they are traded on. For example do oil and all oil products have negative skewness, while both gas futures contracts have a positive skewness.

The Jarque-Bera and augmented Dickey-Füller tests refute the null hypothesis of normality and unit root for all the return series, as expected both a priori and after considering the other descriptive statistics.

According to the Ljung-Box test a majority of the futures display autocorrelation within the first five lags, and for the squared returns all of the futures show signs of autocorrelation. This is consistent with the findings of Aloui and Mabrouk (2010) on crude oil and gas commodities and might be explained by the characteristics of energy commodity price behavior; such as mean reversion and spikes (Deng 2000).

Some of the return series display significant difference between the in- and out-of-sample periods. In appendix D the descriptive statistics for both are given. The general trend is that the series are less volatile in the out-of-sample period, with less extreme values and lower standard deviation. The financial crises occurred during the in-sample period, while the out-of sample period is post-crises. This might contribute to the observed difference. Most of the in-sample periods are however larger than the out-of-sample periods, and are therefore more likely to include extreme values.

# 7. Empirical Results

500 day-ahead VaR and ES forecast are obtained with each of the 14 models for six different quantiles in the return distribution; 1%, 5%, 10%, 90%, 95% and 99%. This corresponds to the 90%, 95% and 99% quantiles in the loss distribution for long and short trading positions, respectively. The number of forecasts is consistent with Engle and Manganelli (2004) and Taylor (2008), and corresponds to around two years of trading. The forecasts are obtained by rolling the sample window and re-estimating the parameters each day for the EWQR and the GARCH models. The parameters are not re-estimated for the CAViaR models, because of limited computing capacity<sup>1</sup>.

In the following subsections each model is evaluated for both VaR and ES results. In appendix E all the details regarding the test results are given for further study. There does not

<sup>&</sup>lt;sup>1</sup>To re-estimate the five CAViaR models' parameters 500 times for each of the 14 futures would require more than three weeks of continuous computations with an average personal computer.

seem to be a clear pattern in which some models are better suited for certain markets or commodities. The results are therefore presented by model rather than market or commodity.

### 7.1 VaR Results

The VaR models are tested by the three tests described in section 4. Of these, we focus on the results from the coverage tests, since, in our opinion, it is more important for a VaR model to be correctly specified and thus predicting the proportion of losses that exceed VaR correctly, than it is that the probability of a VaR violation is independent of the VaR itself. The coverage tests will therefore be used to assess the appropriateness of the VaR models, while the DQ test will serve as a secondary comparable value in case several models have equally good performance in the coverage tests.

The conditional coverage test does however have a weakness. For the extreme quantiles it is unlikely to witness two consecutive VaR violations, and the test is therefore not able to give a result for these. In order to use the test results in a productive way we will focus on the number of quantiles that pass the test at 5% significance level. The results from the unconditional coverage test and DQ test are more complete, and easier to use for model comparison.

None of the models considered perform well for every return series, and it is not one model that clearly outperforms the others. However, there are some conclusions that can be drawn. The most accurate models are the EWQR, the adaptive CAViaR and the GARCH and GJR-GARCH models with student t and skewed student t distributions. GARCH and GJR-GARCH with normal distribution are the two worst performing VaR models.

### 7.1.1 VaR Results for EWQR

EWQR is the model that performs best for both gasoline and heating oil on NYMEX. On five of the fourteen return series the model fails none of the quantiles in the unconditional coverage test at 10% significance level, and in total EWQR slightly outperforms the other models according to this test. With a 5% confidence level it fails 13 of the 84 quantiles considered. It is also the model with the highest number of non-failing quantiles in the conditional coverage test. It is on the dynamic quantile test that EWQR has its worst performance. Out of the fourteen models considered, it is the one with the lowest score.

### 7.1.2 VaR Results for CAViaR

The *symmetric absolute value* CAViaR is together with the *indirect GARCH* CAViaR the models with worst performance. The latter is the best performing model for coal on ICE and light crude oil on NYMEX, but falls through on the rest. Both models have only two series where they clear the unconditional coverage test, and they have the lowest count of reliable quantiles in the conditional coverage test. In the dynamic quantile test they perform in the mid-range.

The *indirect AR-GARCH* CAViaR model can be categorized together with these models. It performs below par for both coverage tests. It is however one of the best models to make sure that the forecast is independent of the previous VaR estimates and violations, according to the dynamic quantile test.

The *asymmetric slope* CAViaR performs slightly better than the *symmetric absolute value*, which is to be expected as it can weigh positive and negative returns differently. It is the best model for carbon futures on NASDAQ OMX and coal futures on NYMEX and it also handles the dynamic quantile test well. Still, it does not perform well on the coverage tests.

The *adaptive* CAViaR is that of the CAViaR models that is most reliable. With exception of the futures for brent crude oil, heating oil and light crude oil, where it fails severely, it has a very stable performance in the coverage tests. It is the best overall model for monthly electricity futures on ICE and EEX and for gas on ICE. Just like EWQR, the problem for the *adaptive* CAViaR is the dynamic quantile test, where it underperforms all the other CAViaR models. Much of the explanation lies in the fact that it is an adaptive model. Once the VaR is breached, it increases significantly, while it decreases slightly otherwise. This makes consecutive breaches of VaR less likely in volatile periods.

Because the parameters in the CAViaR models are not re-estimated, it is natural to assume that they will fit worse the longer the out-of-sample period is. If the parameters were re-estimated for every forecast, the models would probably have a better performance since it would adapt better to changes in the market.

### 7.1.3 VaR Results for GARCH and GJR-GARCH

The GARCH with normal distribution is the worst performing VaR model considered in this paper. For one of the futures, gas on NYMEX, it passes all the tests. However, several other models do the same, and the test results indicate that this is the easiest series to forecast. Other than that, it has a generally poor performance. The same can be said for the GJR-GARCH with normal distribution.

With Student t distribution the models are significantly improved. The GARCH and GJR-GARCH are the best models for gas futures and electricity futures on NYMEX respectively. The performance is stable and high, both for the coverage tests and the dynamic quantile test. The models with student t distribution prove to be a valid and more reliable alternative for VaR forecasting.

There are no futures series where either of the models with GED distribution are the best models. Overall, they perform better than the models with normal distribution and most of the CAViaR models, but worse than the other models. They distinguish themselves only on the DQ test, where they perform better than most other models.

The GARCH model with skewed student t distribution is the best model for carbon futures on EEX and light crude oil on NYMEX. It passes the unconditional coverage test perfectly for five return series, and is one of the best models both on the coverage tests and the dynamic quantile test. The GJR-GARCH with the same distribution has the best test results for yearly electricity futures on EEX and monthly electricity futures and light crude oil futures on NYMEX. Other than that the performance is quite similar to that of the ordinary GARCH model. Both have five return series where they have no p-values under 10% on the unconditional coverage test.

In our results there is little difference between the GJR-GARCH and the ordinary GARCH when they have the same distribution; the GARCH model actually has a slightly better performance. As the GJR-GARCH is more complicated and requires more computational

power, this leads us to suggest that the GARCH model should be preferred for VaR forecasting.

### 7.2 ES Results

The ES forecasts were tested by the one- and two-sided tests described in section 5. In the following we denote the tests dependent on VaR by DV, and the tests that are independent of the VaR forecasts by IV. The two-sided tests concern whether or not the forecast is correct, while the one-sided tests check if the forecast is underestimated or not. If a model obtains good results in the one-sided tests and poor results in the two-sided tests, it is an indication of overestimated ES forecasts.

The IV tests prove to be stricter than the DV tests, since they reject the null hypotheses more often regardless of which model or market is considered. When there is a great difference between a model's performance in the DV and IV tests, this might be explained by the model having incorrect VaR forecast.

The EWQR model has superior performance to the other models when the two-sided tests are considered. The GARCH and GJR-GARCH models with GED distribution pass almost every quantile for every futures contract in the traditional one-sided tests, but fail to a great extent at the two-sided tests. This suggests that they consistently overestimate ES.

### 7.2.1 ES Results for EWQR

EWQR is by far the model that performs best. In the DV tests it passes for every quantile for 11 and 12 of the futures for the two- and one-sided respectively. Only for one quantile is the p-value below 5%. In the two-sided IV test EWQR pass every quantile for four series at a 10% significance level. With the exception of GJR-GARCH with a skewed student t distribution, the other models pass every quantile for at most one series. EWQR has the worst performance in the one-sided IV test, which suggests that ES is underestimated. Considering the results from the two-sided test, the underestimation is however not large enough that the ES forecasts are statistically different from the realized shortfalls. Of the models considered in this paper, EWQR is the best at forecasting ES.

### 7.2.2 ES Results for GARCH and GJR-GARCH

The GJR-GARCH model performs slightly worse than the GARCH model for almost all the distributions. This further promotes the notion from the VaR analysis, that there is no point in using the GJR version instead of an ordinary GARCH.

The GARCH model with normal distribution is surprisingly enough the one that performs best in the two-sided tests. With student-t distribution the GARCH model performs well for the one-sided tests, but falls through on both two-sided tests. The GARCH model with skewed student t distribution does not perform better than that with a student t. GARCH with GED distribution is the model with the worst results in the two-sided tests, but it excels in the one-sided. In other words, the model consistently overestimates ES. An extremely risk averse investor could choose this model, but it would lead to unprofitable allocation of capital.

# 8. Concluding Remarks

Energy markets differ from traditional financial markets due to the nature of production and consumption. This makes risk modelling a challenging and important task. The approach taken in this paper is to consider different models for two popular risk measures, Value at Risk and Expected Shortfall, in an attempt to model risk for energy commodity futures. We have considered 14 different first position energy futures contracts from NYMEX, NASDAQ OMX, ICE and EEX, and estimated VaR and ES for three different quantiles for both long and short trading positions.

This paper's attribution to the existing literature lies both in the variety of models used and the type of markets and financial instruments investigated. In total 14 different VaR models and nine different ES models are evaluated; GARCH and GJR-GARCH with normal, student t, GED and skewed student t distributions and EWQR have been used to obtain both VaR and ES forecasts. In addition, five CAViaR models have been used in the VaR analysis.

In general, the GJR-GARCH model performs slightly worse than the GARCH model, both for VaR and ES. As the GJR-GARCH is more complicated and requires more computational power, the GARCH model should be preferred. EWQR is by far the best ES model. It has very good test results for all markets and quantiles considered. The GARCH and GJR-GARCH models with GED distribution perform well for the one-sided ES tests, as they do not underestimate ES. They are on the other hand the worst ES models according to the two-sided tests. In other words, they are consistently overestimating ES.

It is not as straightforward to generalize the VaR results, as none of the VaR models perform well for every return series, and there is not one model that clearly outperforms the others. The results vary greatly, and there does not appear to be any clear pattern in which some models are better suited for certain markets or commodities. The models with best performance overall are however EWQR, the adaptive CAViaR and GARCH and GJR-GARCH models with student t and skewed student t distributions. GARCH and GJR-GARCH with normal distribution are the two worst performing VaR models.

A natural extension of the analysis done in this paper would be to compare more models. Additional models should preferably be able to forecast both VaR and ES. A second strategy could be to improve the already considered models. It is possible to extend the EWQR model by including exogenous regressors. The CAViaR models' performance would probably be better if the parameters were re-estimated in a rolling window, as for the other models. In order to avoid the problem of computing capacity the parameters could have been re-estimated periodically instead of every day. There are also several other GARCH based models or error distributions that could be implemented. Another extension that could be relevant, particularly to risk managers that want to assess the risk of whole portfolios, is to consider multivariate VaR and ES models.

### References

- Acerbi, C. and D. Tasche (2002). "Expected Shortfall: A Natural Coherent Alternative to Value at Risk." <u>Economic Notes</u> **31**(2): 379-388.
- Alexander, C. (2008). Practical Financial Econometrics, John Wiley & Sons Ltd.
- Aloui, C. and S. Mabrouk (2010). "Value-at-risk estimations of energy commodities via long-memory, asymmetry and fat-tailed GARCH models." <u>Energy Policy</u> **38**(5): 2326-2339.
- Angelidis, T., A. Benos, et al. (2004). "The use of GARCH models in VaR estimation." <u>Statistical</u> <u>Methodology</u> **1**(1-2): 105-128.
- Angelidis, T. and S. A. Degiannakis (2006). "Backtesting VaR Models: An Expected Shortfall Approach." <u>SSRN eLibrary</u>.
- Beder, T. S. (1995). "VAR: Seductive but Dangerous." Financial Analysts Journal 51(5): 12-24.
- Beine, M., A. Bénassy-Quéré, et al. (2002). "Central bank intervention and foreign exchange rates: new evidence from FIGARCH estimations." <u>Journal of International Money and Finance</u> 21(1): 115-144.
- Bertsimas, D., G. J. Lauprete, et al. (2004). "Shortfall as a risk measure: properties, optimization and applications." Journal of economic dynamics & control **28**(7): 1353.
- Bollerslev, T. (1986). "Generalized Autoregressive Conditional Heteroskedasticity." <u>Journal of</u> <u>Econometrics</u>: 307-327.
- Bollerslev, T. (1987). "A Conditionally Heteroskedastic Time Series Model for Speculative Prices and Rates of Return." <u>The Review of Economics and Statistics</u> **69**(3): 542-547.
- Bollerslev, T., J. Russell, et al. (2010). <u>Volatility and Time Series Econometrics: Essays in Honor of</u> <u>Robert Engle</u>. Oxford, Oxford University Press.
- Boudoukh, J., M. Richardson, et al. (1998). "The Best of Both Worlds: A Hybrid Approach to Calculating Value at Risk." <u>Risk</u> **11**(5).
- Byström, H. N. E. (2005). "Extreme value theory and extremely large electricity price changes." International Review of Economics & Finance **14**(1): 41-55.
- Cai, Z. and X. Wang (2008). "Nonparametric estimation of conditional VaR and expected shortfall." Journal of Econometrics **147**(1): 120-130.
- Caillault, C. and D. Guégan (2009). "Forecasting VaR and Expected Shortfall Using Dynamical Systems: A Risk Management Strategy." <u>Frontiers in Finance and Economics</u> **6**(1): 26-50.
- Chan, K. F. and P. Gray (2006). "Using extreme value theory to measure value-at-risk for daily electricity spot prices." <u>International Journal of Forecasting</u> **22**(2): 283-300.
- Chen, S. X. (2008). "Nonparametric Estimation of Expected Shortfall." <u>Journal of Financial</u> <u>Econometrics</u> **6**(1): 87-107.
- Christoffersen, P. F. (1998). "Evaluating Interval Forecasts." <u>International Economic Review</u> **39**(4): 841-862.
- CME Group (2008). New Energy. <u>CME Group Magazine</u>. Chicago.
- Costello, A., E. Asem, et al. (2008). "Comparison of historically simulated VaR: Evidence from oil prices." <u>Energy Economics</u> **30**(5): 2154-2166.
- David Cabedo, J. and I. Moya (2003). "Estimating oil price 'Value at Risk' using the historical simulation approach." <u>Energy Economics</u> **25**(3): 239-253.
- Deng, S. (2000). Stochastic Models of Energy Commodity Prices and Their Applications: Meanreversion with Jumps and Spikes. Berkeley, University of California.
- Dowd, K. (2002). <u>Measuring Market Risk</u>. New York, John Wiley & Sons Ltd.
- Efron, B. and R. Tibshirani (1993). An introduction to the bootstrap, Chapman & Hall.
- Embrechts, P., R. Kaufmann, et al. (2005). "Strategic Long-Term Financial Risks: Single Risk Factors." <u>Computational Optimization and Applications</u> **32**(1): 61-90.
- Embrechts, P., C. Klüppelberg, et al. (1996). <u>Modelling Extremal Events for Insurance and Finance</u>, Springer.Verlag.

Engle, R. F. (1982). "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation." <u>Econometrica</u> **50**(4): 987-1007.

- Engle, R. F. and S. Manganelli (1999). "CAViaR: Conditional Value at Risk by Quantile Regression." <u>National Bureau of Economic Research Working Paper Series</u> No. 7341(published as Robert F. Engle & Simone Manganelli, 2004. "CAViaR: Conditional Autoregressive Value at Risk by Regression Quantiles," Journal of Business & Economic Statistics, American Statistical Association, vol. 22, pages 367-381, October.).
- Engle, R. F. and S. Manganelli (2004). "CAViaR." Journal of Business and Economic Statistics 22(4): 367-381.
- European Energy Exchange AG (2009). <u>Annual Report 2009</u>. Leipzig.
- Füss, R., Z. Adams, et al. (2010). "The predictive power of value-at-risk models in commodity futures markets." Journal of Asset Management **11**(4): 261-285.
- Giot, P. and S. Laurent (2003). "Value-at-Risk for long and short trading position." <u>Journal of Applied</u> <u>Econometrics</u> **18**(6): 641-664.
- Gupta, A. and B. Liang (2005). "Do hedge funds have enough capital? A value-at-risk approach." Journal of Financial Economics **77**(1): 219-253.
- Hansen, B. E. (1994). "Autoregressive Conditional Density Estimation." <u>International Economic</u> <u>Review</u> **35**(3): 705-730.
- Harmantzis, F. C., L. Miao, et al. (2006). "Empirical study of value-at-risk and expected shortfall models with heavy tails." <u>The Journal of Risk Finance</u> **7**(2): 117-135.
- Harvey, C. R. and A. Siddique (1999). "Autoregressive Conditional Skewness." <u>The Journal of Financial</u> <u>and Quantitative Analysis</u> **34**(4): 465-487.
- Huang, Y. C. and B.-J. Lin (2004). "Value-at-Risk Analysis for Taiwan Stock Index Futures: Fat Tails and Conditional Asymmetries in Return Innovations." <u>Review of Quantitative Finance and</u> <u>Accounting</u> 22(2): 79-95.
- Hung, J.-C., M.-C. Lee, et al. (2008). "Estimation of value-at-risk for energy commodities via fat-tailed GARCH models." <u>Energy Economics</u> **30**(3): 1173-1191.
- Härdle, W. and J. Mungo (2008) "Value-at-Risk and Expected Shortfall when there is long range dependence."
- ICE. (2011). "Global Commodity, Currency, Credit & Equity Index Markets." Retrieved 19.05, 2011, from https://www.theice.com/about.jhtml.
- Inui, K. and M. Kijima (2005). "On the significance of expected shortfall as a coherent risk measure." Journal of Banking & Finance **29**(4): 853-864.
- Kuan, C.-M., J.-H. Yeh, et al. (2009). "Assessing value at risk with CARE, the Conditional Autoregressive Expectile models." Journal of Econometrics **150**(2): 261-270.
- Kuester, K., S. Mittnik, et al. (2006). "Value-at-Risk Prediction: A Comparison of Alternative Strategies." Journal of Financial Econometrics **4**(1): 53-89.
- Kupiec, P. H. (1995). "Techniques for Verifying the Accuracy of Risk Measurement Models." <u>Journal of</u> <u>Derivatives</u> **3**(2): 73.
- Lan, H., B. L. Nelson, et al. (2010). "A Confidence Interval Procedure for Expected Shortfall Risk Measurement via Two-Level Simulation." <u>OPERATIONS RESEARCH</u> **58**(5): 1481-1490.
- Lin, G.-H. (2008). Momentum Strategy: Application and Modification of VaR. <u>Grad-Finance</u>, Ming Chuan University: 100.
- Manganelli, S. and R. F. Engle (2001) "Value at Risk Models in Finance." SSRN eLibrary.
- Mapa, D. S. and O. Q. Suaiso (2009) "Measuring market risk using extreme value theory."
- Marinelli, C., S. D'Addona, et al. (2007). "A Comparison of Some Univariate Models for Value-at-Risk and Expected Shortfall." <u>International Journal of Theoretical and Applied Finance</u> **10**(6): 1043-1075.
- McNeil, A. J. and R. Frey (2000). "Estimation of tail-related risk measures for heteroscedastic financial time series: an extreme value approach." <u>Journal of Empirical Finance</u> **7**(3-4): 271-300.
- Nasdaq OMX. (2011). "Our History." Retrieved 19.05, 2011, from http://www.nasdaqomxcommodities.com/about/ourhistory/.

- Nelson, D. B. (1991). "Conditional Heteroskedasticity in Asset Returns: A New Approach." <u>Econometrica</u> **59**(2): 347-370.
- Pilipovic, D. (2007). Energy risk. New York, McGraw-Hill.
- Rockafellar, R. T. and S. Uryasev (2002). "Conditional value-at-risk for general loss distributions." Journal of Banking & Finance 26(7): 1443-1471.
- Sadeghi, M. and S. Shavvalpour (2006). "Energy risk management and value at risk modeling." <u>Energy</u> <u>Policy</u> **34**(18): 3367-3373.
- Sheedy, E. (2009). "Can risk modeling work?" Journal of Financial Transformation 27: 82-87.
- Subbotin, M. T. (1923). "On the Law of Frequency of Error." <u>Matematicheskii Sbornik</u> **31**(2): 296-301.
- Taylor, J. W. (2007). "Forecasting Daily Supermarket Sales Using Exponentially Weighted Quantile Regression." <u>European Journal of Operational Research</u> **178**: 154-167.
- Taylor, J. W. (2008). "Estimating Value at Risk and Expected Shortfall Using Expectiles." Journal of <u>Financial Econometrics</u> 6(2): 231-252.
- Taylor, J. W. (2008). "Using Exponentially Weighted Quantile Regression to Estimate Value at Risk and Expected Shortfall." Journal of Financial Econometrics **6**: 382-406.
- Taylor, S. J. (2005). <u>Asset Price Dynamics, Volatility, and Prediction</u>. New Jersey, Princeton University Press.
- Verhoeven, P. and M. McAleer (2004). "Fat tails and asymmetry in financial volatility models." <u>Mathematics and Computers in Simulation</u> **64**(3-4): 351-361.
- Yamai, Y. and T. Yoshiba (2005). "Value-at-risk versus expected shortfall: A practical perspective." Journal of Banking & Finance **29**(4): 997-1015.

### **Appendix A: Estimating VaR and ES**

#### A.1 GARCH

GARCH(1,1) can be expressed as the following two equations (assuming a conditional mean of zero):

$$r_t = \varepsilon_t, \qquad \varepsilon_t \sim IID(0, \sigma_t^2)$$
$$\sigma_t^2 = \beta_0 + \beta_1 r_{t-1}^2 + \beta_2 \sigma_{t-1}^2$$

In the same way, GJR-GARCH(1,1,1) can be expressed as:

$$\begin{aligned} r_t &= \varepsilon_t, \qquad \varepsilon_t \sim IID(0, \sigma_t^2) \\ \sigma_t^2 &= \beta_0 + \beta_1 r_{t-1}^2 + \beta_2 r_{t-1}^2 I(r_{t-1} < 0) + \beta_3 \sigma_{t-1}^2 \end{aligned}$$

In these expressions,  $\beta_i \ge 0 \forall i$ , so that the variance is non-negative. IID means "identically and independently distributed", and I(·) is the indicator function, which is one when the expression between the parentheses are valid and zero otherwise. An error distribution needs to be specified in order to estimate the parameters. In this paper four distributions are considered: the normal distribution, student t, GED and skewed student t. In the next sections the log-likelihood function for each of the distributions is derived. This expression needs to be maximized in order to obtain parameter estimates. The maximization is done numerically.

When an error distribution is assumed it is also possible to derive expressions for ES. This is also presented for each distribution in the following sections.

#### A.1.1 Assuming a Normal Error Distribution

Let  $f_{SN}$  denote the standard normal distribution.

$$f_{SN}(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}}$$

The scale-family of the standard normal distribution,  $f_N$ , which has a mean zero and a variance  $\sigma_t$  that is allowed to change with time, can then be found as:

$$f_N(x_t) = \frac{1}{\sigma_t} f_{SN}\left(\frac{x_t}{\sigma_t}\right) = \frac{1}{\sigma_t \sqrt{2\pi}} e^{-\frac{x_t^2}{2\sigma_t^2}}$$

From this the maximum likelihood function L follows:

$$L = \prod_{t=1}^{T} \frac{1}{\sigma_t \sqrt{2\pi}} e^{-\frac{x_t^2}{2\sigma_t^2}}$$

Taking the natural logarithm of this yields the log-likelihood function:

$$l = \ln(L) = T\ln(1) - \frac{T}{2}\ln 2\pi - \frac{T}{2}\ln \sigma_t^2 - \frac{1}{2}\sum_{t=1}^T \left(\frac{r_t^2}{\sigma_t^2}\right) = -\sum_{t=1}^T \frac{1}{2}(\ln 2\pi + \ln \sigma_t^2 + \frac{r_t^2}{\sigma_t^2}),$$

where the relevant expression for the conditional variance is inserted for  $\sigma_t^2$ . The derivation of ES from a GARCH with normal distribution follows.

$$\begin{split} ES_{\alpha,t} &= E\left[X_t | x_t \ge VaR_{\alpha,t}\right] = \frac{E\left[x_t * I(x_t \ge VaR_{\alpha,t})\right]}{\alpha} = \frac{1}{\alpha} \int_{VaR_{\alpha,t}}^{\infty} x_t f_N(x_t) \, dx_t \\ &= \frac{1}{\alpha} \left[\frac{1}{\sigma_t \sqrt{2\pi}} \int_{VaR_{\alpha,t}}^{\infty} x_t e^{-\frac{x_t^2}{2\sigma_t^2}} dx_t\right] = \frac{1}{\alpha \sigma_t \sqrt{2\pi}} \left[-\sigma_t^2 e^{-\frac{x_t^2}{2\sigma_t^2}}\right]_{VaR_{\alpha,t}}^{\infty} \\ &= \frac{\sigma_t}{\alpha \sqrt{2\pi}} e^{-\frac{VaR_{\alpha,t}^2}{2\sigma_t^2}} = \frac{\sigma_t}{\alpha \sqrt{2\pi}} e^{-\frac{q_{1-\alpha}^2 \sigma_t^2}{2\sigma_t^2}} = \frac{\sigma_t}{\alpha \sqrt{2\pi}} e^{-\frac{q_{1-\alpha}^2}{2\sigma_t^2}} \end{split}$$

To obtain a numerical value, the estimated volatility  $\sigma_t$  which is found from a GARCH or GJR-GARCH model is inserted in this expression.

#### A.1.2 Assuming a Student t Error Distribution

The student t distribution allows for the tails to be heavier than the normal distribution. Let  $f_{SST}$  denote the standardized student t distribution, with v > 2 degrees of freedom.

$$f_{SST}(x) = \frac{\Gamma(\frac{v+1}{2})}{\sqrt{\pi(v-2)}\Gamma(\frac{v}{2})} \left(1 + \frac{x^2}{(v-2)}\right)^{-\frac{1}{2}(v+1)}$$

The scale-family of the standardized student t distribution,  $f_{ST}$ , which has a mean zero and a variance  $\sigma_t$  that is allowed to change with time, can then be found as:

$$f_{ST}(x_t) = \frac{1}{\sigma_t} f_{SST}\left(\frac{x_t}{\sigma_t}\right) = \frac{\Gamma\left(\frac{\nu+1}{2}\right)}{\sigma_t \sqrt{\pi(\nu-2)}\Gamma\left(\frac{\nu}{2}\right)} \left(1 + \frac{{x_t}^2}{{\sigma_t}^2(\nu-2)}\right)^{-\frac{1}{2}(\nu+1)}$$

From this the maximum likelihood function L follows:

$$L = \prod_{t=1}^{T} \frac{\Gamma\left(\frac{\nu+1}{2}\right)}{\sigma_t \sqrt{\pi(\nu-2)} \Gamma\left(\frac{\nu}{2}\right)} \left(1 + \frac{{x_t}^2}{{\sigma_t}^2(\nu-2)}\right)^{-\frac{1}{2}(\nu+1)}$$

Taking the natural logarithm of this yields the log-likelihood function:

$$l = T\left(\ln\Gamma\left(\frac{v+1}{2}\right) - \ln\Gamma\left(\frac{v}{2}\right) - \frac{1}{2}\ln(\pi(v-2))\right) - \frac{1}{2}\sum_{t=1}^{T}\ln\sigma_{t}^{2} - \frac{v+1}{2}\sum_{t=1}^{T}\ln\left(1 + \frac{r_{t}^{2}}{\sigma_{t}^{2}(v-2)}\right)$$

The derivation of ES from a GARCH with student t distribution follows.

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$$\begin{split} ES_{\alpha,t} &= E\left[X_{t}|x_{t} \geq VaR_{\alpha,t}\right] = \frac{E\left[x_{t} * I\left(x_{t} \geq VaR_{\alpha,t}\right)\right]}{\alpha} = \frac{1}{\alpha} \int_{VaR_{\alpha,t}}^{\infty} x_{t} f_{ST}(x_{t}) \, dx_{t} \\ &= \frac{1}{\alpha} \int_{VaR_{\alpha,t}}^{\infty} x_{t} \frac{\Gamma\left(\frac{V+1}{2}\right)}{\sqrt{\pi(\nu-2)}\Gamma\left(\frac{V}{2}\right)\sigma_{t}} \left(\left(1 + \frac{x_{t}^{2}}{\sigma_{t}^{2}(\nu-2)}\right)^{-\frac{1}{2}(\nu+1)}\right) dx_{t} \\ &= \frac{\Gamma\left(\frac{V+1}{2}\right)}{\alpha\sigma_{t}\sqrt{\pi(\nu-2)}\Gamma\left(\frac{V}{2}\right)} \left[\frac{\sigma_{t}^{2}(\nu-2)\left(1 + \frac{x_{t}^{2}}{\sigma_{t}^{2}(\nu-2)}\right)^{\frac{1}{2}(1-\nu)}}{1-\nu}\right]_{VaR_{\alpha,t}}^{\infty} \\ &= \frac{\sigma_{t}\Gamma\left(\frac{V+1}{2}\right)\sqrt{\nu-2}}{\alpha\sqrt{\pi}(1-\nu)\Gamma\left(\frac{V}{2}\right)} \left(-\left(1 + \frac{VaR_{\alpha,t}^{2}}{\sigma_{t}^{2}(\nu-2)}\right)^{\frac{1}{2}(1-\nu)}\right) \\ &= \frac{\sigma_{t}\Gamma\left(\frac{V+1}{2}\right)\sqrt{\nu-2}}{\alpha\sqrt{\pi}(\nu-1)\Gamma\left(\frac{V}{2}\right)} \left(\left(1 + \frac{q_{1-\alpha}^{2}\sigma_{t}^{2}}{\sigma_{t}^{2}(\nu-2)}\right)^{\frac{1}{2}(1-\nu)}\right) \\ &= \frac{\sigma_{t}\Gamma\left(\frac{V+1}{2}\right)\sqrt{\nu-2}}{\alpha\sqrt{\pi}(\nu-1)\Gamma\left(\frac{V}{2}\right)} \left(\left(1 + \frac{q_{1-\alpha}^{2}}{\sigma_{t}^{2}(\nu-2)}\right)^{\frac{1}{2}(1-\nu)}\right) \end{split}$$

#### A.1.3 Assuming a Generalized Error Distribution

The Generalized Error Distribution (GED) is a symmetrical distribution that allows the tails to be either thin or thick, and includes the normal distribution as a special case. Let  $f_{SGED}$  denote the standardized GED with  $v \ge 1$  degrees of freedom.

$$f_{SGED}(x) = \frac{v}{\omega \Gamma\left(\frac{1}{v}\right) 2^{1+\frac{1}{v}}} x e^{-\frac{1}{2}\left|\frac{x}{\omega}\right|^{v}}$$

where  $\omega = 2^{-\frac{1}{v}} \sqrt{\frac{\Gamma(\frac{1}{v})}{\Gamma(\frac{3}{v})}}$ 

The scale-family of the standardized GED,  $f_{GED}$ , which has a mean zero and a variance  $\sigma_t$  that is allowed to change with time, can then be found as:

$$f_{GED}(x_t) = \frac{1}{\sigma_t} f_{SGED}\left(\frac{x_t}{\sigma_t}\right) = \frac{v}{\sigma_t \omega \Gamma\left(\frac{1}{v}\right) 2^{1+\frac{1}{v}}} x_t e^{-\frac{1}{2}\left|\frac{x_t}{\omega \sigma_t}\right|^v}$$

From this the maximum likelihood function L follows:

$$L = \prod_{t=1}^{T} \frac{v}{\sigma_t \omega \Gamma\left(\frac{1}{v}\right) 2^{1+\frac{1}{v}}} x_t e^{-\frac{1}{2} \left|\frac{x_t}{\omega \sigma_t}\right|^v}$$

Taking the natural logarithm of this yields the log-likelihood function:

$$l = T\left(\ln(v) - \ln(\omega) - \ln\Gamma\left(\frac{1}{v}\right) - \left(1 + \frac{1}{v}\right)\ln 2\right) - \frac{1}{2}\sum_{t=1}^{T} \ln\sigma_t^2 - \frac{1}{2}\sum_{t=1}^{T} \left|\frac{x_t}{\omega\sigma_t}\right|^v$$

The derivation of ES from a GARCH with GED follows.

$$ES_{\alpha,t} = E[X_t | x_t \ge VaR_{\alpha,t}] = \frac{E[x_t * I(x_t \ge VaR_{\alpha,t})]}{\alpha} = \frac{1}{\alpha} \int_{VaR_{\alpha,t}}^{\infty} x_t f(x_t) dx_t$$
$$= \frac{1}{\alpha} \int_{VaR_{\alpha,t}}^{\infty} \frac{v}{\omega \sigma_t \Gamma\left(\frac{1}{v}\right) 2^{1+\frac{1}{v}}} x_t e^{-\frac{1}{2}\left|\frac{x_t}{\omega \sigma_t}\right|^v} dx_t$$
$$= \frac{v}{\alpha \omega \sigma_t \Gamma\left(\frac{1}{v}\right) 2^{1+\frac{1}{v}}} \int_{VaR_{\alpha,t}}^{\infty} x_t e^{-\frac{1}{2}\left|\frac{x_t}{\omega \sigma_t}\right|^v} dx_t$$

Since  $VaR_{\alpha,t} > 0$ , the absolute value sign for  $x_t$  is unnecessary in this interval. Thus,

$$\begin{split} ES_{\alpha,t} &= \frac{\nu}{\alpha\omega\sigma_t\Gamma\left(\frac{1}{\nu}\right)2^{1+\frac{1}{\nu}}} \int_{VaR_{\alpha,t}}^{\infty} x_t e^{\frac{1-\frac{1}{2}|\omega\sigma_t|^2}{2|\omega\sigma_t|^2}} dx_t \\ &= \frac{\nu}{\alpha\omega\sigma_t\Gamma\left(\frac{1}{\nu}\right)2^{1+\frac{1}{\nu}}} \left[ -\frac{2^{\frac{2}{\nu}}|\omega|^2\sigma_t^2\Gamma\left(\frac{2}{\nu},\frac{1}{2}\left(\frac{x_t}{|\omega\sigma_t|}\right)^\nu\right)}{\nu} \right]_{VaR_{\alpha,t}}^{\infty} \\ &= \frac{-\sigma_t\omega2^{\frac{1}{\nu-1}}}{\alpha\Gamma\left(\frac{1}{\nu}\right)} \left[ \Gamma\left(\frac{2}{\nu},\frac{1}{2}\left(\frac{x_t}{|\omega\sigma_t|}\right)^\nu\right) \right]_{VaR_{\alpha,t}}^{\infty} = \frac{\sigma_t\omega2^{\frac{1}{\nu-1}}}{\alpha\Gamma\left(\frac{1}{\nu}\right)} \Gamma\left(\frac{2}{\nu},\frac{1}{2}\left(\frac{VaR_{\alpha,t}}{|\omega\sigma_t|}\right)^\nu\right) \right]_{VaR_{\alpha,t}}^{\infty} \end{split}$$

#### A.1.4 Assuming a Skewed Student t Error Distribution

Hansen's skew student-t distribution is a heavy tailed distribution that allows for asymmetry. It is an extension of the student-t distribution, and includes it as a special case when  $\lambda=0$  (Hansen 1994). Let  $f_{SSKEWT}$  denote standardized skewed student t distribution with v > 2 degrees of freedom and asymmetry parameter  $-1 < \lambda < 1$ .

$$f_{SSKEWT}(x) = \begin{cases} bc \left(1 + \frac{1}{v - 2} \left(\frac{bx + a}{1 - \lambda}\right)^2\right)^{-\frac{1}{2}(v+1)}, for \ x < -\frac{a}{b}\\ bc \left(1 + \frac{1}{v - 2} \left(\frac{bx + a}{1 + \lambda}\right)^2\right)^{-\frac{1}{2}(v+1)}, for \ x \ge -\frac{a}{b} \end{cases}$$

Where  $a = 4\lambda c \frac{\nu-2}{\nu-1}$ ,  $b^2 = 1 + 3\lambda^2 - a^2$  and  $c = \frac{\Gamma(\frac{\nu+1}{2})}{\sqrt{\pi(\nu-2)}\Gamma(\frac{\nu}{2})}$ . The scale-family of the standardized skewed student t,  $f_{SKEWT}$ , which has a mean zero and a variance  $\sigma_t$  that is allowed to change with time, can then be found as:

$$f_{SKEWT}(x_t) = \frac{1}{\sigma_t} f_{SSKEWT}\left(\frac{x_t}{\sigma_t}\right) = \begin{cases} \frac{bc}{\sigma_t} \left(1 + \frac{1}{v - 2} \left(\frac{bx_t}{\sigma_t} + a\right)^2\right)^{-\frac{1}{2}(v+1)}, for \frac{x_t}{\sigma_t} < -\frac{a}{b} \\ \frac{bc}{\sigma_t} \left(1 + \frac{1}{v - 2} \left(\frac{bx_t}{\sigma_t} + a\right)^2\right)^{-\frac{1}{2}(v+1)}, for \frac{x_t}{\sigma_t} \geq -\frac{a}{b} \end{cases}$$

The corresponding log-likelihood function follows.

$$l = T\left(\frac{1}{2}\ln(1+3\lambda^{2}-a^{2}) + \ln\Gamma\left(\frac{v+1}{2}\right) - \ln\Gamma\left(\frac{v}{2}\right) - \frac{1}{2}\ln(\pi(v-2))\right) - \frac{1}{2}\sum_{t=1}^{T}\ln\sigma_{t}^{2}$$
$$-\left(\frac{v+1}{2}\right)\sum_{t=1}^{T}\ln\left(1 + \frac{1}{(v-2)}\left(\frac{bx}{\sigma_{t}} + a}{1-\lambda}\right)^{2}\right)I\left(\frac{x_{t}}{\sigma_{t}} < -\frac{a}{b}\right)$$
$$-\left(\frac{v+1}{2}\right)\sum_{t=1}^{T}\ln\left(1 + \frac{1}{(v-2)}\left(\frac{bx}{\sigma_{t}} + a}{1+\lambda}\right)^{2}\right)I\left(\frac{x_{t}}{\sigma_{t}} \ge -\frac{a}{b}\right)$$

The derivation of ES from a GARCH with Hansen's skewed student t distribution follows:

$$ES_{\alpha,t} = E[X_t | x_t \ge VaR_{\alpha,t}] = \frac{E[x_t * I(x_t \ge VaR_{\alpha,t})]}{\alpha} = \frac{1}{\alpha} \int_{VaR_{\alpha,t}}^{\infty} x_t f(x_t) dx_t$$

$$\begin{split} = I\left(VaR_{a,t} < -\frac{a\sigma_t}{b}\right) \frac{1}{\alpha} \left( \int_{VaR_{a,t}}^{-\frac{a\sigma_t}{b}} x_t \frac{bc}{\sigma_t} \left( 1 + \frac{1}{(v-2)} \left( \frac{bx_t}{\sigma_t} + a}{1-\lambda} \right)^2 \right)^{-\frac{1}{2}(v+1)} dx_t \\ + \int_{-\frac{a\sigma_t}{b}}^{\infty} x_t \frac{bc}{\sigma_t} \left( 1 + \frac{1}{(v-2)} \left( \frac{bx_t}{\sigma_t} + a}{1+\lambda} \right)^2 \right)^{-\frac{1}{2}(v+1)} dx_t \right) \\ + I\left(VaR_{a,t} \ge -\frac{a\sigma_t}{b}\right) \frac{1}{\alpha} \int_{VaR_{a,t}}^{\infty} x_t \frac{bc}{\sigma_t} \left( 1 + \frac{1}{(v-2)} \left( \frac{bx_t}{\sigma_t} + a}{1+\lambda} \right)^2 \right)^{-\frac{1}{2}(v+1)} dx_t \\ ES_{\alpha,t} = \frac{bc}{\alpha\sigma_t} \left( I\left(VaR_{\alpha,t} < -\frac{a\sigma_t}{b}\right) \\ & * \left( \int_{VaR_{a,t}}^{-\frac{a\sigma_t}{b}} x_t \left( 1 + \frac{1}{(v-2)} \left( \frac{bx_t}{\sigma_t} + a}{1-\lambda} \right)^2 \right)^{-\frac{1}{2}(v+1)} dx_t \\ & + \int_{-\frac{a\sigma_t}{b}}^{\infty} x_t \left( 1 + \frac{1}{(v-2)} \left( \frac{bx_t}{\sigma_t} + a}{1-\lambda} \right)^2 \right)^{-\frac{1}{2}(v+1)} dx_t \\ & + I\left(VaR_{a,t} \ge -\frac{a\sigma_t}{b}\right) \int_{VaR_{a,t}}^{\infty} x_t \left( 1 + \frac{1}{(v-2)} \left( \frac{bx_t}{\sigma_t} + a}{1+\lambda} \right)^2 \right)^{-\frac{1}{2}(v+1)} dx_t \\ & + I\left(VaR_{a,t} \ge -\frac{a\sigma_t}{b}\right) \int_{VaR_{a,t}}^{\infty} x_t \left( 1 + \frac{1}{(v-2)} \left( \frac{bx_t}{\sigma_t} + a}{1+\lambda} \right)^2 \right)^{-\frac{1}{2}(v+1)} dx_t \right) \end{split}$$

Let 
$$u = \frac{\frac{bx_t}{\sigma_t} + a}{1 - \lambda} \Leftrightarrow x_t = \frac{u(1 - \lambda) - a}{b} \sigma_t, \frac{du}{dx_t} = \frac{b}{\sigma_t(1 - \lambda)} \Leftrightarrow dx_t = \frac{\sigma_t(1 - \lambda)}{b} du$$
  
As  $x_t = VaR_{\alpha,t} \Rightarrow u = \frac{\frac{bVaR_{\alpha,t}}{\sigma_t} + a}{1 - \lambda} = VaR_u$  and  $x_t = -\frac{a\sigma_t}{b} \Rightarrow u = 0$ .  
Let  $w = \frac{\frac{bx_t}{\sigma_t} + a}{1 + \lambda} \Leftrightarrow x_t = \frac{w(1 + \lambda) - a}{b} \sigma_t, \frac{dw}{dx_t} = \frac{b}{\sigma_t(1 + \lambda)} \Leftrightarrow dx_t = \frac{\sigma_t(1 + \lambda)}{b} dw$ 

As 
$$x_t = VaR_{\alpha,t} \Rightarrow w = \frac{\frac{bVaR_{\alpha,t}}{\sigma_t} + a}{1 + \lambda} = VaR_w, x_t = -\frac{a\sigma_t}{b} \Rightarrow w = 0 \text{ and } x_t \to \infty \Rightarrow w \to \infty$$

It follows by substitution that:

$$\begin{split} ES_{\alpha,t} &= \frac{bc}{a\sigma_t} \Biggl( I \left( VaR_{\alpha,t} < -\frac{a\sigma_t}{b} \right) \\ & * \left( \int_{VaR_u}^0 \frac{u(1-\lambda)-a}{b} \sigma_t \left( 1 + \frac{u^2}{(v-2)} \right)^{-\frac{1}{2}(v+1)} \frac{\sigma_t(1-\lambda)}{b} \, du \\ & + \int_0^\infty \frac{w(1+\lambda)-a}{b} \sigma_t \left( 1 + \frac{w^2}{(v-2)} \right)^{-\frac{1}{2}(v+1)} \frac{\sigma_t(1+\lambda)}{b} \, dw \Biggr) \\ & + I \left( VaR_{\alpha,t} \ge -\frac{a\sigma_t}{b} \right) \\ & * \int_{VaR_w}^\infty \frac{w(1+\lambda)-a}{b} \sigma_t \left( 1 + \frac{w^2}{(v-2)} \right)^{-\frac{1}{2}(v+1)} \frac{\sigma_t(1+\lambda)}{b} \, dw \Biggr) \\ ES_{\alpha,t} &= \frac{\sigma_t c}{\alpha b} \Biggl( I \left( VaR_{\alpha,t} < -\frac{a\sigma_t}{b} \right) \Biggr) \end{split}$$

$$\begin{array}{l} a, t = ab \left( -(1-\lambda) \int_{VaR_{u}}^{0} (u(1-\lambda) - a) \left( 1 + \frac{u^{2}}{(v-2)} \right)^{-\frac{1}{2}(v+1)} du \\ + (1+\lambda) \int_{0}^{\infty} (w(1+\lambda) - a) \left( 1 + \frac{w^{2}}{(v-2)} \right)^{-\frac{1}{2}(v+1)} dw \right) \\ + I \left( VaR_{a,t} \geq -\frac{a\sigma_{t}}{b} \right) (1+\lambda) \\ * \int_{VaR_{w}}^{\infty} (w(1+\lambda) - a) \left( 1 + \frac{w^{2}}{(v-2)} \right)^{-\frac{1}{2}(v+1)} dw \right) \end{array}$$

$$\begin{split} ES_{\alpha,t} &= \frac{\sigma_t}{ab} \Biggl( I \left( VaR_{\alpha,t} < -\frac{a\sigma_t}{b} \right) \\ & * \left( \int_{VaR_u}^0 cu(1-\lambda)^2 \left( 1 + \frac{u^2}{(v-2)} \right)^{-\frac{1}{2}(v+1)} du \\ & - a(1-\lambda) \int_{VaR_u}^0 c \left( 1 + \frac{u^2}{(v-2)} \right)^{-\frac{1}{2}(v+1)} du \\ & + \int_0^\infty cw(1+\lambda)^2 \left( 1 + \frac{w^2}{(v-2)} \right)^{-\frac{1}{2}(v+1)} dw \\ & - a(1+\lambda) \int_0^\infty c \left( 1 + \frac{w^2}{(v-2)} \right)^{-\frac{1}{2}(v+1)} dw \Biggr) + I \left( VaR_{\alpha,t} \ge -\frac{a\sigma_t}{b} \right) \\ & * \int_{VaR_w}^\infty cw(1+\lambda)^2 \left( 1 + \frac{w^2}{(v-2)} \right)^{-\frac{1}{2}(v+1)} dw - a(1+\lambda) \\ & * \int_{VaR_w}^\infty c \left( 1 + \frac{w^2}{(v-2)} \right)^{-\frac{1}{2}(v+1)} dw \Biggr) \end{split}$$

Since  $c\left(1+\frac{u^2}{(v-2)}\right)^{-\frac{1}{2}(v+1)} = \frac{\Gamma\left(\frac{v+1}{2}\right)}{\sqrt{\pi(v-2)}\Gamma\left(\frac{v}{2}\right)} \left(1+\frac{u^2}{(v-2)}\right)^{-\frac{1}{2}(v+1)}$  is the standardized student t

distribution with v degrees of freedom, it follows that

$$\begin{split} ES_{a,t} &= \frac{\sigma_t}{ab} \Biggl( I \left( VaR_{a,t} < -\frac{a\sigma_t}{b} \right) \\ & * \Biggl( c(1-\lambda)^2 \Biggl[ \left( -\frac{v-2}{v-1} \right) \Biggl( 1 + \frac{u^2}{(v-2)} \Biggr)^{\frac{1-v}{2}} \Biggr]_{VaR_u}^0 \\ & - a(1-\lambda) (F_{SST}(0) - F_{SST}(VaR_u)) \\ & + c(1+\lambda)^2 \Biggl[ \Biggl( -\frac{v-2}{v-1} \Biggr) \Biggl( 1 + \frac{w^2}{(v-2)} \Biggr)^{\frac{1-v}{2}} \Biggr]_0^\infty - a(1+\lambda) (1 - F_{SST}(0)) \Biggr) \Biggr) \\ & + I \Biggl( VaR_{a,t} \ge -\frac{a\sigma_t}{b} \Biggr) \\ & * \Biggl( c(1+\lambda)^2 \Biggl[ \Biggl( -\frac{v-2}{v-1} \Biggr) \Biggl( 1 + \frac{w^2}{(v-2)} \Biggr)^{\frac{1-v}{2}} \Biggr]_{VaR_w}^\infty - a(1+\lambda) \\ & * \Biggl( 1 - F_{SST}(VaR_w) \Biggr) \Biggr) \Biggr) \Biggr) \end{split}$$

where  $F_{SST}(\cdot)$  is the scale family of the cumulative standardized student t distribution. Since the standardized student t distribution is symmetric,  $F_{SST}(0) = 0.5$ 

$$\begin{split} ES_{a,t} &= \frac{\sigma_t}{ab} \Biggl( I \left( VaR_{a,t} < -\frac{a\sigma_t}{b} \right) \\ & * \left( c(1-\lambda)^2 \left( -\frac{v-2}{v-1} \right) \Biggl( 1 - \left( 1 + \frac{VaR_u^2}{(v-2)} \right)^{\frac{1-v}{2}} \Biggr) \right) \\ &- a(1-\lambda) (0.5 - F_{SST}(VaR_u)) + c(1+\lambda)^2 \left( -\frac{v-2}{v-1} \right) (-1) \\ &- a(1+\lambda)(1-0.5) \Biggr) + I \left( VaR_{a,t} \ge -\frac{a\sigma_t}{b} \right) \\ & * \left( c(1+\lambda)^2 \left( -\frac{v-2}{v-1} \right) \Biggl( - \left( 1 + \frac{VaR_w^2}{(v-2)} \right)^{\frac{1-v}{2}} \Biggr) - a(1 \\ &+ \lambda) (1 - F_{SST}(VaR_w)) \Biggr) \Biggr) \Biggr) \end{split}$$

This leads to the ES expression:

$$\begin{split} ES_{\alpha,t} &= \frac{\sigma_t}{ab} \Biggl( I \left( VaR_{\alpha,t} < -\frac{a\sigma_t}{b} \right) \\ & * \left( c(1-\lambda)^2 \frac{v-2}{v-1} \Biggl( \left( 1 + \frac{VaR_u^2}{(v-2)} \right)^{\frac{1-v}{2}} - 1 \Biggr) + a(1-\lambda)(F_{SST}(VaR_u) - 0.5) \\ & + c(1+\lambda)^2 \frac{v-2}{v-1} - \frac{a}{2}(1+\lambda) \Biggr) + I \left( VaR_{\alpha,t} \ge -\frac{a\sigma_t}{b} \right) \\ & * \left( c(1+\lambda)^2 \frac{v-2}{v-1} \Biggl( 1 + \frac{VaR_u^2}{(v-2)} \Biggr)^{\frac{1-v}{2}} - a(1+\lambda)(1-F_{SST}(VaR_w)) \Biggr) \Biggr) \Biggr) \end{split}$$

### A.2 CAViaR

The following five versions of CAViaR have been used in this paper.

Symmetric Absolute Value:  $VaR_{\alpha,t} = \beta_0 + \beta_1 VaR_{\alpha,t-1} + \beta_2 |x_{t-1}|$ Asymmetric Slope:  $VaR_{\alpha,t} = \beta_0 + \beta_1 VaR_{\alpha,t-1} + \beta_2 max[x_{t-1}, 0] - \beta_3 min[x_{t-1}, 0]$ Adaptive:  $VaR_{\alpha,t} = VaR_{\alpha,t-1} + \beta_1 [I(x_{t-1} > VaR_{\alpha,t-1}) - \alpha]$ Indirect GARCH(1,1):  $VaR_{\alpha,t} = \sqrt{\beta_0 + \beta_1 (VaR_{\alpha,t-1})^2 + \beta_2 x_{t-1}^2}$ 

*Indirect* AR(1)-GARCH(1,1):

$$VaR_{\alpha,t} = ax_{t-1} + \sqrt{\beta_0 + \beta_1 (ax_{t-2} - x_{t-1})^2 + \beta_2 (VaR_{\alpha,t-1} - ax_{t-2})^2}$$

The parameters of both the *Symmetric Absolute Value* and *Asymmetric Slope* CAViaR are unconstrained. The *Adaptive* CAViaR model increases the VaR when a loss in the last period exceeds the corresponding VaR. Otherwise the VaR is slightly decreased. For the model to work correctly, the parameter  $\beta_1$  should be positive. If this is not the case, the model will perform very poorly, since it will increase VaR each time there is no VaR violation, making a successive VaR violation even less likely. The VaR forecasts will then diverge to infinity, which is obviously an undesirable property of any VaR model. For both the *Indirect GARCH* and *Indirect AR-GARCH* models, the parameters  $\beta_0$ ,  $\beta_1$  and  $\beta_2$  should be non-negative to ensure that the expression under the square root is positive.

Engle and Manganelli (2004) also proposed *an alternative version of the Adaptive CAViaR model*, where the indicator function is replaced by a smoothed version of it. This alternative version is not used in this paper, but is reported here for completeness.

$$VaR_{\alpha,t} = VaR_{\alpha,t-1} + \beta_1 \left\{ \left[ 1 + exp(K[VaR_{\alpha,t-1} - x_{t-1}]) \right]^{-1} - \alpha \right\}$$

K is a smoothing parameter, which may be chosen or estimated. When  $K \rightarrow \infty$ , this version of the Adaptive CAViaR model converges to the other one. Engle and Manganelli (2004) do not give any indication of how to estimate it or choose it appropriately, but instead set K=10 for simplicity.

#### A.3 EWQR

Exponentially weighted quantile regression (EWQR) was introduced by Taylor (2008) as an extension of quantile regression, where a weighting parameter  $\lambda$  is included. For a specific value of  $\lambda$  the EWQR minimization formula is as follows:

$$\min_{\boldsymbol{\beta}} \sum_{t=1}^{I} \lambda^{T-t} (r_t - \boldsymbol{x'}_t \boldsymbol{\beta}) \big( \theta - I(r_t < \boldsymbol{x'}_t \boldsymbol{\beta}) \big)$$

 $\boldsymbol{\beta}$  is a parameter vector,  $\boldsymbol{x}_t$  is a vector of regressors,  $r_t$  is the return at period t, T is the length of the estimation window,  $\boldsymbol{\theta}$  is the quantile considered and  $I(\cdot)$  the indicator function. Even though the EWQR formula generally include regressors, Taylor (2008) argues that an EWQR with an intercept and no regressors is reasonable and should perform well. In this paper the case without regressors will be considered. Consequently the estimator  $\boldsymbol{x}'_t \boldsymbol{\beta}$  can be substituted with a constant  $\hat{q}_{\theta,T+1}$ .

$$\min_{\hat{q}_{\theta,T+1}} \sum_{t=1}^{I} \lambda^{T-t} (r_t - \hat{q}_{\theta,T+1}) \left( \theta - I(r_t < \hat{q}_{\theta,T+1}) \right)$$

The expression presented in this paper has a slightly different notation:

$$\min_{\widehat{VaR}_{\alpha,T+1}} \sum_{t=1}^{T} \lambda^{T-t} (\widehat{VaR}_{\alpha,T+1} - x_t) \left( \alpha - I(x_t > \widehat{VaR}_{\alpha,T+1}) \right)$$

To see that this is an equivalent representation of the formula, consider the two trading positions separately.

Long trading position:

$$\alpha = \theta$$

$$\widehat{VaR}^{L}{}_{\alpha,t} = -\widehat{q}_{\theta,t}$$

$$x_{t} = -r_{t}$$

Here  $q_{\theta}$  denotes the  $\theta$ th quantile of the return distribution. Then,

$$\min_{\overline{VaR}_{\alpha,T+1}} \sum_{t=1}^{T} \lambda^{T-t} (\widehat{VaR}_{\alpha,T+1} - x_t) \left( \alpha - I(x_t > \overline{VaR}_{\alpha,T+1}) \right)$$
  
= 
$$\min_{-\hat{q}_{\theta,T+1}} \sum_{t=1}^{T} \lambda^{T-t} \left( -\hat{q}_{\theta,T+1} - (-r_t) \right) \left( \alpha - I(-r_t > -\hat{q}_{\theta,T+1}) \right)$$
  
= 
$$\min_{\hat{q}_{\theta,T+1}} \sum_{t=1}^{T} \lambda^{T-t} (r_t - \hat{q}_{\theta,T+1}) \left( \theta - I(r_t < \hat{q}_{\theta,T+1}) \right)$$

Short trading position:

$$\begin{aligned} \alpha &= 1 - \theta \\ \widehat{VaR}^{S}_{\alpha,t} &= \widehat{q}_{\theta,t} \\ x_t &= r_t \end{aligned}$$
$$\underset{\widehat{VaR}_{\alpha,T+1}}{\min} \sum_{t=1}^{T} \lambda^{T-t} (\widehat{VaR}_{\alpha,T+1} - x_t) \left( \alpha - I(x_t > \widehat{VaR}_{\alpha,T+1}) \right) \\ &= \min_{\widehat{q}_{\theta,T+1}} \sum_{t=1}^{T} \lambda^{T-t} (\widehat{q}_{\theta,T+1} - r_t) \left( (1 - \theta) - I(r_t > \widehat{q}_{\theta,T+1}) \right) \end{aligned}$$

$$= \min_{\hat{q}_{\theta,T+1}} \sum_{t=1}^{T} \lambda^{T-t} (\hat{q}_{\theta,T+1} - r_t) (I(r_t < \hat{q}_{\theta,T+1}) - \theta)$$
  
$$= \min_{\hat{q}_{\theta,T+1}} \sum_{t=1}^{T} \lambda^{T-t} (r_t - \hat{q}_{\theta,T+1}) (\theta - I(r_t < \hat{q}_{\theta,T+1}))$$

A key aspect to EWQR is to choose an appropriate  $\lambda$ . A high value of  $\lambda$  corresponds to giving past observations high weights, while with smaller  $\lambda$  values older observations become less significant (Taylor 2008). To optimize  $\lambda$  we follow Taylor's approach of using a rolling window of 250 observations to produce day-ahead forecasts for the rest of the observations in an estimation sample of size n. This is done for several different  $\lambda$  values, and the  $\lambda$  with the lowest corresponding QR Sum is chosen and assumed to be optimal also for out-of-sample forecasting. QR Sum is defined as the standard quantile regression formula, but without the minimization; the quantile forecasts obtained with EWQR is entered instead, as in the expression below.

$$QR \ Sum(\lambda,\theta) = \sum_{t=251}^{n} (r_t - \hat{q}_{\theta,t}) \left(\theta - I(r_t < \hat{q}_{\theta,t})\right)$$

Taylor (2008) proposes to use a grid of values of  $\lambda$  from 0.8 to 1 with step size 0.005, when optimizing  $\lambda$ . This is what is done in this analysis as well. As for the estimation sample, a rolling window of 250 observations is used to forecast out-of-sample. From these quantile forecasts the out-of-sample VaR and ES forecasts can be obtained:

$$\widehat{ES}_{\alpha,T+1} = \frac{1}{\alpha \sum_{t=1}^{T} \lambda^{T-t}} \sum_{t=1}^{T} \lambda^{T-t} (r_t - \hat{q}_{\theta,T+1}) \left( \theta - I(r_t < \hat{q}_{\theta,T+1}) \right),$$

or equivalently:

$$\widehat{ES}_{\alpha,T+1} = \frac{1}{\alpha \sum_{t=1}^{T} \lambda^{T-t}} \sum_{t=1}^{T} \lambda^{T-t} \left( \widehat{VaR}_{\alpha,T+1} - x_t \right) \left( \alpha - I \left( x_t > \widehat{VaR}_{\alpha,T+1} \right) \right).$$

#### A.3.1 Comments on the Rolling Window Size for $\lambda$ Estimation

In Taylor's articles about EWQR (2007; 2008) the procedure is to use a rolling window corresponding to one year of observations. For financial assets a typical trading year has 250 days which is why a rolling window of 250 observations has been chosen. The logic is that the window has to be big enough to include as many observations that are deemed to influence the current observation, but small enough that it leaves a sufficiently large number of observations to be forecasted. Furthermore, the larger an estimation window is, the smaller the sample error becomes, but a small window is desirable when the parameters should be able to change rapidly (Sheedy 2009). Taylor (2008) tried different window sizes for  $\lambda$ , but found that none of the other tested window sizes improved results significantly.

# **Appendix B: Backtesting VaR and ES Forecasts**

## **B.1 Backtesting Value at Risk Forecasts**

#### **B.1.1 Test for Unconditional Coverage**

For a VaR model to be appropriate, the proportion of returns more extreme than the VaR estimates should equal  $\alpha$ . The unconditional coverage test checks whether this is the case for a given model, by comparing the two alternative hypotheses,  $H_0: E[H_{\alpha,t}] = \alpha$  and  $H_1: E[H_{\alpha,t}] \neq \alpha$ , where  $H_{\alpha,t} = I(x_t > VaR_{\alpha,t})$ , using the likelihood ratio test statistic:

$$LR_{uc} = -2\ln\left(\frac{L(\theta)}{L(\hat{\theta})}\right) = -2\ln\left(\frac{\theta^{n_1}(1-\theta)^{n_0}}{\hat{\theta}^{n_1}(1-\hat{\theta})^{n_0}}\right) \stackrel{a}{\sim} \chi_1^2.$$

 $L(\cdot)$  denotes the binomial likelihood function,  $n_1$  is the number of VaR-violations ( $H_{\alpha,t} = 1$ ),  $n_0$  is the number of non-violations ( $H_{\alpha,t} = 0$ ) and  $\hat{\theta} = \frac{n_1}{n_1 + n_0}$  the observed proportion of violations. Under the null hypothesis,  $LR_{uc}$  asymptotically has a chi-squared distribution with one degree of freedom. This test rejects models that either overestimate or underestimate VaR (Hung, Lee et al. 2008).

#### **B.1.2 Test for Conditional Coverage**

The test for conditional coverage is a joint test of correct coverage and independence of VaR violations. (Christoffersen 1998). The test statistic is defined as follows:

$$LR_{cc} = -2\ln\left(\frac{\theta^{n_1}(1-\theta)^{n_0}}{\hat{\theta}_{01}^{n_{01}}(1-\hat{\theta}_{01})^{n_{00}}\hat{\theta}_{11}^{n_{11}}(1-\hat{\theta}_{11})^{n_{10}}}\right) \stackrel{a}{\sim} \chi_2^2$$

Here  $n_{ij}$  denotes the observed number of times an observation of value i is followed by an observation of value j, (for i,j = 0,1). For example  $n_{01}$  is the observed number of times an observation of value 0 (non-violation) is followed by an observation of value 1 (violation).  $n_1 = n_{11} + n_{01}$ , while  $n_0 = n_{10} + n_{00}$ . The estimated probability of going from a 0 to 1, from a non-violation to a violation, is  $\hat{\theta}_{01} = \frac{n_{01}}{n_{00} + n_{01}}$  and the estimated probability of going from 1 to 1 is  $\hat{\theta}_{11} = \frac{n_{11}}{n_{10} + n_{11}}$ .

 $LR_{cc}$  is compared to a chi-squared distribution with two degrees of freedom. This test rejects models that either overestimate or underestimate VaR or that generate either too many or too few clustered violations (Hung, Lee et al. 2008).

A drawback of the test is that it is unable to give an answer for the extreme quantiles when there are not a sufficient number of forecasts. Then it becomes unlikely that two returns in a row will exceed the forecasted VaR, resulting in a division by 0, which is unfortunate.

#### **B.1.3** The Dynamic Quantile Test

Engle and Manganelli (1999) argue that a good VaR model should not just be uncorrelated with  $H_{\alpha,t}$ , like in the conditional coverage test, but that it also should be uncorrelated with the

VaR estimate for the period itself. They then propose another method for assessing VaR models called the dynamic quantile (DQ) test, which takes this into account. The DQ test considers a Hit<sub> $\alpha,t$ </sub> variable similar to the H<sub> $\alpha,t$ </sub> in the coverage tests:

$$Hit_t = I(x_t > VaR_{\alpha,t}) - \alpha$$

By comparison  $\text{Hit}_{\alpha,t} = \text{H}_{\alpha,t} - \alpha$ . This variable is then regressed on its lags, the period's estimated VaR and other variables if desired. This is called an artificial regression (Engle and Manganelli 1999). The form of artificial regression that is used most often is the one that include four lags and the VaR estimate (Engle and Manganelli 1999; Kuester, Mittnik et al. 2006). This is done also for the analysis in this paper:

$$\begin{split} Hit_{t} &= \beta_{0} + \beta_{1}Hit_{t-1} + \beta_{2}Hit_{t-2} + \beta_{3}Hit_{t-3} + \beta_{4}Hit_{t-4} + \beta_{5}\overline{VaR}_{t} + u_{t} \\ & \text{where } u_{t} = \begin{cases} -\alpha & \text{with probability } 1 - \alpha \\ 1 - \alpha & \text{with probability } \alpha \end{cases} \end{split}$$

In matrix form the same expression yields:  $Hit = X\beta + u$ . The null hypothesis of no influence by the regressors then becomes  $H_0$ :  $\beta = 0$ . The ordinary least squares solution to this is  $\hat{\beta} = (X'X)^{-1}X'Hit \stackrel{a}{\sim} N(0, \alpha(1 - \alpha)(X'X)^{-1})$ , from which Engle and Manganelli (1999) derive the DQ test statistic

$$DQ = \frac{\hat{\beta}' X' X \hat{\beta}}{\alpha (1-\alpha)} \stackrel{a}{\sim} \chi_6^2$$

The DQ test statistic is asymptotically distributed as a chi-squared distribution with six degrees of freedom.

#### **B.2 Backtesting Expected Shortfall Forecasts**

#### **B.2.1** An Expected Shortfall Test Dependent on VaR (DV)

For the ES test dependent of VaR, a bootstrap test is performed on the following residuals to check whether the ES forecasts are correct.

$$z_{\alpha,t} = \left\{ \frac{x_t - \widehat{ES}_{\alpha,t}}{\widehat{VaR}_{\alpha,t}} | x_t > \widehat{VaR}_{\alpha,t} \right\}$$

#### **B.2.2** An Expected Shortfall Test Independent of VaR (IV)

For the ES test independent of VaR, a bootstrap test is performed on the following residuals instead.

$$z_{\alpha,t} = \{x_t - \widehat{ES}_{\alpha,t} | x_t - \widehat{ES}_{\alpha,t} > D_{\alpha}\}, \text{ where } D_{\alpha} \text{ is the } \alpha \text{-th quantile of } x_t - \widehat{ES}_{\alpha,t}.$$

#### **B.2.3 Bootstrapping**

The bootstrap hypothesis test is explained well in chapter 16.4, pages 224-227, of Efron and Tibshirani (1993). The idea is to find an appropriate null distribution of a test statistic

empirically, instead of assuming one, and then compare the test statistic with it to test the hypothesis of zero mean.

Consider the test statistic

$$T(\mathbf{z}_{\alpha}) = \frac{\hat{\mu}_{z} - \mu_{z}}{\frac{\hat{\sigma}_{z}}{\sqrt{n_{z}}}} = \frac{\hat{\mu}_{z}}{\frac{\hat{\sigma}_{z}}{\sqrt{n_{z}}}}$$

where  $\hat{\mu}_z$  and  $\hat{\sigma}_z$  are the mean and standard deviation of the variable to bootstrap test  $z_{\alpha,t}$ , respectively, and  $n_z$  is the number of losses greater than the VaR forecasts. An appropriate null distribution should follow the null hypothesis, which in this case is to have a zero mean. Since  $\hat{\mu}_z$  is not necessarily zero, the following transformation is made to get a zero mean variable.

$$\tilde{z}_{\alpha,t} = z_{\alpha,t} - \hat{\mu}_z$$

By drawing random bootstrap samples  $\tilde{z}_{\alpha}^*$  of size  $n_z$  from  $\tilde{z}_{\alpha}$ , with replacement, and calculating corresponding test statistic for each sample,

$$T(\tilde{\mathbf{z}}_{\alpha}^{*}) = \frac{\hat{\mu}_{\tilde{z}^{*}}}{\frac{\hat{\sigma}_{\tilde{z}^{*}}}{\sqrt{n_{\tilde{z}^{*}}}}} = \frac{\hat{\mu}_{\tilde{z}^{*}}}{\frac{\hat{\sigma}_{\tilde{z}^{*}}}{\sqrt{n_{z}}}},$$

an empirical null distribution of T is obtained. The achieved significance level corresponds to the proportion of samples that have  $T(\tilde{z}_{\alpha}^*)$  more extreme than  $T(z_{\alpha})$  for a two-sided hypothesis test, or the proportion of samples for which  $T(\tilde{z}_{\alpha}^*)$  is higher than  $T(z_{\alpha})$  for a one-sided hypothesis test of the mean being smaller than or equal to zero.

#### **B.2.4 One-sided Versus Two-sided Hypothesis Test**

For both the discussed ES tests it is possible to choose between performing a one-sided or a two-sided hypothesis test of zero mean. McNeil and Frey (2000) use a one-sided test to check for underestimation of ES, formulated as a hypothesis test below.

$$H_0: \mu_z = 0 \qquad \qquad H_1: \mu_z > 0$$

Their argument for performing a one-sided test is that it is more likely for a model to underestimate ES than it is to overestimate it. Another argument could be that a risk manager would prefer to be conservative, thus rather overestimate risk than underestimating it. On the other hand, a model which systematically overestimates risk is not adequate either. This would lead the manager to allocate unnecessary much resources to face a huge, but unrealistic, risk. Thus, a two-sided hypothesis test might be more appropriate, since it tests whether or not a model produces ES forecasts that are accurate.

$$H_0: \mu_z = 0 \qquad \qquad H_1: \mu_z \neq 0$$

In this paper we choose to implement both the one-sided and two-sided hypothesis test for completeness. It will then be easier to compare our results with for example those of McNeil and Frey (2000) or Taylor (2008), and it will also enable us to check whether McNeil and Frey's expectations about ES models generally underestimating ES are supported by our findings.

# **Appendix C: Last Trading Day**

This appendix contains the rules for when the last trading day for each of the futures series considered in this paper. These are found at the home pages of the respective markets; <u>www.theice.com</u>, <u>www.nasdaqomxcommodities.com</u>, <u>www.cmegroup.com</u> and <u>www.eex.com</u>.

## **ICE Rotterdam Coal:**

The month contracts cease trading at the close of business on the last Friday of the contract delivery period.

### **ICE Natural Gas:**

Trading shall cease at the close of business two business days prior to the first calendar day of the delivery month.

### **ICE Brent Crude Oil:**

Trading shall cease at the end of the designated settlement period on the Business Day (a trading day which is not a public holiday in England and Wales) immediately preceding:

(i) Either the 15th day before the first day of the contract month, if such 15th day is a Business Day

(ii) If such 15th day is not a Business Day the next preceding Business Day.

### NASDAQ OMX (Nord Pool) Carbon:

The Last Trading Day for EUA/CER Futures is specified in relation to each Futures Series, and will normally be the last Monday of the contract month. If the last Monday of the month is a non-Banking Day, or there is a non-Banking Day in the four calendar days following the last Monday of the month, the Last Trading Day will normally be the penultimate Monday of the contract month. If the previously stated conditions are also in conflict with the penultimate Monday, the Last Trading Day will normally be the antepenultimate Monday of the contract month, unless stated otherwise in the Product Calendar.

#### NYMEX Light Crude Oil

Trading terminates at the close of business on the third business day prior to the 25th calendar day of the month preceding the delivery month. If the 25th calendar day of the month is a non-business day, trading shall cease on the third business day prior to the business day preceding the 25th calendar day.

#### **NYMEX Heating Oil:**

The last trading day is the last business day of the month preceding the contract month.

#### **NYMEX Gasoline:**

The last trading day is the last business day of the month preceding the contract month.

## **NYMEX Natural Gas:**

The last trading day is the third business day prior to the first calendar day of the contract month.

#### **NYMEX Coal:**

Trading terminates on the fourth last business day of the month prior to the delivery month.

## **NYMEX Monthly Electricity Peak:**

Trading shall cease one business day prior to the last peak day of the contract month.

# **EEX Yearly Electricity Peak:**

Baseload/Peakload Year Futures (Contract cascades three exchange trading days before beginning of the delivery year).

# **EEX Monthly Electricity Peak:**

First day of expiry for German-Baseload/Peakload-Month-Futures and French-Baseload/Peakload-Month-Futures (Reduction of the contract volume starts two exchange trading days before beginning of the delivery period).

## **EEX Carbon Emissions:**

The last trading day is stated in the product calendar. The product calendar can be found at: http://www.eex.com/en/Market%20Data/Market%20Information/Trading%20Calendar

# **ICE Monthly Electricity Peak:**

The last trading day is two business days prior to the first EFA calendar day of the delivery period. Table C1-C3 present the EFA calendar for the years 2002-2011. They are constructed after the following pattern: "EFA blocks have an anchor point of 31/12/01 starting with 4,4,5 week cycles. Month contracts are based on the number of days in an EFA month, namely 28 days in January, February, April, May, July, August, October and November; 35 days in March, June, September, December. Exceptions are December 2004 which will have 42 days and every sixth year there is an additional week added to one of the EFA periods." (https://www.theice.com/productguide/ProductDetails.shtml?specId=911)

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					00	29	30	31			24	25	26	27	28	29	30
		25	26	5	N												1 1
	ary	18 25	19 26	20 27	21 28					γe	17			20			23
	anuary	18	19	20	21	22	23	24		anuary	10 17	18	19	20	21	22	16 23
	January				7 14 21 2			17 24		January	3 10 17			6 13 20			9 16 23
	January	11 18	12 19	13 20	21	15 22	16 23	24		January	10 17	11 18	12 19	13 20	21	15 22	Su 9 16 23

Table C3: EFA calendar 2010-2011

# **Appendix D: Data and Descriptive Statistics**

The prices used in this paper are gathered from the Reuters EcoWin Pro database. We have however discovered a couple of errors in the data set, which we have corrected. For Coal Rotterdam on ICE, the price was reported to be 0 on the 23.04.2007, but it turns out that it in reality was 71.8. The 20.04.2007 EcoWin reported the price to be 71.35 while it actually was 72. The mentioned prices can be found at the ICE home page, by choosing the relevant dates: https://www.theice.com/marketdata/reports/ReportCenter.shtml?reportId=10&productId=517 & https://www.theice.com/marketdata/reportS/ReportCenter.shtml?reportS/ReportCenter.shtml?reportS/ReportS

**Table D1**: Start date, end date and the length of the return series after removing the price changes between the last trading day of a futures contract and the first trading day of the subsequent contract. (See appendix C for more details)

	CO <sub>2</sub>	CO <sub>2</sub>	El M	El M	El M	El Y	Gas ICE
	EEX	Nordpool	EEX	ICE	NYMEX	EEX	
Start	05.10.05	05.07.07	08.01.03	14.09.04	01.08.06	01.07.02	31.01.97
End	11.04.11	11.04.11	11.04.11	11.04.11	11.04.11	11.04.11	11.04.11
Length	1391	927	1993	1597	1126	2217	3430
	Gas	Coal ICE	Coal	Oil ICE	Gasoline	НО	LCO
	Gas NYMEX	Coal ICE	Coal NYMEX	Oil ICE	Gasoline NYMEX	HO NYMEX	LCO NYMEX
Start		Coal ICE 01.08.06		Oil ICE 03.06.96		-	
Start End	NYMEX		NYMEX		NYMEX	NYMEX	NYMEX

00***) 448.4 00***) 28.72 0***) 11.2 ***) 194.6	0.038409 0.000000 19.10552 -20.90090	0.019870 0.000000	-0.161382	-0.099144	-0.445351
an         0.00000         an           mum         34.64810         1           mum         -33.45324         1           Dev         -33.45324         1           Dev         2.859554         1           Dev         2.855554         1           Dev         2.855554         1           Dev         2.85554         1           Dev         2.85554         1           Dev         2.85554         1           Dev         37.02982         1           Deve         67123.88 (0.0000***)         1           Deve         41.324 (0.0000***)         1           Dev         424.98 (0.0000***)         1           Dev         1391         1	0.000000 19.10552 -20.90090	0.00000	0 201010		
mum         34.64810         mum           mum         -33.45324            Dev         2.859554            Dev         2.859554            Dev         2.859554            Dev         2.859554            Dev         2.859554            Dev         2.859554            Dess         -0.166823            Dess         37.02982            Dess         67123.88 (0.0000***)            nented Dickey-Füller         -17.6003 (0.0000***)            O         41.324 (0.0000***)            Notestions         1391	19.10552 -20.90090	~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~	-0.204710	-0.071082	0.00000
mum         -33.45324         mum           Dev         2.859554            Dev         2.859554            mess         -0.166823            ness         37.02982            sis         67123.88 (0.000***)            nented Dickey-Füller         -17.6003 (0.000***)            nented Dickey-Füller         -17.4003 (0.000***)            value         -17.4003 (0.000***)            nented Dickey-Füller         -17.4003 (0.000***)            value         -17.4003 (0.000***)            nented Dickey-Füller         1.324 (0.0000***)            nvations         1391	-20.90090	11.12256	33.91509	26.96636	24.30778
Dev         2.859554         2           mess         -0.166823         -           ness         37.02982         -           sis         37.02982         -           ce-Bera         67123.88 (0.000***)         -           nented Dickey-Füller         -17.60033 (0.000***)         -           0         -17.60033 (0.000***)         -           11.324 (0.000***)         -         -           10         424.98 (0.0000***)         -           10         1324 (0.0000***)         -           1291         -         -		-10.77459	-37.64776	-23.31835	-26.66533
Thess     -0.166823       sis     37.02982       self     37.02982       te-Bera     67123.88 (0.000***)       nented Dickey-Füller     -17.6003 (0.000***)       nented Dickey-Füller     41.324 (0.000***)       1324 (0.0000***)     -       nvations     1391	1.797325	2.071445	3.349222	2.985190	5.695212
sis 37.02982 37.02982 ce-Bera 67123.88 (0.000***) - 17.6003 (0.000***) - 17.6003 (0.000***) - 17.6003 (0.000***) - 141.324 (0.000***) - 141.324 (0.0000***) - 1424.98 (0.0000***) - 1391 rvations 1391 El YP EEX	-1.375732	-0.421948	1.873721	0.739658	-0.436990
ic-Bera         67123.88 (0.0000***)         -           nented Dickey-Füller         -17.60033 (0.0000***)         -           41.324 (0.0000***)         -         -           nented Dickey         424.98 (0.0000***)         -           nented Dickey         1391         -	40.46536	8.497960	35.29957	15.99622	6.460047
nented Dickey-Füller -17.6003 (0.000***) + 17.6003 (0.000***) + 13.24 (0.000***) + 13.24 (0.000***) + 13.24	***) 67738.73 (0.0000***)	$1320.095(0.000^{***})$	87800.43 (0.0000***)	11384.62 (0.0000***)	597.5198 (0.0000***)
41.324 (0.000***)       41.324 (0.000***)       rvations       424.98 (0.0000***)       El YP EEX	***) -38.84502 (0.0000***)	$-26.51426(0.0000^{***})$	$-37.44907 (0.0000^{***})$	$-37.45553 (0.0000^{***})$	$-32.12734(0.0000^{***})$
424.98 (0.0000***) 1391 El YP EEX	*) 33.124 (0.0000***)	$50.748\ (0.0000^{***})$	$77.041 (0.0000^{***})$	13.287 (0.0208**)	9.7819 (0.0817*)
EI YP EEX	*) 168.71 (0.0000***)	218.04(0.0000***)	$301.29(0.0000^{***})$	198.88(0.0000***)	62.332 (0.0000***)
	1152	1024	1993	1597	1126
	Gas NVMFY	OilICE	Gasoline NVMFY	Heating Oil NVMFY	I inht Crude Oil NVMEY
Mean 0.017701 -0.114770	-0.099095	0.053965	0.037288	0.039815	0.039061
Median 0.025870 -0.096204	-0.078447	0.117947	0.135543	0.000000	0.067499
Maximum 6.704807 35.77702	32.43538	12.89825	12.99953	10.40314	14.54637
Minimum -6.154219 -16.50143	-16.69867	-14.43716	-11.50368	-14.89902	-16.54451
Std. Dev 0.991491 3.140458	3.549166	2.307953	2.553516	2.302317	2.436475
Skewness -0.034303 1.809383	0.205909	-0.151191	-0.164068	-0.055027	-0.171649
Kurtosis 7.647625 21.76132	6.656350	5.651866	5.149029	4.619831	6.494140
Jarque-Bera 1995.774 (0.0000***) 52176.36 (0.0000***)	***) 1974.362 (0.0000***)	$1038.892 (0.0000^{***})$	$260.7176(0.0000^{***})$	$384.4116(0.0000^{***})$	$1694.431  (0.0000^{***})$
Augmented Dickey-Füller -40.77566 (0.0000***) -41.27427 (0.0000***)	***) -60.09238 (0.0001***)	$-61.93710(0.0001^{***})$	$-36.50976$ ( $0.0000^{***}$ )	$-60.32120(0.0001^{***})$	-58.11021 (0.0001***)
67.484 (0.0000***)		11.790 (0.0377**)	6.9132 (0.2272)	8.7314 (0.1203)	7.7555 (0.1702)
Q <sup>2</sup> (5) 325.29 (0.0000***) 78.795 (0.0000***)	*) 180.18 (0.0000***)	$436.79 (0.0000^{***})$	$263.27 (0.0000^{***})$	$223.23 (0.0000^{***})$	566.53 (0.0000***)
Observations 2217 3430	3500	3500	1324	3500	3299

Table D2: Descriptive Statistics for the Energy commodity futures

Q(5) and Q<sup>2</sup>(5) denotes the Ljung-Box test statistics with 5 lags for returns and squared returns respectively. \*, \*\* and \*\*\* denotes significance at the 10%, 5% and 1% level, respectively

Mean Median	CO	CO2 EEX	CO.	CO2 NP	Coal	Coal ICE	Coal NYMEX	YMEX	EIMI	EI MP EEX	EIM	EI MP ICE	EI MP NYMEX	VYMEX
Mean Median	In-Sample	Out-of Sample	In-Sample	Out-of Sample	In-Sample	Out-of Sample	In-Sample	Out-of Sample	In-Sample	Out-of Sample	In-Sample	Out-of Sample	In-Sample	Out-of Sample
Median	-0.057200	0.029323	-0.096518	0.045198	-0.008210	0.099201	-0.012991	0.054308	-0.190435	-0.074632	-0.134249	-0.022124	-0.497002	-0.380683
	0.000000	0.063920	0.000000	0.000000	0.000000	0.066116	0.000000	0.075876	-0.273785	-0.048427	-0.100150	-0.033863	-0.009072	0.000000
MAXIMUM	34.64810	5.503707	9.684983	7.117628	19.10552	6.632264	11.12256	8.025294	33.91509	12.18746	26.96636	4.686992	24.30778	22.89704
Minimum	-33.45324	-9.048314	-10.78890	-8.356508	-20.90090	-5.788377	-10.77459	-4.332426	-37.64776	-9.007901	-23.31835	-4.077549	-25.13144	-26.66533
Std. Dev	3.318916	1.768216	2.456425	1.857670	2.146279	1.197908	2.514398	1.472462	3.731056	1.773784	3.501324	1.251891	5.741701	5.641538
Skewness	-0.114122	-0.382364	-0.376478	-0.211858	-1.403225	0.144485	-0.515325	0.414492	1.793556	0.952272	0.688417	0.262297	-0.390009	-0.497828
Kurtosis	31.67263	4.597905	6.332839	4.627495	34.40086	9.118354	7.072524	4.979233	30.40386	14.92040	12.30503	4.460452	5.619999	7.590331
Jarque-Bera	30523.12 (0.0000***)	65.37725 (0.0000***)	207.7134 (0.0000***)	58.92240 (0.0000***)	27000.67 (0.0000***)	781.6201 (0.0000***)	385.3080 (0.0000***)	95.92873 (0.0000***)	47517.16 (0.0000***)	3035.899 (0.0000***)	4044.242 (0.0000***)	50.16916 (0.0000***)	194.9161 (0.0000***)	459.6348 (0.0000***)
Augmented Dickey-Füller	-13.81555 (0.0000***)	-21.55972 (0.0000***)	-18.70171 (0.0000***)	-22.38021 (0.0000***)	-30.90723 ( $0.0000^{***}$ )	-20.38887 ( $0.0000^{***}$ )	-19.57803 ( $0.0000^{***}$ )	-16.69987 (0.0000***)	-32.62462 (0.0000***)	-17.14760 (0.0000***)	-31.16907 (0.0000***)	-19.53247 (0.0000***)	-23.17579 (0.0000***)	-22.30358 (0.0000***)
Q(5)	34.385 (0.0000***)	6.3854 (0.2705)	10.265 (0.0681*)	1.0782 (0.9560)	35.857 (0.0000***)	11.599 (0.0407**)	23.113 (0.0000***)	45.823 (0.0000***)	55.090 (0.0000***)	40.955 $(0.0000***)$	8.0426 (0.1539)	18.918 (0.0020***)	14.126 (0.0148**)	2.2139 (0.8188)
Q <sup>2</sup> (5)	268.49 (0.0000***)	24.141 (0.0000***)	99.630 (0.0000***)	28.306 (0.0000***)	93.118 (0.0000***)	81.139 (0.0000***)	94.261 (0.0000***)	$30.003$ $(0.0000^{***})$	218.23 (0.0000***)	19.494 (0.0016***)	115.46 (0.0000***)	45.795 (0.0000***)	12.100 (0.0334**)	67.308 (0.0000***)
Observations	168	500	427	500	652	500	524	500	1493	500	1097	500	626	500
	EIY	EI YP EEX	Gas	Gas ICE	Gas NYMEX	YMEX	Oil ICE	ICE	Gasoline	Gasoline NYMEC	Heating O	Heating Oil NYMEX	Light Crude	Light Crude Oil NYMEX
	In-Sample	Out-of Sample	In-Sample	Out-of Sample	In-Sample	Out-of Sample	In-Sample	Out-of Sample	In-Sample	Out-of Sample	In-Sample	Out-of Sample	In-Sample	Out-of Sample
Mean	0.037953	-0.051845	-0.149549	0.089037	-0.085044	-0.183403	0.033925	0.174205	-0.036634	0.159110	0.029565	0.101316	0.026094	0.111652
Median	0.065244	-0.145946	-0.102104	-0.029719	-0.034421	-0.431016	0.114903	0.130174	0.134794	0.137071	-0.010280	0.114692	0.069180	0.033000
Maximum	5.440327	6.704807	33.97698	35.77702	32.43538	0.400026	12.89825	8.523785	11 50260	7.281123	14 80000	7.912581	14.54637	8.418311
Std. Dev	-0.134219	0.951051	3.122467	3.239588	3.566495	3.445637	2.367885	1.906890	2.824074	2.027307	2.351974	-0.003400 1.979349	2.49111	2.105349
Skewness	-0.340068	1.172901	1.594638	2.934989	0.141915	0.627288	-0.159685	0.060717	-0.133098	-0.106306	-0.063043	0.067103	-0.180531	-0.039952
Kurtosis	7.539357	8.565647	19.64249	32.20691	6.927143	4.806227	5.667017	3.952895	4.891280	3.893933	4.609410	4.050599	6.587968	4.548954
Jarque-Bera	1507.265	759.9835 (0.0000***)	35055.48 (0.0000***)	18489.59	1937.877	100.7587	901.8718	19.22407	125.2411	17.59002	325.7622	23.37020 (0.0000***)	1516.578 (0.0000***)	50.11757
Augmented Dickey-Füller	-36.16327 (0.0000***)	-18.87306 (0.0000***)	-37.88992 (0.0000***)	-21.97226 (0.0000***)	-54.55850 (0.0000***)	-14.65948 (0.0000***)	-57.73499 (0.0001***)	-22.03494 (0.0000***)	-28.60972 (0.0000***)	-22.97944 -22.0000***)	-55.78529 (0.0001***)	-22.98591 (0.0000***)	-53.47467 (0.0001***)	-22.77832 (0.0000***)
	51.309	16.725	71.456	13.504	2.8313	26.468	15.019	0.5378	10.224	3.7475	10.877	2.7031	6.4315	10.303
Q(5)	$(0.0000^{***})$	$(0.0051^{***})$	$(0.0000^{***})$	$(0.0191^{**})$	(0.7260)	$(0.0000^{***})$	$(0.0103^{**})$	(0.9907)	(0.0691*)	(0.5863)	(0.0539*)	(0.7456)	(0.1692)	(0.0671*)
Q²(5)	358.32 (0.0000***)	16.410 (0.0058***)	104.82 (0.0000***)	3.2437 (0.6625)	134.55 (0.0000***)	86.258 (0.0000***)	373.43 (0.0000***)	13.658 (0.0179**)	165.35 (0.0000***)	15.493 (0.0085***)	171.88 (0.0000***)	45.111 (0.0000***)	501.20 (0.0000***)	18.153 (0.0028***)
Observations	1717	500	1930	500	3000	500	3000	500	824	500	3000	500	2799	500

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	GJR Skew t		0.1250	0.0822*	0.1674	0.4491	0.1313	1.0000		NaN	0.1924	0.3601	0.7506	0.2930	0.1063		0.0000***	0.4034	0.6225	0.7527	0.2449	0.0006***
	GJR GED		0.1250	0.0822*	0.1674	0.1674	$0.0271^{**}$	0.3315		NaN	0.1924	0.3601	0.3601	0.0664*	NaN		$0.0000^{***}$	0.4021	0.4046	0.4002	0.1182	0.8154
	GJR Student t		0.1250	0.2885	0.2862	0.4491	$0.0486^{**}$	1.0000		NaN	0.5551	0.5581	0.7506	0.1175	0.1063		$0.0000^{***}$	0.7329	0.6249	0.7332	0.1473	$0.0006^{***}$
	GJR Normal		0.6414	$0.0486^{**}$	$0.0288^{**}$	0.0043***	$0.0271^{**}$	1.0000		NaN	NaN	$0.0885^{*}$	$0.0170^{**}$	$0.0664^{*}$	0.1063		$0.0002^{***}$	0.2713	0.4053	$0.0830^{*}$	0.1184	$0.0007^{***}$
	GARCH Skew t		0.1250	0.0822*	0.2213	0.6518	0.1313	0.6414		NaN	0.1924	0.4565	0.8811	0.2930	NaN		$0.0000^{***}$	0.3733	0.6843	0.9267	0.2434	0.7442
	GARCH GED		0.1250	0.1313	0.2213	0.1674	$0.0271^{**}$	0.3315		NaN	0.2930	0.4565	0.3601	$0.0664^{*}$	NaN		0.0000***	0.4724	0.6208	0.5934	0.3181	0.8358
EEX	GARCH Student t	Test for unconditional coverage	0.1250	0.2885	0.3622	0.4491	0.0486**	0.3315	<b>Fest for conditional coverage</b>	NaN	0.5551	0.6586	0.7506	0.1175	NaN	uantile test	$0.0000^{***}$	0.7301	0.7487	0.9092	0.1712	0.8335
CO2 EEX	GARCH Normal	Test for uncond	1.000	0.0486**	0.0629*	0.0025***	0.0271**	0.6414	Test for condit	NaN	0.1175	0.1411	$0.0103^{**}$	0.0664*	NaN	Dynamic quantile test	$0.0000^{***}$	0.2777	0.3365	0.1115	0.3185	0.7593
	Indirect AR-GARCH CAViaR		NaN	0.0142**	$0.0118^{**}$	$0.0043^{***}$	0.0013***	0.3315		NaN	NaN	$0.0377^{**}$	$0.0118^{**}$	NaN	NaN		0.3831	0.3534	0.0863*	0.1680	0.1165	0.8411
	Adaptive CAViaR		0.6414	0.5301	0.6518	0.2862	0.1994	NaN		NaN	0.8206	0.3407	0.5581	0.4167	NaN		$0.0001^{***}$	$0.0007^{***}$	0.0616*	$0.0012^{***}$	0.0629*	$0.0228^{**}$
	Indirect GARCH CAViaR		0.0282**	0.0031***	$0.0043^{***}$	0.1674	$0.0013^{***}$	0.3315		NaN	$0.0071^{***}$	$0.0136^{**}$	0.3601	NaN	NaN		0.7769	0.1265	0.1749	0.7420	0.1146	0.8420
	Asymmetric Slope CAViaR		0.1250	0.0069***	$0.0187^{**}$	0.1674	0.0031***	0.1250		NaN	NaN	$0.0339^{**}$	0.2653	0.0071***	NaN		0.9288	0.2102	0.2403	0.7226	0.1092	0.8131
	Symmetric Absolute Value CAViaR Slope CAViaR		0.1250	0.0005***	0.0072***	0.1238	$0.0005^{***}$	0.6414		NaN	$0.0010^{***}$	0.0132**	0.2265	$0.0010^{***}$	NaN		$0.0000^{***}$	0.0355**	0.1066	0.6582	0.0299**	0.5704
	EWQR		0.6414	0.1313	0.3622	0.4625	0.6776	0.0282**		NaN	NaN	0.5493	0.3373	0.9156	NaN		0.0001***	0.2843	0.2155	$0.0003^{***}$	0.1815	0.7407
	Quantile	<u> </u>	1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	96 % 0		1 %	5 %	10 %	30%	95 %	99 %

# Table E1: VaR test results for CO2 futures on EEX

The table presents both the coverage tests and the dynamic quantile test for the daily forecasts. \*, \*\* and \*\*\* denotes significance at the 10%, 5% and 1% level, respectively.

# **Appendix E: Test Results**

	GJR Skew t		0.0282**	0.5301	0.5461	0.3622	0.3992	1.0000		NaN	0.8206	0.8270	0.3478	0.6951	0.1063		0.7241	0.6409	0.2779	0.6423	0.1522	0.0008***
	GJR GED		0.0282**	0.0486**	0.2862	0.0431**	0.0271**	1.0000		NaN	0.1175	0.5209	0.1140	0.0664*	0.1063		0.7139	0.2715	0.4577	0.4084	0.0910*	0.0010*** (
	GJR Student t		0.0282**	0.8364	0.5461	0.1674	0.1313	1.0000		NaN	0.9677	0.8270	0.2653	0.2930	0.1063		0.7147	0.3888	0.2824	0.7379	0.0419**	0.0009***
	GJR Normal		0.6414	0.1313	0.1674	0.0187**	0.0822*	1.0000		NaN	0.2930	0.2653	0.0600*	0.1924	0.1063		0.0002***	0.5265	0.5002	0.1361	0.2260	0.0008***
	GARCH Skew t		0.0282**	0.2885	0.8811	0.3622	0.3992	0.6414		NaN	0.5551	0.9071	0.3478	0.6951	0.0583*		0.7549	0.2254	0.3441	0.6254	0.1860	0.0001***
	GARCH GED		0.1250	0.0822*	0.6518	0.0893*	0.0142**	0.6414		NaN	0.1924	0.8811	0.1868	0.0345**	0.0583*		0.9334	0.3213	0.3722	0.5602	0.0574*	0.0001***
q OMX	GARCH Student t	onal coverage	0.1250	0.6776	1.0000	0.2862	0.1313	0.6414	nal coverage	NaN	0.9156	0.8775	0.3285	0.2930	0.0583*	ntile test	0.9299	0.0528*	0.4069	0.6646	0.0537*	0.0001***
CO2 Nasdaq OMX	GARCH Normal	Test for unconditional coverage	0.6414	0.0822*	$0.0431^{**}$	0.0072***	$0.0142^{**}$	0.6414	Test for conditional coverage	NaN	0.1924	0.1140	$0.0174^{**}$	0.0345**	0.0583*	Dynamic quantile test	$0.0002^{***}$	0.3309	0.3124	0.0726*	$0.0626^{*}$	0.0001***
	Indirect AR-GARCH CAViaR		NaN	0.3992	1.0000	0.2862	0.5455	0.6414		NaN	0.6951	0.5712	0.1166	0.7310	NaN		0.2090	0.2563	0.6143	0.6120	$0.0108^{**}$	0.0001***
	Adaptive CAViaR		0.3315	0.6776	0.0893*	0.3622	0.3992	0.1250		NaN	NaN	0.2361	0.3478	0.6951	NaN		0.7691	$0.0064^{***}$	0.1854	0.0335**	0.1128	0.7618
	Indirect GARCH CAViaR		NaN	0.0005***	0.6575	0.2862	0.5455	0.3315		NaN	NaN	0.8920	0.3285	0.7310	NaN		0.6081	$0.0035^{***}$	0.1501	0.5956	$0.0140^{**}$	0.9887
	Asymmetric Slope CAViaR		0.3315	0.2885	1.0000	0.8811	0.6776	0.6414		NaN	0.5551	0.8775	0.0758*	0.9156	0.0583*		0.8721	0.3571	0.2221	0.1445	0.8721	0.0001***
	Symmetric Absolute Value CAViaR		NaN	0.0005***	0.5556	0.8811	0.2885	0.6414		NaN	NaN	0.8380	0.2879	0.5551	0.0583*		0.8374	$0.0035^{***}$	0.2638	0.2777	0.1287	0.0001***
	EWQR		0.6414	0.1994	0.7642	0.6575	0.8384	1.0000		NaN	NaN	0.9085	$0.0316^{**}$	0.9265	0.1063		$0.0002^{***}$	0.1092	0.1739	0.0016***	0.0703*	0.0011***
	Quantile	-	1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	% 66

Table E2: VaR test results for CO2 futures on Nasdaq OMX (Nord Pool)

	GJR Skew t		1.0000	0.0486**	0.2862	0.0223**	0.0337**	0.6630		NaN	NaN	0.0173**	0.0009***	0.1011	NaN		0.9997	0.5756	0.0636*	0.0000***	0.0514*	0.8996
	GJR GED		1.0000	0.0271**	0.0118**	0.5556	0.5455	0.6630		NaN	NaN	0.0231**	0.1667	0.7829	NaN		0.9992	0.4641	0.3014	0.0234**	0.1407	0.8948
	GJR Student t	-	1.0000	0.2885	0.4491	0.0223**	$0.0337^{**}$	0.6630		NaN	NaN	0.0417**	0°0009***	0.1011	NaN		0.9996	0.8315	0.0694*	0.0000***	0.0522*	0.9060
	GJR Normal		0.6414	$0.0013^{***}$	0.0000***	0.0288**	0.2885	0.6630		NaN	NaN	NaN	0.0621*	0.5551	0.1419		0.9987	0.1839	0.0001***	0.0264**	0.2019	0,0046***
	GARCH Skew t		1.0000	0.1313	0.2213	0.0047***	0.0523*	0.6630		NaN	NaN	0.0337**	0.0008***	0.1423	NaN		0.9998	0.7701	0.1494	0.0000***	0.1915	0.9374
	GARCH GED		0.6630	0.02710**	0.0043***	0.7669	0.4229	0.6630		NaN	NaN	0.0136**	0.2628	0.6062	NaN		0.9965	0.4917	0.1957	0.0564*	0.2967	0.9495
Е	GARCH Student t	nal coverage	1.0000	0.3992	0.4491	$0.0070^{***}$	0.0523*	0.6630	al coverage	NaN	NaN	0.1114	0.0009***	0.1423	NaN	tile test	0.9998	0.8267	0.2016	0.0000***	0.1926	0.9425
Coal ICE	GARCH Normal	Test for unconditional coverage	0.6414	0.0031***	0.0000***	0.0043***	0.0005***	0.3315	Test for conditional coverage	NaN	NaN	NaN	0.0072***	NaN	NaN	Dynamic quantile test	0.9995	0.2191	0.0000***	0.0547*	0.0907*	0.7527
	Indirect AR-GARCH CAViaR		1.0000	0.1313	0.7669	0.6518	0.8364	1.0000		NaN	NaN	0.0498**	0.8633	0.9677	0.1063		0.9199	0.7626	0.0105**	0.6026	0.6066	0.0029***
	Adaptive CAViaR		0.1250	0.6776	0.7642	0.3622	0.0822*	0.1250		NaN	0.0557*	0.4862	0.3551	0.1924	NaN		0.7629	0.0003***	0.0193**	0.0005***	0.0523*	0.9301
	Indirect GARCH CAViaR		1.0000	0.0822*	1.0000	0.0629	0.8364	1.0000		NaN	NaN	0.6373	0.0699*	0.9677	NaN		0.9997	0.6615	0.1374	0.1104	0.6071	0.9756
	Asymmetric Slope CAViaR		0.6414	0.1313	0.3622	$0.0431^{**}$	0.5301	1.0000		NaN	NaN	0.0082***	0.1140	0.8206	0.1063		0.9993	0.7198	0.0378**	0.2385	$0.0440^{**}$	0.0021***
	Symmetric Absolute Value CAViaR		0.6414	0.1994	0.6518	0.0431**	0.2885	0.3315		NaN	NaN	0.0304**	0.0569*	NaN	NaN		0.9993	0.8160	0.0737*	0.0805*	0.2017	0.9333
	EWQR		0.1250	0.5455	0.8811	0.4491	0.3992	0.1250		NaN	0.0099***	$0.0016^{***}$	0.0417**	0.6951	NaN		0.8879	0.0001***	0.0001***	0.0001***	$0.0048^{***}$	0.8924
	Quantile		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	% 66

Table E3: VaR test results for coal futures on ICE

	GJR Skew t		0.1250	0.3992	0.5461	0.1907	0.1678	1.0000		NaN	0.3908	$0.0205^{**}$	0.0001***	$0.0181^{**}$	0.1063		0.8978	0.7937	0.0333**	0.0000***	0.0031***	0.0008***
	GJR GED		0.1250	0.1313	0.0629*	0.8818	0.8384	1.0000		NaN	0.2930	0.0009***	0.0002*** 0	0.0303** (	0.1063		0.9025	0.7198	0.0026***	0.0000*** 0	0.0045*** 0	0.0008*** 0
	35		0.1	0.1	90.0	0.8	0.8	1.0		Ň	0.2	0.000	0.000	0.03	0.1		6.0	0.7	0.002	0.00		0.00(
	GJR Student t		0.1250	0.5301	0.6518	0.2436	0.2346	1.0000		NaN	0.5121	$0.0304^{**}$	0.0000***	$0.0169^{**}$	0.1063		0.8978	0.8240	0.0576*	0.0000***	$0.0025^{***}$	0.0009***
	GJR Normal		0.3315	0.0486**	$0.0043^{***}$	0.3622	1.0000	0.6630		NaN	0.1175	$0.0008^{***}$	0.0021***	0.1062	0.1419		0.9360	0.5310	0.0243**	$0.0022^{***}$	0.0435**	0.0018***
	GARCH Skew t		0.1250	0.1994	0.4491	0.3063	0.4229	1.0000		NaN	0.1870	$0.0417^{**}$	0.0006***	0.0560*	0.1063		0.8932	0.5343	0.0605*	0.0002***	0.0220**	0.0007***
	GARCH GED		0.1250	0.0822*	0.0629*	0.7669	0.8384	1.0000		NaN	0.1924	$0.0038^{***}$	0.0001***	$0.0303^{**}$	0.1063		0.9002	0.6508	0.0098***	0.0000***	0.0051***	0.0010***
<b>ZMEX</b>	GARCH Student t	tional coverage	0.1250	0.5301	0.6518	0.4625	0.4229	1.0000	onal coverage	NaN	0.5122	$0.0304^{**}$	0.0003***	0.0560*	0.1063	iantile test	0.8904	0.7298	0.0089***	0.0001***	$0.0215^{**}$	0.0008***
Coal NYMEX	GARCH Normal	Test for unconditional coverage	0.3315	0.0486**	0.0025***	0.1674	0.8364	0.3966	Test for conditional coverage	NaN	0.1175	$0.0004^{***}$	0.0015***	0.0795*	0.1489	Dynamic quantile test	0.9390	0.5469	0.0135**	0.0027***	0.0145**	0.0028***
	Indirect AR-GARCH CAViaR		0.3315	$0.0013^{***}$	$0.0187^{**}$	0.3063	0.5455	0.1250		NaN	NaN	$0.0387^{**}$	0.2026	0.1765	NaN		0.9459	0.1789	0.4390	0.4491	0.1243	0.8152
	Adaptive CAViaR		0.6414	0.6776	0.4491	0.8818	0.8364	0.0282**		NaN	NaN	$0.0417^{**}$	$0.0037^{***}$	0.7340	NaN		0.1776	0.0006***	$0.0034^{***}$	$0.0004^{***}$	$0.0974^{*}$	0.7839
	Indirect GARCH CAViaR		0.1250	$0.0002^{***}$	$0.0288^{**}$	0.7669	0.5455	0.1250		NaN	0.0003***	$0.0038^{***}$	$0.0053^{***}$	$0.0484^{**}$	NaN		0.8822	$0.0411^{**}$	0.0206**	$0.0035^{***}$	$0.0102^{**}$	0.8890
	Asymmetric Slope CAViaR		0.0282**	0.0486**	0.0893*	0.4491	0.6776	0.1250		NaN	0.1175	0.0595*	0.4522	0.9156	NaN		0.7467	0.2990	0.1430	0.3789	0.5783	0.9222
	Symmetric Absolute Value CAViaR		0.0282**	$0.0002^{***}$	$0.0014^{***}$	0.5461	0.5301	0.1250		NaN	0.0003***	$0.0006^{***}$	0.0059***	0.1710	NaN		0.7673	0.0438**	0.0307**	0.0233**	0.2051	0.9293
	EWQR		0.3315	0.2346	0.2436	0.3063	0.0129**	0.0199**		NaN	0.0169**	0.1102	$0.0021^{***}$	$0.0034^{***}$	0.0325**		0.9054	0.0006***	$0.0001^{***}$	0.0000***	0.0000***	0.0016***
	Quantile		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	96 %		1 %	5 %	10 %	% 06	95 %	% 66

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	GJR Skew t		1.0000	0.6776	0.0893*	0.0007***	$0.0486^{**}$	0.3315		NaN	NaN	0.2361	0.0001***	0.1175	NaN		0.0050***	0.9107	0.8407	0.0014***	0.2265	0.9721
	GJR GED		1.0000	0.0271**	0.0004***	0.0000*** 0.	0.0142** 0	0.6414		NaN	NaN	0.0016***	0.0000*** 0.0	0.0345**	NaN		0.0049*** 0.	0.4980	0.0919*	0.0010*** 0.	0.2642	0.7407
	GJR Student t		0.3315	0.3992	0.0431**	0.0007*** (	0.0822*	0.3315		NaN	NaN	0.1140	0.0001*** (	0.1924	NaN		0.9826	0.8846	0.6778	0.0014*** (	0.3366	0.9662
	GJR Normal		1.0000	0,0000***	0.0000***	0.0000***	$0.0002^{***}$	0.6414		NaN	NaN	NaN	$0.0000^{***}$	$0.0003^{***}$	NaN		0.0048***	0.0137**	0.0001***	0.0001***	$0.0072^{***}$	0.8231
	GARCH Skew t		0.6414	0.5301	0.0629*	0.0025***	$0.0486^{**}$	0.6414		NaN	NaN	0.0699*	0.0000***	0.1175	NaN		0.9985	0.9723	0.5738	$0.0004^{***}$	0.1601	0.9750
	GARCH GED		0.6414	0.0271**	0.0007***	$0.0001^{***}$	0.0271**	1.0000		NaN	NaN	$0.0028^{***}$	0.0000***	0.0664*	NaN		0.9979	0.4992	0.1256	0.0000***	0.1030	$0.0018^{***}$
ty futures EEX	GARCH Student t	tional coverage	0.3315	0.2885	0.0288**	$0.0043^{***}$	0.0822*	0.6414	onal coverage	NaN	NaN	0.0448**	$0.0000^{***}$	0.1924	NaN	antile test	0.9793	0.7687	0.4208	$0.0010^{***}$	0.0256**	0.9683
Monthly electricity futures EEX	GARCH Normal	Test for unconditional coverage	0.6414	0.0002***	0.0000***	$0.0000^{***}$	0.0005***	0.6414	Test for conditional coverage	NaN	NaN	NaN	0.0000***	$0.0010^{***}$	NaN	Dynamic quantile test	0.9978	0.0509*	0.0001***	0.0000***	$0.0188^{**}$	0.9879
	Indirect AR-GARCH CAViaR		0.3315	$0.0031^{***}$	$0.0007^{***}$	$0.0004^{***}$	$0.0031^{***}$	0.1250		NaN	NaN	$0.0033^{***}$	$0.0017^{***}$	$0.0071^{***}$	NaN		0.9867	0.1767	$0.0360^{**}$	$0.0318^{**}$	0.0981*	0.9247
	Adaptive CAViaR		0.6414	0.8364	1.0000	0.8818	0.6852	1.0000		NaN	NaN	1.0000	0.1005	0.0395**	NaN		0.0003***	0.3359	$0.0669^{*}$	$0.0002^{***}$	$0.0008^{***}$	0.1194
	Indirect GARCH CAViaR		0.0282**	0.0031***	0.0007***	$0.0072^{***}$	$0.0486^{**}$	0.3315		NaN	NaN	$0.0033^{***}$	$0.0132^{**}$	0.0357**	NaN		0.7777	0.1506	$0.0352^{**}$	0.1614	0.0222**	0.9874
	Asymmetric Slope CAViaR		1.0000	0.0031***	$0.0025^{***}$	$0.0014^{***}$	0.0271**	0.1250		NaN	NaN	$0.0103^{**}$	0.0059***	0.0664*	NaN		0.9995	0.2108	0.0841*	0.1100	0.3815	0.9329
	Symmetric Absolute Value CAViaR		0.1060	0.0142**	$0.0014^{***}$	0.1238	0.0142**	0.0282**		NaN	NaN	0.0059***	0.1810	$0.0077^{***}$	NaN		0.3068	0.2631	0.0993*	0.3857	0.0508*	0.7833
	EWQR		0.1060	0.0211**	0.7669	0.3063	0.0792*	0.6630		NaN	0.0517*	0.1233	$0.0190^{**}$	0.1177	NaN	5	$0.0001^{***}$	0.0003***	$0.0280^{**}$	$0.0008^{***}$	$0.0050^{***}$	0,0000***
	Quantile	•	1 %	5 %	10%	% 06	95 %	% 66		1 %	5 %	10 %	%06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	66 %

Table E5: VaR test results for monthly electricity futures on EEX

Table E6: VaR test results for yearly electricity futures on EEX

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EWQR         Symmetric Absolute Value         Asymmetric Slope CAViaR         Indirect GARCH         Adaptive Adaptive CAViaR	Asymmetric Indirect Slope CAViaR CAViaR	Asymmetric Indirect Slope CAViaR CAViaR		Adaptiv CAViaF	<u>ه</u> م	Indirect AR-GARCH CAViaR	GARCH Normal	GARCH Student t	GARCH GED	GARCH Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
							Test for uncond	<b>Test for unconditional coverage</b>						
0.0282** 0.1250 0.1250 0.0282** NaN	0.1250 0.0282**	0.0282**		NaN		NaN	$0.0282^{**}$	0.0282**	0.0282**	0.0282**	0.0282**	$0.0282^{**}$	$0.0282^{**}$	$0.0282^{**}$
0.0008**** 0.0000**** 0.0000*** 0.3992	0.0000*** 0.0000***	$0.0000^{***}$		0.3992		$0.0000^{***}$	$0.0005^{***}$	0.0069***	0.0031***	0.0271**	$0.0069^{***}$	$0.0142^{**}$	0.0031***	0.0271**
0.1116 0.0000*** 0.0000*** 0.0000*** 0.0642	0.0000*** 0.0000***	$0.000^{***}$		0.7642		$0.0000^{***}$	$0.0000^{***}$	0.0629*	0.0072***	$0.0629^{*}$	$0.0000^{***}$	$0.0629^{*}$	$0.0288^{**}$	0.0629*
0.6575 0.0000*** 0.0000*** 0.0000*** 0.0000*** 0.7642	0.0000*** 0.0000***	$0.0000^{***}$		0.7642		$0.0000^{***}$	$0.0007^{***}$	0.2213	0.0629*	0.0629*	$0.0014^{***}$	$0.0893^{*}$	0.0629*	0.0629*
0.3992 0.0000*** 0.0000*** 0.0000*** NaN	0.0000*** 0.0000***	$0.0000^{***}$		NaN		$0.0000^{***}$	0.0069***	0.2885	$0.0271^{**}$	0.1994	$0.0142^{**}$	0.1994	$0.0486^{**}$	0.1313
0.21489 NaN NaN NaN 1.0000	NaN NaN	NaN		1.0000		NaN	0.3966	0.3315	0.3315	0.3315	0.6630	0.3315	0.3315	0.3314
							Test for condit	Test for conditional coverage						
NaN NaN NaN NaN NaN	NaN NaN	NaN		NaN		NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
0.0027*** NaN NaN NaN 0.6951	NaN NaN	NaN		0.6951		NaN	NaN	NaN	NaN	0.0664*	$0.0164^{**}$	0.0345**	NaN	0.0664*
0.2331 0.0000*** 0.0000*** NaN 0.9371	0.0000*** NaN	NaN		0.9371		NaN	$0.0000^{***}$	$0.0369^{**}$	0.0054***	0.0369**	$0.0000^{***}$	0.0369**	$0.0124^{**}$	$0.0369^{**}$
0.0021*** 0.0000*** NaN 0.0000*** 0.9371	NaN 0.0000***	$0.0000^{***}$		0.9371	_	NaN	$0.0003^{***}$	$0.0337^{**}$	$0.0130^{**}$	$0.0131^{**}$	$0.0006^{***}$	$0.0226^{**}$	$0.0131^{**}$	$0.0131^{**}$
0.0029*** NaN NaN NaN NaN	NaN NaN	NaN		NaN		NaN	$0.0164^{**}$	0.2797	0.0664*	0.1870	0.0345**	0.1870	0.1175	0.2930
NaN NaN NaN NaN NaN	NaN NaN	NaN		NaN		NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
							Dynamic q	Dynamic quantile test						
0.7601 0.9264 0.9304 0.7808 0.0544*	0.9304 0.7808	0.7808		0.0544*		0.3041	0.7685	0.7678	0.7693	0.7691	0.7730	0.7706	0.7729	0.7711
0.0000*** 0.0026*** 0.0025*** 0.0023*** 0.0996*	0.0025*** 0.0023***	0.0023***		0.0996*		$0.0023^{***}$	0.1011	0.2783	0.2010	0.4295	0.2080	0.2965	0.1968	0.4263
0.0140** 0.0010*** 0.0011*** 0.0000*** 0.0066***	0.0011*** 0.0000***	$0.000^{***}$		0.0066***		$0.0000^{***}$	$0.0018^{***}$	$0.0596^{**}$	$0.0207^{**}$	0.0597*	$0.0051^{***}$	0.0588*	$0.0194^{**}$	0.0595*
0.0002*** 0.0000*** 0.0000*** 0.0001*** 0.0315**	0.0000*** 0.0001***	$0.0001^{***}$		0.0315**		$0.0000^{***}$	$0.0001^{***}$	0.0079***	$0.0011^{***}$	$0.0012^{***}$	$0.0002^{***}$	$0.0029^{***}$	$0.0015^{***}$	$0.0014^{***}$
0.0000*** 0.0104** 0.0051*** 0.0103** 0.0000***	0.0051*** 0.0103** 0.00	0.0103** 0.00	0.00	0.0000**	**	$0.0044^{***}$	$0.0144^{**}$	$0.0167^{**}$	0.0524*	$0.0088^{***}$	$0.0238^{**}$	$0.0107^{**}$	0.0795*	0.1538
0.0000*** 0.8827 0.5012 0.7313 0.3620	0 5012 0 7313	0.7313		0.3620		0.7617	$0.0070^{***}$	0.9554	0.9606	0.9547	0.7284	0.9632	0.9692	0.9600

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	GJR Skew t		0.6630	0.2346	0.3792	0.2213	1.0000	0.2149		NaN	0.4925	0.5118	0.4565	0.8069	NaN		0.9795	0.1184	0.6550	0.7305	0.8762	0.7339
	GJR GED		0.2149	0.4229	0.6575	0.0893*	0.6776	0.2149		NaN	0.7024	0.7416	0.2361	0.6313	NaN		0.6282	0.3514	0.9166	0.5932	0.8907	0.8350
	GJR Student t		0.2149	0.1678	0.3792	0.2213	1.0000	0.3966		NaN	0.3860	0.5118	0.4565	0.8069	NaN		0.6316	0.1251	0.6532	0.7301	0.8772	0.9616
	GJR Normal		0.0077	0.5455	0.4491	$0.0043^{***}$	0.6776	0.0199**		NaN	0.7829	0.7506	0.0170**	0.6313	0.0325**		0.0087***	0.1936	0.7924	0.1678	0.8687	0.0162**
	GARCH Skew t		0.2149	0.2346	0.4625	0.6518	0.8384	0.6630		NaN	NaN	0.7632	0.8633	0.8407	NaN		0.8078	$0.0109^{**}$	0.8586	0.8702	0.8602	0.9947
	GARCH GED		0.1060	0.3192	0.5556	0.1238	0.6776	0.6630		NaN	NaN	0.8380	0.2738	0.6313	NaN		0.0587*	0.2796	0.7692	0.8098	0.8137	0.9906
futures NYMEX	GARCH Student t	tional coverage	0.2149	0.1678	0.3792	0.5461	1.0000	1.0000	onal coverage	NaN	NaN	0.6743	0.7688	0.8069	NaN	antile test	0.8119	$0.0116^{**}$	0.8467	0.9912	0.8741	0.9988
Monthly electricity futures NYMEX	GARCH Normal	Test for unconditional coverage	$0.0027^{***}$	0.4229	0.4491	$0.0007^{***}$	0.5301	0.1060	Test for conditional coverage	NaN	NaN	0.7506	$0.0021^{***}$	0.5122	NaN	Dynamic quantile test	0.0037***	0.2595	0.5163	0.0698*	0.8594	0.0448**
M	Indirect AR-GARCH CAViaR		0.0009***	0.5301	0.1238	0.7642	0.6776	0.0077***		0.0006***	0.5122	0.0373**	0.9371	0.6313	NaN		$0.0000^{***}$	0.0870*	0.1805	0.9286	0.7712	0.0064***
	Adaptive CAViaR		0.6630	0.8364	0.5461	0.0288**	0.5455	0.6414		0.1419	0.7340	0.1532	0.0317**	0.4591	NaN		0.0129**	$0.0070^{***}$	$0.0414^{**}$	$0.0000^{***}$	0.2535	0.8494
	Indirect GARCH CAViaR		NaN	0.3992	0.2213	0.6518	0.5455	0.0479**		NaN	0.6951	0.1956	0.6578	0.7829	NaN		0.2397	0.0943*	0.5219	0.8306	0.8883	0.0275**
	Asymmetric Slope CAViaR		$0.0000^{***}$	0.2885	$0.0000^{***}$	0.2862	0.8384	0.0077***		0.0000***	0.2797	0.0000***	0.5581	0.8407	$0.0160^{**}$		0.0000***	0.0136	$0.0000^{***}$	0.9558	0.8669	0.0079***
	Symmetric Absolute Value CAViaR		$0.0000^{***}$	0.5301	0.0072***	0.6518	1.0000	0.0199**		0.0000***	0.5122	0.0231**	0.6578	0.8069	NaN		0.0000***	0.0759*	0.0373**	0.9378	0.8751	0.0195**
	EWQR		0.2149	0.8384	0.8818	0.0614*	0.6852	0.1060		0.1282	0.8407	0.2257	0.1738	0.8424	NaN		$0.0466^{**}$	$0.0214^{**}$	$0.0011^{***}$	$0.0028^{***}$	0.3060	0.2591
	Quantile		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	90 %	95 %	% 66

Table E8: VaR test results for monthly electricity futures on NYMEX

	GJR Skew t		1.0000	0.8364	0.2436	0.0614*	0.0337**	0.3966		NaN	0.0795*	0.5032	0.1588	0.0710*	NaN		0.9839	0.0896*	0.4046	0.0539*	$0.0416^{**}$	0.9631	
	GJR GED		0.6414	0.0822*	0.7669	0.3063	0.3192	0.6630		NaN	0.0121**	0.9385	0.3373	0.1879	NaN		0.9895	0.0504*	0.6895	0.2128	0.1522 0	0.9964	
	0.0		0.6	0.0	0.7	0.3	0.3	0.6		z	0.01	0.0	0.3	0.1	z		0.9	0.0	0.6	0.2	0.1	5.0	
	GJR Student t		1.0000	0.5301	0.2436	0.0614*	0.0337**	0.2149		NaN	0.1710	0.5032	0.1588	0.0710*	NaN		0.9822	0.2248	0.4015	0.0547*	0.0422**	0.8357	
	GJR Normal		1.0000	$0.0031^{***}$	$0.0000^{***}$	$0.0288^{**}$	1.0000	$0.0479^{**}$		NaN	$0.0011^{***}$	$0.0000^{***}$	$0.0317^{**}$	0.3635	0.0588*		0.9935	0.0228**	$0.0048^{***}$	0.1608	0.2479	$0.0026^{***}$	
	GARCH Skew t		1.0000	1.0000	0.2436	0.1116	$0.0337^{**}$	0.3966		NaN	0.1062	0.5032	0.2747	0.0710*	NaN		0.9834	0.1073	0.4027	0.0789*	$0.0439^{**}$	0.9630	
	GARCH GED		0.6414	0.0822*	1.0000	0.3063	0.5455	0.6630		NaN	0.0121**	1.0000	0.4805	0.1765	NaN		0.9885	0.0510*	0.6508	0.1910	0.1801	0.9963	respectively.
ICE	GARCH Student t	tional coverage	1.0000	0.6776	0.2436	0.0834*	$0.0337^{**}$	0.2149	onal coverage	NaN	0.0557*	0.5032	0.2217	0.0710*	NaN	iantile test	0.9826	0.0658*	0.4030	0.0495**	$0.0439^{**}$	0.8310	5% and 1% level.
Gas ICE	GARCH Normal	Test for unconditional coverage	1.0000	0.0013***	$0.0000^{***}$	$0.0118^{**}$	0.6776	0.2149	Test for conditional coverage	NaN	0.0004***	$0.0000^{***}$	$0.0103^{**}$	0.2340	NaN	Dynamic quantile test	0.9913	$0.0102^{**}$	0.0005***	0.0488**	0.2469	0.8303	icance at the 10%,
	Indirect AR-GARCH CAViaR		1.0000	0.1994	0.8818	$0.0003^{***}$	$0.0337^{**}$	0.6630		NaN	0.1870	0.9842	***6000.0	0.0512*	NaN		0.9969	0.5260	0.4524	0.0007***	$0.0830^{*}$	0.9813	*** denotes signif
	Adaptive CAViaR		NaN	0.1994	0.4491	0.5461	0.6776	0.6414		NaN	NaN	0.6614	0.7688	0.6313	NaN		0.9184	0.3006	$0.0670^{*}$	0.3535	0.2147	0.5144	forecasts. *, ** and
	Indirect GARCH CAViaR		1.0000	0.1994	0.7669	0.0005	$0.0337^{**}$	0.6630		NaN	0.0441**	0.9385	$0.0021^{***}$	0.0710*	NaN		0.9969	0.1553	0.4131	$0.0047^{***}$	$0.0461^{**}$	0.9884	test for the daily f
	Asymmetric Slope CAViaR		0.6414	$0.0486^{**}$	1.0000	0.0154**	$0.0014^{***}$	0.2149		NaN	0.0357**	1.0000	0.0258**	0.0039	NaN	L	0.9989	0.1926	0.5189	$0.0082^{***}$	$0.0001^{***}$	0.8101	e dynamic quantile
	Symmetric Absolute Value CAViaR		0.3315	0.0486**	0.6518	0.007***	0.0523*	0.6630		NaN	0.0357**	0.6578	0.0228**	0.0934*	NaN		0.9644	0.1823	0.2618	0.0251**	$0.0171^{**}$	0.9935	The table presents both the coverage tests and the dynamic quantile test for the daily forecasts. * ** and *** denotes significance at the 10%. 5% and 1% level, respectively.
	EWQR		1.000	1.000	0.7642	0.7669	0.4229	0.2149		0.1063	0.3635	0.7526	0.9385	0.4468	NaN		$0.0008^{***}$	0.0733*	$0.0466^{**}$	0.2814	0.1997	0.4243	resents both the co
	Quantile		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	% 66	The table p

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	GJR Skew t		0.1250	0.6776	0.6575	1.0000	0.8364	0.6630		NaN	0.9156	0.1442	0.5712	NaN	NaN		0.9320	0.7364	0.1574	0.0836*	0.8053	0.9867
	GJR GED		0.1250	0.1313	0.7642	1.0000	0.8364	0.6630		NaN	0.2930	0.3180	0.5712	NaN	NaN		0.9314	0.6092	0.2213	0.0840*	0.8069	0.9867
	GJR Student t	-	0.1250 (	0.5301 (	0.7669 (	1.0000	0.8364 (	0.6630 (		NaN	0.8206 (	0.1790 (	0.5712 (	NaN	NaN		0.9315 0	0.8641 (	0.2300 (	0.0835* 0.0835	0.8044 (	0.9839 0
		-		0.5				0.0		Z			0.5	Z	Z		5.0	0.8			0.8	0.0
	GJR Normal	-	0.3315	0.1313	0.2862	0.6518	0.8364	0.3966		NaN	0.2930	0.3285	0.6651	NaN	NaN	×	0.9888	0.6069	0.4472	0.3896	0608.0	0.9630
	GARCH Skew t		0.1250	0.5301	0.3792	0.7669	1.0000	0.6630		NaN	0.8206	0.0637*	0.9385	NaN	NaN		0.9320	0.8622	0.1535	0.1906	0.4549	0.9573
	GARCH GED		0.0282**	0.3992	0.7669	0.8818	0.6776	0.6630		NaN	0.6951	0.1790	0.9842	NaN	NaN		0.7818	0.8493	0.4901	0.1676	0.7005	0.9477
MEX	GARCH Student t	tional coverage	0.1250	0.3992	0.5556	0.7669	0.8384	0.6630	onal coverage	NaN	0.6951	0.1129	0.9385	0.9265	NaN	antile test	0.9314	0.8475	0.2983	0.1902	0.7386	0.9485
Gas NYMEX	GARCH Normal	Test for unconditional coverage	0.3315	0.3992	0.3622	0.5461	0.5301	0.3966	Test for conditional coverage	NaN	0.6951	0.3478	0.6572	NaN	NaN	Dynamic quantile test	0.9913	0.8515	0.3194	0.1531	0.8338	0.9510
	Indirect AR-GARCH CAViaR		0.1250	0.2885	0.8818	0.5556	0.6852	0.6630		NaN	0.5551	0.5107	0.7778	NaN	NaN		0.9324	0.6830	0.2858	$0.0661^{*}$	0.3543	0.9885
	Adaptive CAViaR		1.0000	0.2885	0.6518	0.8811	0.8364	0.2149		NaN	0.5551	0.0987*	0.9840	NaN	NaN		0.7697	0.9270	0.2345	0.4241	0.6648	0.0000***
	Indirect GARCH CAViaR		0.1250	0.3992	0.6575	0.7669	0.8364	0.6630		NaN	0.6951	0.1442	0.9385	NaN	NaN		0.9305	0.8358	0.2169	$0.0398^{**}$	0.5254	0.9488
	Asymmetric Slope CAViaR		0.3315	0.1994	0.3622	0.5556	0.6852	0.3966		NaN	0.4167	0.3478	0.7778	NaN	NaN		0.9898	0.7440	0.2965	0.2647	0.0873*	0.0354**
	Symmetric Absolute Value CAViaR		0.3315	0.1994	0.5461	0.8818	0.3992	0.6630		NaN	0.4167	0.1077	0.9842	NaN	NaN		0.9899	0.6643	0.2409	0.0878*	0.4848	0.9263
	EWQR		0.6414	0.8384	1.0000	1.0000	0.3992	0.6630		NaN	0.9265	0.2530	0.8775	0.6951	NaN		0.9995	0.8087	0.3044	0.0295**	$0.0000^{***}$	0.9633
	Quantile		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	90 %	95 %	96 %		1 %	5 %	10 %	% 06	95 %	% 66

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	GJR Skew t		0.1250	0.1313	0.0187**	0.7669	1.0000	0.1250		NaN	0.0241**	$0.0004^{**}$	0.7481	NaN	NaN		0.8989	0.1456	$0.0109^{**}$	0.6459	0.6022	0.9252
	GJR GED		0.1250	0.1313	$0.0187^{**}$	0.7642	0.8364	0.1250		NaN	0.0241**	$0.0004^{***}$	0.6522	NaN	NaN		0.9051	0.1455	$0.0108^{***}$	0.8657	0.6883	0.9265
	GJR Student t		0.1250	0.1994	0.0431**	1.0000	1.0000	0.1250		NaN	0.0441**	***6100.0	0.5712	NaN	NaN		0.9013	0.2248	$0.0203^{**}$	0.6789	0.6088	0.9255
	GJR Normal		0.6414	0.1313	0.0072***	0.5461	0.8364	0.1250		NaN	0.0241**	0.0004***	0.6572	NaN	NaN		0.8659	0.1455	$0.0140^{**}$	0.8018	0.6978	0.9271
	GARCH Skew t		0.1250	0.0822*	0.0288**	0.6575	0.8384	0.1250		NaN	0.0121**	$0.0010^{***}$	0.3735	NaN	NaN		0.9161	0.0924*	0.0213**	0.3150	0.5205	0.9273
	GARCH GED		0.1250	0.0822*	0.0187**	0.8811	0.8364	0.1250		NaN	0.0121**	$0.0004^{***}$	0.6198	NaN	NaN		0.9183	0.0926*	0.0157**	0.6728	0.5066	0.9280
le Oil ICE	GARCH Student t	tional coverage	0.1250	0.0822*	$0.0431^{**}$	0.8818	0.8364	0.1250	onal coverage	NaN	0.0121**	$0.0004^{***}$	0.5107	NaN	NaN	iantile test	0.9170	0.0925*	0.0096***	0.5888	0.4962	0.9277
Brent Crude Oil ICE	GARCH Normal	Test for unconditional coverage	0.6414	0.0822*	$0.0118^{**}$	0.5461	1.0000	0.1250	Test for conditional coverage	NaN	0.0121**	$0.0002^{***}$	0.3540	NaN	NaN	Dynamic quantile test	0.9074	0.0926*	0.0061***	0.6813	0.5815	0.9282
	Indirect AR-GARCH CAViaR		NaN	0.1313	0.0629*	0.4491	0.5301	0.1250		NaN	0.0241**	$0.0131^{**}$	0.7506	NaN	NaN		0.3184	0.1442	0.0866*	0.1182	0.4601	0.9284
	Adaptive CAViaR		NaN	0.0031***	0.0629*	0.0629*	0.0271**	0.0282**		NaN	0.0001***	0.0131**	*6690.0	NaN	NaN		0.0222**	0.0006***	0.0313**	$0.0320^{**}$	0.1078	0.7091
	Indirect GARCH CAViaR		NaN	0.1994	0.1674	0.8811	0.5301	0.1250		NaN	0.0065***	0.0061***	0.6178	NaN	NaN		1.000	0.0219**	$0.0333^{**}$	0.2211	0.4637	0.9285
	Asymmetric Slope CAViaR		0.0282**	0.2885	0.2862	0.3792	1.0000	0.3315		NaN	0.0126**	$0.0173^{**}$	0.3798	NaN	NaN	-	0.7828	0.0397**	0.0596*	0.1242	0.6015	0.4376
	Symmetric Absolute Value CAViaR		NaN	0.1994	0.1674	0.7669	0.8364	0.1250		NaN	0.0065***	0.0061***	0.4432	NaN	NaN	l	0.1314	0.0214**	$0.0280^{**}$	0.0612*	0.4192	0.9291
	EWQR		1.0000	$0.0013^{***}$	0.7642	$0.0118^{**}$	0.5301	0.1250		NaN	$0.0028^{***}$	0.2586	0.0248**	0.8206	NaN		0.7119	0.1043	0.1321	0.0157**	0.2074	0.8340
	Quantile		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	%06	95 %	% 66

Table E11: VaR test results for brent crude oil futures on ICE

	GJR Skew t		0.1250	0.1313	0.1674	0.4625	0.0271**	0.1250		NaN	0.1164	0.3601	0.6767	0.0174**	NaN		0.9329	0.5001	0.1965	0.2374	0.2020	0.8879
	ъ в В в		0.	0	0.	0	0.0	0.		2	0	0.0	0.0	0.0	Z		0.0	0.1	0.	0.0	0.0	0.8
	GJR GED		0.6414	0.3992	0.1674	0.8818	0.0031***	$0.0282^{***}$		NaN	0.3908	0.3601	0.8227	0.0071***	NaN		0.9963	0.5253	0.1880	0.1953	0.1951	0.7635
	GJR Student t		0.3315	0.5301	0.1674	0.5556	0.0271**	0.0282**		NaN	0.5122	0.3601	0.7778	0.0174**	NaN		0.9789	0.2419	0.1961	0.0932*	0.2020	0.7647
	GJR Normal		0.6414	0.3992	0.1238	0.6518	0.0069***	0.3315		NaN	0.6951	0.2738	0.8811	0.0164**	NaN		0.9988	0.9261	0.1367	0.1232	0.2364	0.9789
	GARCH Skew t		0.1250	0.1313	0.2213	0.7669	0.0486**	0.3315		NaN	0.1164	0.3399	0.9385	0.0357**	NaN		0.9328	0.2793	0.2245	0.2989	0.2729	0.9709
	GARCH GED		0.3315	0.3992	0.2213	1.0000	0.0069***	0.1250		NaN	0.3908	0.4565	0.8775	0.0164**	NaN		0.9787	0.1877	0.2893	0.2114	0.3005	0.8783
DII NYMEX	GARCH Student t	iional coverage	0.3315	0.3992	0.5461	1.0000	0.0142**	0.1250	onal coverage	NaN	0.3908	0.1532	0.87745	0.0077***	NaN	antile test	0.9799	0.1871	0.1595	0.1313	0.1349	0.8794
Light Crude Oil NYMEX	GARCH Normal	Test for unconditional coverage	0.6414	0.6776	0.0893*	0.4491	0.0142**	0.3315	Test for conditional coverage	NaN	0.2340	0.2004	0.7506	0.0345**	NaN	Dynamic quantile test	0.9980	0.2191	0.0720*	0.2201	0.3756	0.9699
	Indirect AR-GARCH CAViaR		0.1250	0.0486**	0.4491	0.2213	0.0271**	0.1250		NaN	NaN	0.7506	0.4565	0.0174**	NaN		0.9317	0.2545	0.4321	0.3417	0.1390	0.9198
	Adaptive CAViaR		NaN	0.0142**	$0.0118^{**}$	0.0187**	0.0069***	$0.0282^{**}$		NaN	0.0345**	$0.0035^{***}$	0.0590*	$0.0031^{***}$	NaN		1.0000	0.1153	0.0073***	0.0972*	0.0251**	0.7094
	Indirect GARCH CAViaR		0.1250	0.3992	0.8811	0.3622	0.0486**	0.1250		NaN	0.6951	0.5664	0.6586	0.0357**	NaN		0.9364	0.9373	0.1354	0.3979	0.1920	0.9160
	Asymmetric Slope CAViaR		0.3315	0.0486**	0.3622	0.7669	0.0069***	$0.0282^{**}$		NaN	0.0357**	0.3551	0.9385	0.0164**	NaN		0.9910	0.1137	0.1498	0.3293	0.2968	0.7713
	Symmetric Absolute Value CAViaR		0.1250	0.1994	0.5461	0.7642	0.0271**	0.3315		NaN	0.1870	0.3218	0.9085	0.0174**	NaN		0.9365	0.3720	0.0612*	0.1811	0.1343	0.9227
	EWQR		0.1250	0.0486**	$0.0187^{**}$	0.0288**	0.0069***	0.1250		NA	0.0357**	0.0067***	0.0885*	0.0031***	NA		0.8476	0.1742	0.0301**	0.0613*	0.0269**	0.8526
	Quantile	<u> </u>	1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	% 66

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Quantile	EWQR	Symmetric Absolute Value CAViaR	Asymmetric Slope CAViaR	Indirect GARCH CAViaR	Adaptive CAViaR	Indirect AR-GARCH CAViaR	GARCH Normal	GARCH Student t	GARCH GED	GARCH Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
							Test for uncondi	Test for unconditional coverage						
1 %	1.0000	0.3315	0.3315	0.6414	0.6414	0.0282**	1.0000	1.0000	1.0000	0.6414	1.0000	1.0000	1.0000	1.0000
5 %	0.1994	0.1313	0.1994	0.0822*	0.0822*	0.1994	0.1994	0.1994	0.1994	0.1313	0.2885	0.2885	0.2885	0.0822*
10 %	0.2862	0.0629*	0.0288**	0.0629*	0.1238	0.1238	0.0187**	0.0431**	0.0187**	0.0187**	0.0072***	0.0118**	0.0072***	0.0043***
% 06	0.5461	0.4491	0.7642	0.0431**	0.2213	0.2862	0.6518	0.7642	0.7642	0.8811	0.3622	0.5461	0.4491	0.7669
95 %	0.0486**	0.0486**	0.1313	0.0271**	0.1313	0.0271**	0.1313	0.1313	0.0822*	0.8364	$0.0486^{**}$	0.1313	$0.0486^{**}$	0.6776
% 66	0.6414	0.1060	0.6630	1	0.0282**	0.3966	0.3315	0.0282**	0.0282**	0.6414	0.1250	0.1250	0.1250	0.1250
							Test for condit	Test for conditional coverage						
1 %	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
5 %	0.4167	0.2930	0.4167	0.1924	0.0672*	0.4167	0.4167	0.4167	0.4167	0.2930	0.5551	0.5551	0.5551	0.1924
10 %	0.1311	0.0369**	0.0124**	0.0369**	0.0922*	0.0922*	0.0067***	0.0218**	0.0067***	0.0067***	0.0132**	0.0103**	0.0132**	0.0072***
% 06	0.6572	0.3565	0.3180	NaN	0.4507	0.1166	0.3407	0.3180	0.3180	0.2879	0.5819	0.8270	0.6287	0.7481
95 %	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
% 66	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
							Dynamic quantile test	uantile test						
1 %	0.4462	0.9250	0.9896	0.8891	0.3139	0.7739	0.6833	0.6626	0.6576	0.8205	0.9622	0.9501	0.9469	0.9438
5 %	0.6771	0.7731	0.5703	0.6830	0.1525	0.8258	0.8640	0.8648	0.8639	0.7725	0.6989	0.6995	0.6979	0.6115
10 %	0.0944*	0.2884	0.1299	0.3033	0.1102	0.4251	0.0870*	0.2340	0.0873*	$0.0876^{*}$	0.1552	0.1231	0.1554	0.1068
90 %	0.0780*	0.2578	0.1320	0.0706*	0.0312**	0.2153	0.1960	0.1540	0.1542	0.1648	0.3085	0.4028	0.3408	0.2315
95 %	0.1421	0.5002	0.3665	0.3661	0.1697	0.1365	0.7045	0.7043	0.5959	0.7879	0.4974	0.7092	0.4976	0.7744
% 66	0.8082	0.0107**	0.6539	0.9979	0.7260	0.0119	0.9893	0.7760	0.7762	0.9995	0.9355	0.9354	0.9351	0.9343

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Heating Oli - Nymex	ti Adaptive Indirect GARCH GARCH GARCH GARCH GJR GJR GJR GJR GJR GJR R-CAViaR CAViaR CAViaR CAViaR CAVia	Test for unconditional coverage	* NaN 0.1250 0.022** NaN NaN NaN 0.022** NaN NaN NaN	6 0.0013*** 0.5301 0.2885 0.3992 0.2885 0.5301 0.1994 0.3992 0.2885 0.5301	0.0043*** 0.2862 0.2213 0.4491 0.4491 0.4491 0.4213 0.2213	2 0.0893* 0.1674 0.1674 0.5461 0.3622 0.3622 0.1238 0.5461 0.3622 0.4491	** 0.0822* 0.0486** 0.1994 0.2885 0.1994 0.1994 0.1994 0.1994 0.1994 0.1994 0.1994 0.1994	0.0282** 0.1250 0.0282** NaN NaN NaN 0.0282** NaN NaN NaN	Test for conditional coverage	NaN	) 0.0028*** 0.5122 0.0746* 0.1169 0.0746* 0.1710 0.1870 0.1169 0.0746* 0.1710	** 0.0008*** 0.0173** 0.0105** 0.0132** 0.0132** 0.0132** 0.0105 0.0132** 0.0132** 0.0132**	0 0.1245 0.2653 0.3765 0.8270 0.6586 0.6586 0.3036 0.8270 0.5819 0.7506	5 0.0672* 0.1175 0.1870 0.2797 0.1870 0.1870 0.1870 0.2797 0.1870 0.1870	NaN	Dynamic quantile test	0.5198 0.8450 0.7772 0.2303 0.5420 0.3933 0.7773 1.0000 0.2390 0.9682	7 0.1435 0.8934 0.2966 0.2947 0.2954 0.3932 0.4858 0.2930 0.2934 0.3918	0	* 0.2532 0.0566* 0.1978 0.6911 0.2589 0.6354 0.2624 0.6794 0.3789 0.8104	0.4567 0.2283 0.6652 0.7243 0.6778 0.6917 0.6594 0.7206 0.6725 0.6878	0 00073*** 0.7715 0.0000*** 0.7313 0.9160 0.4927 0.2947 0.4507 0.1941 0.2534
	GARCH GED	Be	NaN	0.2885	0.4491	0.3622	0.1994	NaN		NaN	0.0746*	0.0132**	0.6586	0.1870	NaN		0.5420	0.2954	0.0423**	0.2589	0.6778	0.9160
ating Oil - Nymex	- • •	unconditional coverag							r conditional coverage							namic quantile test						
He		Test for							Test for							Dyn						
			NaN	0.0013***	$0.0043^{***}$	0.0893*	0.0822*	0.0282**		NaN	0.0028***	0.0008***	0.1245	0.0672*	NaN		0.5198	0.1435	0.0278**	0.2532	0.4567	$0.0073^{***}$
	c Indirect IR GARCH CAViaR		0.0282**	0.6776	0.4491	0.2862	0.0486**	NaN		NaN	0.2340	0.0132**	0.5209	0.1175	NaN		0.7551	0.6017	0.0431**	0.0607*	0.2330	0.3740
	c Asymmetric Ilue Slope CAViaR		0.3315	0.2885	0.4491	0.0893*	0.1313	NaN		NaN	0.0746*	0.0417**	0.2004	0.2930	NaN		0.9867	0.2951	0.1102	0.3744	0.4674	0.4930
	Symmetric Absolute Value CAViaR		0.0282**	0.2885	0.4491	0.0431**	0.1313	NaN		NaN	0.0746*	0.0417**	0.1275	0.2930	NaN		0.7516	0.2936	0.1102	0.2531	0.4929	0.2102
	EWQR		6 0.1250	6 0.0822*	6 0.1674	6 0.1674	6 0.1994	6 0.6414		6 NaN	6 0.0672*	6 0.0208**	6 0.2529	6 0.1870	6 NaN		6 0.8582	6 0.3339	6 0.1689		6 0.3913	6 0.7966
	Quantile		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	% 66		1 %	5 %	10 %	% 06	95 %	% 66

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Two-sided Dependent on VaR           Two-sided Dependent on VaR           0.8243         0.5046         0.3311         0.5753         0.3311         0.5753         0.3311         0.5753         0.3311         0.5753         0.01072         0.3311         0.5753         0.01072         0.3311         0.5762         0.1416         0.3311         0.5762         0.1416         0.3166         0.0000         0.0006         0.3256         0.01221         0.01012		EWQR	Garch Normal	Garch Student t	Garch GED	Garch Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
08120         0511         0.5046         0.5047         0.5047         0.5046 <th>I</th> <th></th> <th></th> <th></th> <th>Two-</th> <th>sided Dependent on</th> <th>VaR</th> <th></th> <th></th> <th></th>	I				Two-	sided Dependent on	VaR			
0.8244         0.2701         0.4460         0.000***         0.000***         0.000***         0.000***         0.000***           0.3913         0.69146         0.1683         0.0000***         0.3375         0.3375         0.3357         0.3357         0.000***           0.3119         0.5546         0.9634         0.000***         0.7503         0.64580         0.8329         0.000***           0.3119         0.5534         0.5934         0.000***         0.5763         0.3325         0.3325         0.3325         0.3325         0.3337         0.3337         0.3337         0.3331 <t< th=""><th>1 %</th><th>0.8120</th><th>0.5131</th><th>0.5046</th><th>0.5046</th><th>0.5046</th><th>0.3731</th><th>0.5046</th><th>0.5046</th><th>0.5046</th></t<>	1 %	0.8120	0.5131	0.5046	0.5046	0.5046	0.3731	0.5046	0.5046	0.5046
$(0.913)$ $(0.9146$ $(0.282)$ $(0.000^{mec})$ $(0.217)$ $(0.213)$ $(0.213)$ $(0.233)$ $(0.000^{mec})$ $(0.353)$ $(0.353)$ $(0.353)$ $(0.333)$	5 %	0.8244	0.2701	0.4460	$0.0000^{***}$	$0.0674^{*}$	0.4041	0.3133	$0.000^{***}$	0.0749*
	10 %	0.3913	0.9146	0.2982	$0.0000^{***}$	0.2057	0.9175	0.2459	$0.0000^{***}$	0.3214
0.3119         0.5546         0.9634         0.010 <sup>444</sup> 0.7333         0.7503         0.6004         0.8329         0.000 <sup>444</sup> NaN         0.5753         0.5911         0.3733         0.5753         0.5753         0.3311         0.3331           Aix         0.5753         0.5753         0.5753         0.5753         0.5765         0.331           0.6009         0.5309         0.3046         0.017 <sup>446</sup> 0.1072         0.5753         0.1458         0.000 <sup>444</sup> 0.3357         0.2347         0.1786         0.017 <sup>441</sup> 0.1666         0.2763         0.000 <sup>444</sup> 0.3273         0.1392         0.7504         0.1741         0.1247         0.100 <sup>444</sup> 0.000 <sup>444</sup> 0.3337         0.1387         0.03849         0.000 <sup>444</sup> 0.1766         0.1741         0.1253         0.000 <sup>444</sup> 0.3018         0.03849         0.000 <sup>444</sup> 0.1764         0.1741         0.0127         0.000 <sup>444</sup> 0.3017         0.5934         0.7504         0.7541         0.5952         0.1266         0.7504           0.7664         0.7574         0.5450         0.1867         0.7564         0.7966         0.7016	% 06	0.7510	0.6510	0.1663	$0.0000^{***}$	0.3370	0.6042	0.2357	$0.000^{***}$	0.5266
Nav $0.5733$ $0.5391$ $0.3331$ $0.5733$ $0.5699$ $0.8743$ $0.3331$ $0.3331$ $0.6009$ $0.3004$ $0.010$ $0.01072$ $0.6666$ $0.1048^{\circ}$ $0.0104^{\circ}$ $0.000^{\circ}$ $0.0104^{\circ}$ $0.000^{\circ}$ $0.0111$ $0.0121$ $0.000^{\circ}$ $0.0111$ $0.0121$ $0.000^{\circ}$ $0.0111$ $0.0121$ $0.000^{\circ}$ $0.0111$ $0.0121$ $0.000^{\circ}$ $0.0111$ $0.000^{\circ}$ $0.0111$ $0.000^{\circ}$ $0.0111^{\circ}$ $0.000^{\circ}$ $0.000^{\circ}$ $0.0112^{\circ}$ $0.0000^{\circ}$ $0.0112^{\circ}$	95 %	0.3119	0.5546	0.9634	$0.0019^{***}$	0.7608	0.4580	0.8329	$0.0004^{***}$	0.6577
Two-sided Independent of VaR           0.3339         0.0346         0.0107**         0.0104**           0.3609         0.3339         0.0138*         0.0017**         0.1072         0.0000***         0.0104**           0.3335         0.2147         0.1786         0.0017**         0.1411         0.1216         0.000***           0.3333         0.2477         0.1786         0.000***         0.3375         0.1411         0.1217         0.000***           0.3333         0.0138*         0.008**         0.000**         0.3375         0.1411         0.1212         0.000***           0.3050         0.2152         0.356*         0.0017**         0.0117**         0.016**         0.000***           0.3614         0.5514         0.5952         0.1117         0.5962         0.1000***         0.2356           0.3614         0.7524         0.387         0.1887         0.266*         0.1000         0.2566           0.5614         0.0175*         0.2152         0.2560         0.3875         0.1607         0.2366           0.5614         0.7524         0.7524         0.1867         0.2669         0.7000         0.2000           0.5616	% 66	NaN	0.5753	0.5591	0.3331	0.5753	0.5629	0.8743	0.3331	0.5962
0.6000         0.3300         0.3046         0.001***         0.104**         0.0104**         0.0104**           0.3357         0.2385         0.2198         0.0000***         0.1458         0.0000***         0.0104**           0.3357         0.2384         0.0100***         0.141         0.1221         0.0000***           0.3357         0.1384         0.000***         0.1141         0.1221         0.0000***           0.3392         0.0384*         0.0100***         0.01141         0.1221         0.000***           0.3928         0.0387*         0.0000***         0.01141         0.1221         0.0000***           0.3934         0.5934         0.0000***         0.0117         0.5962         0.1341         0.1236         0.0000***           0.9018         0.5934         0.0000***         0.7117         0.5962         0.6167         0.2366         0.0000***           0.5614         0.5157         0.5564         0.7564         0.6000         0.7564         0.7564         0.7564         0.7564         0.7564         0.7564         0.7564         0.7564         0.7564         0.7564         0.7564         0.7564         0.7564         0.7564         0.7564         0.7564         0.7564					Two-s	ided Independent o	f VaR			
$0.337$ $0.7255$ $0.2198$ $0.000^{\text{mm}}$ $0.1380$ $0.000^{\text{mm}}$ $0.1786$ $0.000^{\text{mm}}$ $0.0174$ $0.0166^{\circ}$ $0.000^{\text{mm}}$	1 %	0.6009	0.5309	0.3046	$0.0017^{***}$	0.1072	0.6606	0.2763	$0.0104^{**}$	0.1067
$0.2273$ $0.2447$ $0.1786$ $0.000^{\text{sec}}$ $0.221$ $0.0121$ $0.000^{\text{sec}}$ $0.0174$ $0.000^{\text{sec}}$ $0.000^{\text{sec}}$ $0.0176$ $0.000^{\text{sec}}$ $0.0176$ $0.000^{\text{sec}}$ $0.0127$ $0.0526$ $0.0127$ $0.0526$ $0.0127$ $0.0526$ $0.0127$ $0.0526$ $0.0126$ $0.000^{\text{sec}}$ $0.0526$ $0.0127$ $0.0506$ $0.000^{\text{sec}}$ $0.0753$ $0.2715$ $0.2716$ $0.0250$ $0.0526$ $0.0126$ $0.0000^{\text{sec}}$ $0.0750^{\text{sec}}$ $0.0000^{\text{sec}}$ $0.0750^{\text{sec}}$	5 %	0.3357	0.7255	0.2198	$0.0000^{***}$	0.1309	0.4575	0.1458	$0.0000^{***}$	0.2021
0.3333 $0.013%$ $0.003%$ $0.001%$ $0.017%$ $0.016%$ $0.000%$ $0.000%$ $0.1322$ $0.1332$ $0.056%$ $0.000%$ $0.1741$ $0.061%$ $0.000%$ $0.000%$ $0.9018$ $0.3934$ $0.056%$ $0.000%$ $0.1741$ $0.061%$ $0.000%$ $0.9018$ $0.5934$ $0.000%$ $0.0717$ $0.5952$ $0.016%$ $0.000%$ $0.9015$ $0.5934$ $0.5934$ $0.000%$ $0.0173$ $0.2350$ $0.0187$ $0.2356$ $0.000%$ $0.5610$ $0.0753$ $0.2550$ $0.1877$ $0.2550$ $0.7364$ $0.7504$ $0.7364$ $0.7654$ $0.2430$ $0.8493$ $1.0000$ $0.7624$ $0.7430$ $0.7016$ $0.7016$ $0.1181$ $0.1973$ $0.4642$ $0.9981$ $0.3640$ $0.9996$ $0.7015$ $0.7504$ $0.2561$ $0.2561$ $0.2332$ $0.71391$ $0.7015$ $0.7015$ $0.7606$ $0.2751$ $0.2$	10 %	0.2273	0.2447	0.1786	$0.0000^{***}$	0.5275	0.1411	0.1221	$0.0000^{***}$	0.8509
$0.132$ $0.0368^{*}$ $0.000^{***}$ $0.1741$ $0.0616^{*}$ $0.000^{***}$ $0.9018$ $0.5934$ $0.05934$ $0.0503^{*}$ $0.0177$ $0.0612^{*}$ $0.000^{***}$ $0.000^{***}$ $0.01236$ $0.9018$ $0.5934$ $0.5934$ $0.0800^{**}$ $0.01717$ $0.5962$ $0.06127$ $0.02366$ $0.06127$ $0.02366$ $0.06127$ $0.02366$ $0.0107^{**}$ $0.02366$ $0.0107^{**}$ $0.02366$ $0.01677$ $0.07504$ $0.02366$ $0.06167$ $0.07504$ $0.02606$ $0.07604$ $0.02604$ $0.00000000$ $0.0760$	% 06	0.3393	0.0138**	0.0087***	$0.0000^{***}$	$0.0415^{**}$	$0.0177^{**}$	$0.0166^{**}$	$0.0000^{***}$	0.0524*
$0.9018$ $0.5934$ $0.5934$ $0.6080^{\bullet}$ $0.7117$ $0.5962$ $0.6127$ $0.2236$ $10.2236$ <b>Ome-sided Dependent on XA</b> $0.3699$ $0.2152$ $0.2550$ $0.7504$ $0.2550$ $0.7539$ $0.7504$ $0.7504$ $0.5614$ $0.0753^{\bullet}$ $0.2257$ $0.7504$ $0.2550$ $0.7504$ $0.7504$ $0.7504$ $0.7664$ $0.0753^{\bullet}$ $0.1607$ $0.7257$ $0.7504$ $0.7504$ $0.7504$ $0.7504$ $0.7763$ $0.2715$ $0.8175$ $1.0000$ $0.000^{\bullet\bullet\bullet\bullet}$ $0.1607$ $0.7249$ $0.7922$ $1.0000$ $0.7763$ $0.2715$ $0.8449$ $1.0000$ $0.7644$ $0.7439$ $0.7844$ $1.0000$ $0.1181$ $0.2715$ $0.8449$ $0.7926$ $0.7849$ $0.7849$ $0.7000$ $0.1181$ $0.2561$ $0.2316$ $0.7433$ $0.7249$ $0.7016$ $0.7016$ $0.1181$ $0.2561$ $0.2316$ $0.7329$ $0.7719$ $0.7016$ $0.7715$ $0.1181$ $0.2561$ $0.7243$ $0.7249$ $0.7016$ $0.7016$ $0.1181$ $0.2561$ $0.7243$ $0.7240$ $0.7016$ $0.7015$ $0.1181$ $0.2561$ $0.7264$ $0.2328$ $0.7715$ $0.7016$ $0.2561$ $0.7331$ $0.7229$ $0.7916$ $0.7016$ $0.7715$ $0.2333$ $0.7332$ $0.7232$ $0.7916$ $0.7015$ $0.7015$ $0.2803$ $0.7829$ $0.9986$ $0.9988$ $0.9996$ $0.7016$ <td< td=""><th>95 %</th><td>0.1928</td><td>0.1392</td><td>0.0568*</td><td><math>0.0000^{***}</math></td><td>0.1766</td><td>0.1741</td><td>0.0616*</td><td><math>0.0000^{***}</math></td><td>0.1778</td></td<>	95 %	0.1928	0.1392	0.0568*	$0.0000^{***}$	0.1766	0.1741	0.0616*	$0.0000^{***}$	0.1778
One-sided Dependent on YaR $0.3699$ $0.2152$ $0.2550$ $0.784$ $0.2550$ $0.1887$ $0.2550$ $0.7504$ $0.7504$ $0.5614$ $0.0753*$ $0.2550$ $0.7504$ $0.1607$ $0.7922$ $1.0000$ $0.0000$ $0.7763$ $0.4270$ $0.8175$ $1.0000$ $0.0626*$ $0.1450$ $0.7922$ $1.0000$ $0.7763$ $0.2715$ $0.8443$ $1.0000$ $0.0626*$ $0.1391$ $0.7922$ $1.0000$ $0.01973$ $0.8473$ $0.8473$ $0.9881$ $0.0566$ $0.7624$ $0.2483$ $0.8164$ $1.0000$ $0.1811$ $0.1973$ $0.4642$ $0.9811$ $0.02561$ $0.2483$ $0.8164$ $1.0000$ $0.1811$ $0.1973$ $0.2561$ $0.2561$ $0.2328$ $0.7015$ $0.7015$ $0.1811$ $0.1973$ $0.2660$ $0.7015$ $0.2561$ $0.2328$ $0.7015$ $0.7015$ $NaN$ $0.2533$ $0.2561$ $0.2328$ $0.7063$ $0.7015$ $0.7015$ $NaN$ $0.2339$ $0.7982$ $0.9989$ $0.0068***$ $0.2328$ $0.7992$ $0.9966$ $0.7577$ $0.6065$ $0.8229$ $0.9989$ $0.0068***$ $0.7729$ $0.7992$ $0.9906$ $0.7577$ $0.83313$ $0.7889$ $0.8709$ $0.9906$ $0.9906$ $0.7577$ $0.8389$ $0.9889$ $0.9906$ $0.9906$ $0.7577$ $0.8889$ $0.9889$ $0.9906$ $0.9906$ $0.7577$ $0.8889$ $0.9816$ $0.9996$ $0.090$	% 66	0.9018	0.5934	0.5934	0.0800*	0.7117	0.5962	0.6127	0.2236	0.6567
0.3699 $0.2152$ $0.2550$ $0.7504$ $0.7504$ $0.7534$ $0.7564$ $0.7564$ $0.7564$ $0.7564$ $0.7564$ $0.7564$ $0.7564$ $0.7564$ $0.7564$ $0.7564$ $0.7564$ $0.7922$ $1.0000$ $0.00000$ $0.00000$ $0.00000$ $0.00000$ $0$					One-	sided Dependent on	VaR			
$0.5614$ $0.0753*$ $0.7257$ $1.0000$ $0.0002^{***}$ $0.1607$ $0.7922$ $1.0000$ $1.0000$ $0.7763$ $0.4270$ $0.8175$ $1.0000$ $0.0626*$ $0.4369$ $0.8449$ $1.0000$ $1.0000$ $0.7763$ $0.2715$ $0.8493$ $1.0000$ $0.0626*$ $0.4369$ $0.8449$ $1.0000$ $1.0000$ $0.6006$ $0.2715$ $0.8493$ $1.0000$ $0.7624$ $0.2483$ $0.8164$ $1.0000$ $0.181$ $0.1973$ $0.4642$ $0.9981$ $0.7624$ $0.2483$ $0.8164$ $1.0000$ $0.181$ $0.2561$ $0.2339$ $0.2340$ $0.9996$ $0.7015$ $0.7922$ $0.7922$ $0.7915$ $NN$ $0.2561$ $0.2339$ $0.7922$ $0.7922$ $0.7922$ $0.7922$ $0.7912$ $0.7915$ $0.7915$ $0.7803$ $0.2339$ $0.7922$ $0.9989$ $0.0068^{***}$ $0.7333$ $0.7922$ $0.7922$ $0.7922$ $0.7777$ $0.6065$ $0.8829$ $0.9864$ $0.0066^{***}$ $0.72267$ $0.8709$ $0.7926$ $0.9906$ $0.7810$ $0.8839$ $0.7922$ $0.7923$ $0.7922$ $0.9849$ $0.7929$ $0.9000$ $0.7810$ $0.9862$ $0.9913$ $0.0000$ $0.2267$ $0.8889$ $0.8709$ $0.9000$ $0.7810$ $0.9889$ $0.9889$ $0.9889$ $0.9906$ $0.0000$ $0.7810$ $0.9889$ $0.98147$ $0.9889$ $0.9906$ $0.0000$ $0.7810$ $0.9889$ $0.98147$ $0.9399$	1 %	0.3699	0.2152	0.2550	0.7504	0.2550	0.1887	0.2550	0.7504	0.2550
0.7763 $0.4270$ $0.8175$ $1.0000$ $0.0606$ $0.8449$ $1.0000$ $1.0000$ $1.0000$ $0.6006$ $0.2715$ $0.8493$ $1.0000$ $0.7624$ $0.2483$ $0.8164$ $1.0000$ $1.0000$ $0.181$ $0.1973$ $0.8493$ $0.08493$ $1.0000$ $0.7624$ $0.2483$ $0.8164$ $1.0000$ $1.0000$ $NaN$ $0.2561$ $0.2483$ $0.8164$ $0.9966$ $0.9961$ $0.9981$ $0.2561$ $0.2382$ $0.8164$ $0.0996$ $1.0000$ $NaN$ $0.2561$ $0.2339$ $0.2606$ $0.7015$ $0.2561$ $0.2328$ $0.5192$ $0.7015$ $1.0000$ $0.2803$ $0.2339$ $0.7982$ $0.9999$ $0.0068***$ $0.2333$ $0.7982$ $0.7015$ $1.0000$ $0.7777$ $0.2339$ $0.7329$ $0.7279$ $0.7799$ $0.7982$ $0.9906$ $1.0000$ $0.7777$ $0.8313$ $0.8829$ $0.0068***$ $0.3033$ $0.7799$ $0.9906$ $1.0000$ $0.7777$ $0.8839$ $0.7799$ $0.8709$ $0.9906$ $1.0000$ $0.0060***$ $0.7279$ $0.8709$ $0.9906$ $0.1416$ $0.9862$ $0.9913$ $1.0000$ $0.2267$ $0.8889$ $0.9889$ $1.0000$ $0.9906$ $0.1416$ $0.9862$ $0.9913$ $1.0000$ $0.9601$ $0.9828$ $0.9834$ $1.0000$ $0.1416$ $0.9862$ $0.9133$ $0.9207$ $0.8467$ $0.9399$ $1.0000$ $0.1416$ $0.9739$ $0.9399$ $0.0999$ <	5 %	0.5614	0.0753*	0.7257	1.0000	$0.0002^{***}$	0.1607	0.7922	1.0000	0.0029***
$0.6006$ $0.2715$ $0.8493$ $1.0000$ $0.7624$ $0.2483$ $0.8164$ $1.0000$ $1.0000$ $0.1181$ $0.1973$ $0.4642$ $0.9881$ $0.3316$ $0.1391$ $0.8164$ $1.0000$ $0.9966$ $NaN$ $0.2561$ $0.2606$ $0.7015$ $0.3316$ $0.1391$ $0.5192$ $0.9966$ $0.7015$ $NaN$ $0.2561$ $0.2561$ $0.2328$ $0.5192$ $0.7015$ $0.7015$ $NaN$ $0.2339$ $0.7060$ $0.7015$ $0.2066$ $0.7015$ $0.7015$ $0.7377$ $0.2339$ $0.7329$ $0.7982$ $0.7926$ $0.9906$ $0.7015$ $0.7577$ $0.6065$ $0.7982$ $0.9989$ $0.0068^{***}$ $0.7279$ $0.7982$ $0.9906$ $0.7016$ $0.7577$ $0.6065$ $0.7829$ $0.9999$ $0.0060^{***}$ $0.7279$ $0.7879$ $0.9906$ $0.9906$ $0.7779$ $0.8313$ $0.8664$ $1.0000$ $0.2267$ $0.8889$ $0.8709$ $1.0000$ $0.9906$ $0.1416$ $0.9862$ $0.9913$ $1.0000$ $0.2267$ $0.8889$ $0.9888$ $1.0000$ $0.1416$ $0.9862$ $0.9913$ $1.0000$ $0.9861$ $0.9889$ $0.9898$ $1.0000$ $0.1416$ $0.9879$ $0.9889$ $0.9889$ $0.9906$ $0.0000$ $0.1416$ $0.98729$ $0.98167$ $0.9828$ $0.9399$ $1.0000$ $0.1416$ $0.2569$ $0.9433$ $0.9207$ $0.98161$ $0.9399$ $1.0000$	10 %	0.7763	0.4270	0.8175	1.0000	$0.0626^{*}$	0.4369	0.8449	1.0000	0.1239
0.1181 $0.1973$ $0.4642$ $0.9981$ $0.3316$ $0.1391$ $0.3640$ $0.9996$ $1$ NaN $0.2561$ $0.2606$ $0.7015$ $0.2561$ $0.2328$ $0.5192$ $0.7015$ $1$ NaN $0.2501$ $0.2606$ $0.7015$ $0.2561$ $0.2328$ $0.5192$ $0.7015$ $1$ $0.2803$ $0.2339$ $0.7079$ $0.7015$ $0.7015$ $0.7015$ $0.7015$ $1$ $0.7577$ $0.2339$ $0.7239$ $0.9890$ $0.0068**$ $0.2267$ $0.8709$ $1.0000$ $10.000$ $0.7777$ $0.8313$ $0.8229$ $1.0000$ $0.0068**$ $0.7279$ $0.7879$ $0.9906$ $10000$ $0.8407$ $0.8313$ $0.8229$ $0.9993$ $0.0068**$ $0.7279$ $0.8709$ $1.0000$ $10.000$ $0.1416$ $0.9862$ $0.9913$ $1.0000$ $0.2267$ $0.8889$ $0.8709$ $1.0000$ $10.000$ $0.1416$ $0.9862$ $0.9913$ $1.0000$ $0.9601$ $0.9828$ $0.9834$ $1.0000$ $10.000$ $0.1416$ $0.9862$ $0.9433$ $1.0000$ $0.8467$ $0.8521$ $0.9399$ $1.0000$ $0.1416$ $0.2569$ $0.9433$ $0.9207$ $0.8467$ $0.8521$ $0.9399$ $1.0000$	% 06	0.6006	0.2715	0.8493	1.0000	0.7624	0.2483	0.8164	1.0000	0.6801
NaN $0.2561$ $0.2606$ $0.7015$ $0.2561$ $0.2328$ $0.5192$ $0.7015$ $1$ $IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII$	95 %	0.1181	0.1973	0.4642	0.9981	0.3316	0.1391	0.3640	0.9996	0.2755
One-sided Independent of VaR           0.2803         0.2339         0.7982         0.9989         0.0068***         0.3033         0.7982         0.9906           0.7577         0.6065         0.8229         1.0000         0.0066***         0.3033         0.7982         0.9906           0.8407         0.8313         0.8664         1.0000         0.0267         0.8889         0.8709         1.0000           0.1416         0.9862         0.9913         1.0000         0.2267         0.8889         0.8988         1.0000           0.1416         0.9862         0.9913         1.0000         0.2267         0.8889         0.9838         1.0000           0.1416         0.9862         0.9913         1.0000         0.2267         0.9828         0.9938         1.0000           0.1416         0.9862         0.9433         1.0000         0.9861         0.9834         1.0000         0.9828           0.14151         0.2569         0.93351         0.9399         1.0000         0.98467         0.93599         1.0000	% 66	NaN	0.2561	0.2606	0.7015	0.2561	0.2328	0.5192	0.7015	0.2661
$0.2803$ $0.2339$ $0.7982$ $0.9989$ $0.0068^{***}$ $0.3033$ $0.7982$ $0.9906$ $0.7577$ $0.6065$ $0.8229$ $1.0000$ $0.0066^{***}$ $0.7279$ $0.8709$ $1.0000$ $1.0000$ $0.8407$ $0.8313$ $0.8664$ $1.0000$ $0.2267$ $0.8889$ $0.8988$ $1.0000$ $1.0000$ $0.1416$ $0.9862$ $0.9913$ $1.0000$ $0.9601$ $0.9828$ $0.9334$ $1.0000$ $1.0000$ $0.612^{**}$ $0.8721$ $0.9433$ $1.0000$ $0.8467$ $0.9828$ $0.9334$ $1.0000$ $1.0000$ $0.6151^{**}$ $0.8721$ $0.9433$ $0.9207$ $0.8467$ $0.9329$ $1.0000$ $1.0000$ $0.4151$ $0.2569$ $0.6635$ $0.9207$ $0.3371$ $0.2661$ $0.6699$ $0.7769$					One-s	ided Independent o	f VaR			
$0.7577$ $0.6065$ $0.8229$ $1.0000$ $0.0060^{***}$ $0.7279$ $0.8709$ $1.0000$ $1.0000$ $0.8407$ $0.8313$ $0.8664$ $1.0000$ $0.2267$ $0.8889$ $0.8988$ $1.0000$ $0.1416$ $0.9862$ $0.9913$ $1.0000$ $0.9601$ $0.9828$ $0.9834$ $1.0000$ $0.6512^{**}$ $0.8721$ $0.9433$ $1.0000$ $0.8467$ $0.8551$ $0.9339$ $1.0000$ $0.4151$ $0.2569$ $0.6635$ $0.9207$ $0.3371$ $0.2661$ $0.6699$ $0.7769$	1 %	0.2803	0.2339	0.7982	0.9989	$0.0068^{***}$	0.3033	0.7982	0.9906	0.0073***
$0.8407$ $0.8313$ $0.8664$ $1.0000$ $0.2267$ $0.8889$ $0.8988$ $1.0000$ $1.0000$ $0.1416$ $0.9862$ $0.9913$ $1.0000$ $0.9601$ $0.9828$ $0.9334$ $1.0000$ $0.0512^*$ $0.0512^*$ $0.8721$ $0.9433$ $1.0000$ $0.8467$ $0.8551$ $0.9339$ $1.0000$ $1.0000$ $0.4151$ $0.2569$ $0.6635$ $0.9207$ $0.3371$ $0.2661$ $0.6699$ $0.7769$	5 %	0.7577	0.6065	0.8229	1.0000	$0.0060^{***}$	0.7279	0.8709	1.0000	$0.0348^{**}$
0.1416         0.9862         0.9913         1.0000         0.9601         0.9828         0.9834         1.0000         1.0000           0.0512*         0.8721         0.9433         1.0000         0.8467         0.8551         0.9399         1.0000         1.0000           0.4151         0.2569         0.6635         0.9207         0.3371         0.2661         0.6699         0.7769	10 %	0.8407	0.8313	0.8664	1.0000	0.2267	0.8889	0.8988	1.0000	0.3986
0.0512*         0.8721         0.9433         1.0000         0.8467         0.8551         0.9399         1.0000           0.4151         0.2569         0.6635         0.9207         0.3371         0.2661         0.6699         0.7769	90 %	0.1416	0.9862	0.9913	1.0000	0.9601	0.9828	0.9834	1.0000	0.9505
0.4151 0.2569 0.6635 0.9207 0.3371 0.2661 0.6699 0.7769	95 %	0.0512*	0.8721	0.9433	1.0000	0.8467	0.8551	0.9399	1.0000	0.8596
	66 %	0.4151	0.2569	0.6635	0.9207	0.3371	0.2661	0.6699	0.7769	0.3119

Table E15: ES test results for CO2 futures on EEX

	0.5046
0.0211**	0.0211**
0.9824 0.0416** 0.0000***	$0.0416^{**}$
0.5735 0.3241 0.0000****	0.3241
0.1874 0.8236 0.0014***	0.8236
0.1124 0.8473 0.0151**	0.8473
0.9519 0.0104** 0.0122**	0.0104**
0.2516 0.0291** 0.0000***	0.0291**
0.1036	0.1036
0.0502* 0.0384** 0.0000***	0.0384**
0.3968 0.0693* 0.0000****	0.0693*
0.1526 0.5313 0.0533*	0.5313
0.2676 0.7504 0.7450	0.7504
0.3549 0.9812 1.0000	0.9812
0.4972 0.9683 1.0000	0.9683
0.2425 0.7904 1.0000	0.7904
0.0502* 0.5526 0.9986	0.5526
0.0512* 0.4088 0.9918	0.4088
0.4993 0.9901 0.9995	0.9901
0.8294 0.9725 1.0000	0.9725
0.9407 0.9211 1.0000	0.9211
0.9536 0.9638 1.0000	0.9638
	0 0400
0.1040 0.7146 0.9475	0.7400

Table E16: ES test results for CO2 futures on NASDAQ OMX (Nord Pool)

EWQR         Garch Normal           0.5046         0.3789           0.5585         0.2641           0.5585         0.2641           0.4871         0.0746*           0.3529         0.5317           0.3529         0.0746*           0.3529         0.6395           0.3529         0.03511           0.3546         0.1217           0.3086         0.1048           0.30876         0.1048           0.3284         0.1048           0.3284         0.1048           0.3284         0.1048           0.1374         0.0388**           0.1374         0.0572*           0.1374         0.0572*           0.1374         0.0572*           0.3240         0.3498           0.3240         0.3498           0.3240         0.0572*           0.3240         0.024***           0.7504         0.024***           0.7504         0.2915           0.7504         0.2914           0.7504         0.2914	Garch Student t     Garch GE       0.1300     0.0016****					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	0.0016***	Garch Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	0.0016***	<b>Two-sided Dependent on VaR</b>	VaR			
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		0.4236	0.1268	0.0782*	$0.0218^{**}$	0.3621
$0.4871$ $0.0746^{*}$ $0.3529$ $0.6395$ $0.3529$ $0.6395$ $0.3557$ $0.3529$ $0.0351$ $0.1217$ $0.3357$ $0.3357$ $0.5046$ $0.3357$ $0.3357$ $0.1217$ $0.3357$ $0.5046$ $0.3357$ $0.3357$ $0.3357$ $0.3357$ $0.793$ $0.3357$ $0.3357$ $0.3357$ $0.3357$ $0.7793$ $0.3354$ $0.3357$ $0.0358^{***}$ $0.057^{**}$ $0.1374$ $0.057^{**}$ $0.057^{**}$ $0.0252^{**}$ $0.0257^{**}$ $0.3240$ $0.32498$ $0.0729^{**}$ $0.0729^{**}$ $0.0729^{**}$ $0.5520$ $0.0729^{**}$ $0.0729^{**}$ $0.0729^{**}$ $0.0729^{**}$ $0.7504$ $0.024^{****}$ $0.0729^{**}$ $0.0729^{**}$ $0.0199^{**}$ $0.7504$ $0.0199^{**}$ $0.0199^{**}$ $0.0199^{**}$ $0.0124^{**}$		0.4217	0.1844	0.5185	$0.0074^{***}$	0.3336
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	0.3804 0.0095***	0.9750	$0.0964^{*}$	0.2754	0.0063***	0.7317
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	0.3364 0.0014***	0.4487	0.1805	0.6768	$0.0045^{***}$	0.8881
0.5046 $0.3357$ $0.3357$ $0.3086$ $0.3684$ $0.3684$ $0.30876$ $0.1048$ $0.3684$ $0.7793$ $0.0648$ $0.1048$ $0.7793$ $0.038**$ $0.038**$ $0.1374$ $0.0572*$ $0.03296$ $0.3240$ $0.3498$ $0.02915$ $0.3240$ $0.3498$ $0.02915$ $0.3240$ $0.3498$ $0.02915$ $0.3240$ $0.02915$ $0.07256$ $0.3240$ $0.0729*$ $0.0729*$ $0.7314$ $0.0024****$ $0.0729*$ $0.7314$ $0.0024****$ $0.0729*$ $0.7314$ $0.0024****$ $0.0729*$ $0.7704$ $0.2902$ $0.0199**$ $0.7704$ $0.2911$ $0.2911$ $0.7206$ $0.1547$ $0.1547$		0.3540	0.2163	0.2603	0.0076***	0.4006
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	0.1689 0.0927*	0.2782	0.1566	0.2529	0.1787	0.3069
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	wT	<b>Two-sided Independent of VaR</b>	VaR			
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	3 0.0115**	0.4461	0.3533	0.0960*	0.0508*	0.3239
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	0.3394 0.0014***	0.7810	0.1514	0.2139	$0.0010^{***}$	0.5917
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	0.2425 0.0005***	0.4450	0.0082***	0.1813	$0.0007^{***}$	0.3583
0.8254         0.2915         0           0.3240         0.3498         0.3498           0.3250         0.3498         0.3498           0.2550         0.3498         0.3498           0.2550         0.0597*         0.3498           0.6638         0.0729*         0.0729*           0.7314         0.0729*         0.0729*           0.7313         0.0924***         0.0729*           0.7504         0.2902         0.099**           0.7504         0.2971         0.2971           0.7906         0.1547         0.1547           0.4240         0.9148         0.0148		0.1479	0.7371	0.1587	$0.0110^{***}$	0.1042
0.3240         0.3498         0.3250         0.3498         0.3498         0.3498         0.3498         0.3498         0.3498         0.3498         0.3498         0.3498         0.3498         0.3459         0.371         0.371         0.371         0.373         0.3023         0.02902         0.3902         0.3902         0.3902         0.3902         0.3902         0.3902         0.3971         0.3974 <td>0.8876 0.0096***</td> <td>0.7197</td> <td>0.5762</td> <td>0.8400</td> <td>0.0155**</td> <td>0.6375</td>	0.8876 0.0096***	0.7197	0.5762	0.8400	0.0155**	0.6375
0.2550         0.0597*           0.6638         0.0729*           0.7314         0.0729*           0.7312         0.0024***           0.7922         0.2902           0.5023         0.0199**           0.7504         0.2971           0.7906         0.1547           0.4240         0.9148	0.3730 0.0998*	0.4702	0.1880	0.4596	0.2664	0.5397
0.2550         0.0597*         0           0.6638         0.0729*         0           0.7314         0.0729*         0           0.7322         0.01024***         0           0.7922         0.2902         0           0.7504         0.2971         0           0.7504         0.2971         0           0.7406         0.1547         0	0	<b>One-sided Dependent on VaR</b>	VaR			
0.6638         0.0729*           0.7314         0.0024***           0.7314         0.0024***           0.7922         0.2902           0.5023         0.0199**           0.7504         0.2971           0.7906         0.1547           0.4240         0.9148	0.8799 1.0000	0.6635	$0.0612^{*}$	0.9312	0.9884	0.6682
0.7314         0.0024***           0.7922         0.2902           0.5023         0.2902           0.5024         0.2971           0.7504         0.2971           0.7906         0.1547           0.4240         0.9148	0.6918 0.9922	0.1965	$0.0464^{**}$	0.7244	0.9927	0.1490
0.7922         0.2902           0.5023         0.0199**           0.7504         0.2971           0.7906         0.1547           0.4240         0.9148	0.7796 0.9905	0.4943	$0.0050^{***}$	0.8285	0.9937	0.6098
0.5023         0.0199**           0.7504         0.2971           0.7906         0.1547           0.4240         0.9148	1	0.7464	0.0395**	0.6401	0.9955	0.5416
0.7504         0.2971           0.7906         0.1547           0.4240         0.9148	0.8363 0.9994	0.7704	$0.0519^{*}$	0.8065	0.9924	0.7442
0.7906 0.1547 0.4240 0.9148	0.8798 0.9093	0.7981	$0.0310^{**}$	0.8093	0.8278	0.7840
0.7906         0.1547           0.4240         0.9148	On	<b>One-sided Independent of VaR</b>	VaR			
0.4240 0.9148	0.8086 0.9894	0.6685	0.1453	0.9118	0.9888	0.7205
	0.7975 0.9986	0.5946	0.8779	0.8537	0.9990	0.6848
0.5867 0.9962	0.8391 0.9995	0.7394	0.9918	0.8714	0.9993	0.7812
90 % 0.9006 0.9443 0.0605*	0.0605* 0.9966	$0.0310^{**}$	0.6066	$0.0350^{**}$	0.9890	$0.0154^{**}$
95 % 0.5674 0.7912 0.4089	0.4089 0.9904	0.3125	0.2483	0.3804	0.9845	0.2726
99 % 0.6810 0.1478 0.7988	0.7988 0.9196	0.7439	$0.0267^{**}$	0.7545	0.7602	0.7030

Table E17: ES test results for coal futures on ICE

						Coal - NYMEX					
Two-sided Dependent on YaR           Two-sided Dependent on YaR           0.5379         0.7796         0.5046	Quantile	EWQR	Garch Normal		Garch GED	Garch Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t	
0.5391         0.7796         0.5046         0.5046         0.5046         0.5046         0.5046         0.5046           0.02379         0.5397         0.0589*         0.0088**         0.0088**         0.0088**         0.0008**         0.0008**           0.0517         0.0889*         0.0018**         0.0550         0.1644         0.7762         0.0008**           0.8517         0.1524         0.8677         0.001***         0.6601         0.0008**         0.0001***         0.0001***           0.8517         0.1524         0.307         0.001***         0.6601         0.0001***         0.0164**         0.7762         0.0001***           0.8517         0.1524         0.307         0.001***         0.6601         0.001***         0.001***         0.001***           0.186         0.3522         0.044**         0.001***         0.014***         0.014***         0.000***           0.069**         0.023**         0.014***         0.014***         0.000***         0.000***           0.0601**         0.025**         0.3244         0.014***         0.014***         0.000***           0.0601**         0.025**         0.3244         0.014***         0.014***         0.000***           0					Two-	sided Dependent on	L . I				
$0.2379$ $0.6197$ $0.0182^{***}$ $0.000^{***}$ <th>1 %</th> <th></th> <th>0.7796</th> <th>0.5046</th> <th></th> <th>0.5046</th> <th></th> <th>0.5046</th> <th>0.5046</th> <th>0.5046</th>	1 %		0.7796	0.5046		0.5046		0.5046	0.5046	0.5046	
0.06(1)         0.0531         0.0080 <sup>***</sup> 0.0060 <sup>***</sup> 0.0010 <sup>***</sup> 0.0106 <sup>***</sup> 0.0106 <sup>***</sup> 0.0000 <sup>***</sup> 0.8213         0.0989 <sup>**</sup> 0.6601         0.0000 <sup>***</sup> 0.6605         0.1644         0.7752         0.0000 <sup>***</sup> 0.0000 <sup>***</sup> 0.8116         0.1186         0.3007         0.0630 <sup>**</sup> 0.1634         0.0650 <sup>*</sup> 0.0000 <sup>***</sup> 0.0000 <sup>***</sup> 0.0000 <sup>***</sup> 0.0000 <sup>***</sup> 0.0005 <sup>***</sup> 0.0000 <sup>***</sup> 0.0005 <sup>***</sup> 0.0000 <sup>***</sup> 0.0005 <sup>***</sup> 0.0000 <sup>***</sup> 0.0005 <sup>***</sup> 0.0000 <sup>***</sup> <	5 %		0.5497	$0.0182^{**}$	$0.0000^{***}$	0.1209	0.6155	$0.0240^{**}$	$0.0000^{***}$	$0.0866^{*}$	
0.8213         0.098%         0.6601         0.000 <sup>444</sup> 0.6505         0.1644         0.7762         0.000 <sup>4444</sup> 0.1514         0.1524         0.8827         0.000 <sup>4445</sup> 0.6512         0.1885         0.9882         0.000 <sup>4444</sup> 0.1524         0.3012 <sup>448</sup> 0.1524         0.000 <sup>4445</sup> 0.012 <sup>448</sup> 0.010 <sup>4446</sup> 0.000 <sup>4446</sup> 0.1285         0.012 <sup>348</sup> 0.011 <sup>448</sup> 0.011 <sup>448</sup> 0.011 <sup>448</sup> 0.011 <sup>448</sup> 0.000 <sup>4446</sup> 0.1293         0.012 <sup>348</sup> 0.011 <sup>448</sup> 0.011 <sup>448</sup> 0.011 <sup>448</sup> 0.011 <sup>448</sup> 0.001 <sup>4446</sup> 0.1186         0.5299         0.000 <sup>4446</sup> 0.5264         0.5175         0.2299         0.000 <sup>446</sup> 0.1186         0.5299         0.000 <sup>4448</sup> 0.120 <sup>446</sup> 0.118 <sup>44</sup> 0.012 <sup>446</sup> 0.001 <sup>446</sup> 0.1186         0.5299         0.000 <sup>4448</sup> 0.120 <sup>446</sup> 0.120 <sup>446</sup> 0.010 <sup>4464</sup> 0.1186         0.5294         0.5357         0.2364         0.5379         0.000 <sup>4464</sup> 0.10124         0.5364         0.7450         0.7450         0.7450         0.7450           0.7015         0.5867	10 %		0.6531	0.0089***	$0.0000^{***}$	0.0656*	0.5982	$0.0105^{**}$	$0.000^{***}$	0.0525*	
$0.8317$ $0.1524$ $0.867$ $0.0001^{***}$ $0.0011^{***}$ $0.0001^{***}$ $0.0011^{***}$ $0.0001^{***}$ $0.0001^{***}$ $0.0011^{***}$ $0.0001^{***}$ $0.0001^{***}$ $0.0011^{***}$ $0.0001^{***}$ $0.0114^{***}$ $0.0114^{***}$ $0.0011^{***}$ $0.00001^{***}$ $0.0001^{***}$	% 06		0.0989*	0.6601	$0.0000^{***}$	0.6505	0.1644	0.7762	$0.0000^{***}$	0.6766	
$0.7776$ $0.1186$ $0.3007$ $0.00333$ $0.0650^{\circ}$ $0.3966$ $0.0353^{\circ}$ $0.0356^{\circ}$ $0.007^{\circ}$ $0.007^{\circ}$ $0.007^{\circ}$ $0.017^{\circ}$ $0.007^{\circ}$ $0.0114^{\circ}$ $0.007^{\circ}$ $0.014^{\circ}$ $0.007^{\circ}$ $0.0114^{\circ}$ $0.007^{\circ}$ $0.0114^{\circ}$ $0.007^{\circ}$ $0.0114^{\circ}$ $0.007^{\circ}$ $0.0114^{\circ}$ $0.007^{\circ}$ $0.0114^{\circ}$ $0.007^{\circ}$ $0.0114^{\circ}$ $0.000^{\circ}$ $0.000^{\circ}$ $0.000^{\circ}$ $0.0015^{\circ}$ $0.000^{\circ}$ $0.000^{\circ}$ $0.0000^{\circ}$ $0.000^{\circ}$ $0.0000^{\circ}$ $0.0115^{\circ}$ $0.0000^{\circ}$ $0.00000^{\circ}$ $0.0000^{\circ}$ $0.0000$	95 %		0.1524	0.8627	$0.0001^{***}$	0.6512	0.1885	0.9802	$0.0001^{***}$	0.8969	
Two-sided Independent of YaR           Two-sided Independent of YaR           0.1386         0.3552         0.0494**         0.0017***         0.0114***         0.0017***           0.1286         0.3552         0.0494***         0.0011***         0.0115***         0.0017***           0.1286         0.0111**         0.0011***         0.0011***         0.0017***         0.0017***           0.014***         0.0012***         0.0111**         0.0116***         0.0000***         0.0000***           0.0697*         0.5440         0.4318         0.0000***         0.3264         0.115**         0.0000***           0.0677*         0.5386         0.3316         0.0116***         0.3164         0.3164         0.000***           0.1567         0.3694         0.3166         0.3264         0.3173         0.0115**           0.7015         0.3694         0.7450         0.3694         0.3164         0.3164           0.7015         0.3694         0.3694         0.3664         0.3173         0.0115**           0.7015         0.3694         0.7450         0.3694         0.7450         0.7450           0.7015         0.5867         0.6817         0.364         0.7450	% 66		0.1186	0.3007	$0.0033^{***}$	0.1634	0.0650*	0.3966	$0.0035^{***}$	0.1687	
0.1886 $0.352$ $0.0494*$ $0.0017**$ $0.0129*$ $0.0017**$ $0.0017**$ $0.1235$ $0.0113*$ $0.00114**$ $0.0113**$ $0.0017**$ $0.0000***$ $0.0115*$ $0.0115*$ $0.0115*$ $0.0115*$ $0.01000***$ $0.0115*$ $0.0115*$ $0.0115*$ $0.0115*$ $0.0115*$ $0.0115*$ $0.0115*$ $0.0115*$ $0.0115*$ $0.0115*$ $0.0115*$ $0.0115*$ $0.0115*$ $0.00100***$ $0.0115*$ <td< th=""><th></th><th></th><th></th><th></th><th>Two-s</th><th>ided Independent of</th><th>f VaR</th><th></th><th></th></td<>					Two-s	ided Independent of	f VaR				
0.1234 $0.0113*$ $0.011*$ $0.0013*$ $0.0113*$ $0.0013*$ $0.0013*$ $0.000***$ $0.000***$	1 %		0.3552	0.0494**	$0.0017^{***}$	0.3313	0.4144	$0.0120^{**}$	$0.0017^{***}$	0.2403	
0.0014****         0.0014****         0.0014****         0.0001****         0.0000****         0.0115**         0.0115**         0.0105****         0.0100****         0.0100****         0.0100****         0.0100****         0.0100****         0.0100****         0.0100****         0.0100****         0.0100****         0.0100****         0.0100****         0.0100****         0.0100****         0.0100***         0.0100***         0.0100***         0.0100****         0.0100****         0.0100****         0.0100****         0.0115*         0.0115*         0.0115*         0.0115*         0.0100***         0.0100***         0.0100***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0100***         0.0100***         0.0100***         0.0100***         0.0100***         0.0100***         0.0100***         0.0100***         0.01000         0.0100***         0.0100***	5 %		0.0123**	0.0111**	0.0000***	0.0238**	$0.0134^{**}$	0.0115**	$0.0000^{***}$	$0.0287^{**}$	
0.0697* $0.5440$ $0.4318$ $0.000**$ $0.3297$ $0.000**$ $0.000**$ $0.0253**$ $0.2386$ $0.5299$ $0.000**$ $0.3257$ $0.212$ $0.000**$ $0.000**$ $0.1205*$ $0.5299$ $0.004**$ $0.316$ $0.3316$ $0.139*$ $0.2132$ $0.000***$ $0.000***$ $0.1806$ $0.3694$ $0.7450$ $0.7450$ $0.713$ $0.015**$ $0.015**$ $0.015**$ $0.015**$ $0.015**$ $0.015**$ $0.015**$ $0.015**$ $0.015**$ $0.015**$ $0.015**$ $0.09999$ $0.0760*$ $0.0210**$ $0.09999$ $0.000***$ $0.09999$ $0.000***$ $0.09999$ $0.000***$ $0.09999$ $0.000***$ $0.09999$ $0.000***$ $0.09999$ $0.000***$ $0.09999$ $0.000***$ $0.09999$ $0.09999$ $0.000***$ $0.09999$ $0.09999$ $0.09999$ $0.09999$ $0.09999$ $0.09999$ $0.09999$ $0.09999$ $0.09999$ $0.09999$ $0.09999$ $0.099999$ $0.099999$	10 %		0.0007***	0.003***	$0.0000^{***}$	0.0114**	$0.0016^{***}$	$0.0031^{***}$	0.0000***	$0.0130^{**}$	
$0.023^{**}$ $0.236$ $0.239$ $0.000^{**}$ $0.000^{**}$ $0.000^{**}$ $0.000^{**}$ $0.000^{**}$ $0.000^{**}$ $0.000^{**}$ $0.000^{**}$ $0.000^{**}$ $0.000^{**}$ $0.000^{**}$ $0.000^{**}$ $0.0115^{**}$ $0.0120^{**}$ $0.0000^{**}$ $0.0000^{**}$	% 06		0.5440	0.4318	$0.0000^{***}$	0.3264	0.5172	0.3297	$0.000^{***}$	0.2458	
$0.1806$ $0.0907*$ $0.3316$ $0.0139**$ $0.2066$ $0.0891^*$ $0.3713$ $0.0115*$ $0.715$ $0.3694$ $0.7450$	95 %		0.2386	0.5299	$0.0004^{***}$	0.4059	0.2657	0.4212	$0.0005^{***}$	0.3420	
<b>One-sided Dependent on XaR</b> 0.7015         0.3694         0.7450 <th c<="" td=""><th>% 66</th><td></td><td>0.0907*</td><td>0.3316</td><td><math>0.0139^{**}</math></td><td>0.2066</td><td>0.0891*</td><td>0.3713</td><td><math>0.0115^{**}</math></td><td>0.2121</td></th>	<th>% 66</th> <td></td> <td>0.0907*</td> <td>0.3316</td> <td><math>0.0139^{**}</math></td> <td>0.2066</td> <td>0.0891*</td> <td>0.3713</td> <td><math>0.0115^{**}</math></td> <td>0.2121</td>	% 66		0.0907*	0.3316	$0.0139^{**}$	0.2066	0.0891*	0.3713	$0.0115^{**}$	0.2121
0.7015 $0.3694$ $0.7450$ $0.7450$ $0.7450$ $0.7450$ $0.7450$ $0.7450$ $0.7450$ $0.8657$ $0.6879$ $0.9818$ $1.0000$ $0.8922$ $0.6537$ $0.9760$ $1.0000$ $1.0000$ $0.9801$ $0.6426$ $0.9912$ $1.0000$ $0.9433$ $0.6705$ $0.9895$ $1.0000$ $1.0000$ $0.9801$ $0.6426$ $0.9912$ $1.0000$ $0.9433$ $0.6705$ $0.9895$ $1.0000$ $1.0000$ $0.9801$ $0.0151*$ $0.0399*$ $0.3711$ $1.0000$ $0.9999$ $0.9999$ $0.9999$ $0.9999$ $0.7557$ $0.0323**$ $0.1411$ $0.9999$ $0.2982$ $0.0399**$ $0.3711$ $1.0000$ $0.3750$ $0.0323**$ $0.1411$ $0.9999$ $0.2982$ $0.0399**$ $0.9979$ $0.9999$ $0.3750$ $0.0323**$ $0.1411$ $0.9999$ $0.2982$ $0.021**$ $0.9979$ $0.9999$ $0.3750$ $0.937**$ $0.1971$ $0.9999$ $0.7976$ $0.9970$ $0.9999$ $0.029**$ $0.9899$ $0.9970$ $0.9702$ $0.9995$ $0.9990$ $0.029**$ $0.9879$ $0.9989$ $0.0996$ $0.9996$ $0.9990$ $0.000***$ $0.9993$ $0.9970$ $0.9986$ $0.9969$ $0.0990$ $0.000***$ $0.02375$ $0.1701$ $0.0996$ $0.0996$ $0.9996$ $0.9996$ $0.000***$ $0.001***$ $0.0121**$ $0.1701$ $0.9997$ $0.1000$ $0.9995$ $0.000***$ $0.0121**$ $0$					One-t	sided Dependent on	VaR				
0.8657 $0.6879$ $0.9818$ $1.0000$ $0.8022$ $0.6537$ $0.9760$ $1.0000$ $1.0000$ $0.9801$ $0.6426$ $0.9912$ $1.0000$ $0.9433$ $0.6705$ $0.9895$ $1.0000$ $1.0000$ $0.4021$ $0.0418$ $0.0413$ $0.0413$ $0.0518$ $0.9895$ $1.0000$ $1.0000$ $0.4021$ $0.0312**$ $0.3049$ $1.0000$ $0.2982$ $0.039**$ $0.3711$ $1.0000$ $0.557$ $0.032**$ $0.1411$ $0.9999$ $0.2982$ $0.039**$ $0.9995$ $0.9999$ $0.557$ $0.032**$ $0.1411$ $0.9999$ $0.2982$ $0.051**$ $0.9999$ $0.9999$ $0.3750$ $0.032**$ $0.1411$ $0.9999$ $0.2982$ $0.051**$ $0.9999$ $0.9999$ $0.3750$ $0.032**$ $0.1567$ $0.9999$ $0.0991*$ $0.9999$ $0.9999$ $0.9999$ $0.9175$ $0.8099$ $0.9947$ $0.9990$ $0.9706$ $0.9995$ $0.9999$ $0.9999$ $0.029**$ $0.9993$ $0.9990$ $0.9706$ $0.9986$ $0.9986$ $0.9995$ $0.9990$ $0.007**$ $0.9993$ $0.0996$ $0.0995$ $0.09995$ $0.0999$ $0.0999$ $0.008**$ $0.0645*$ $0.1701$ $0.9996$ $0.1000$ $0.9995$ $0.9995$ $0.008**$ $0.018**$ $0.0106**$ $0.0106**$ $0.0995$ $0.9995$ $0.9995$	1 %		0.3694	0.7450	0.7450	0.7450	0.3694	0.7450	0.7450	0.7450	
0.9801 $0.6426$ $0.9912$ $1.0000$ $0.9433$ $0.6705$ $0.9895$ $1.0000$ $1.0000$ $0.4021$ $0.0151*$ $0.0151*$ $0.3049$ $1.0000$ $0.2985$ $0.0399*$ $0.3711$ $1.0000$ $1.0000$ $0.5677$ $0.0032*$ $0.1411$ $0.9999$ $0.2982$ $0.0399*$ $0.3711$ $1.0000$ $1.0000$ $0.3750$ $0.0323*$ $0.1411$ $0.9999$ $0.2982$ $0.071*$ $0.4678$ $0.9999$ $0.3750$ $0.0324*$ $0.1261$ $0.9999$ $0.2982$ $0.071*$ $0.9479$ $0.9999$ $0.3750$ $0.0324*$ $0.1970$ $0.9947$ $0.9990$ $0.9706$ $0.9999$ $0.175$ $0.8099$ $0.9947$ $0.9990$ $0.6794$ $0.1907$ $0.9990$ $0.0299*$ $0.9889$ $0.9702$ $0.9996$ $0.9990$ $0.9990$ $0.9990$ $0.0299*$ $0.9970$ $0.9990$ $0.9762$ $0.9986$ $0.9995$ $0.9990$ $0.000**$ $0.9993$ $0.9970$ $0.0996$ $0.9986$ $0.9986$ $0.9999$ $0.0990$ $0.078**$ $0.2375$ $0.1701$ $0.0996$ $0.1811$ $0.2200$ $0.1896$ $0.9995$ $0.9995$ $0.001***$ $0.0645*$ $0.1330$ $0.9997$ $0.0764*$ $0.0706*$ $0.9995$ $0.9995$	5 %		0.6879	0.9818	1.0000	0.8922	0.6537	0.9760	1.0000	0.9170	
0.4021 $0.0151*$ $0.3049$ $1.0000$ $0.2985$ $0.0399*$ $0.3711$ $1.0000$ $1.0000$ $0.5657$ $0.0323*$ $0.4141$ $0.9999$ $0.2982$ $0.0511*$ $0.4678$ $0.9999$ $0.9999$ $0.3750$ $0.0323*$ $0.1411$ $0.9999$ $0.2982$ $0.0511*$ $0.4678$ $0.9999$ $0.9999$ $0.3750$ $0.0323*$ $0.1411$ $0.9999$ $0.9999$ $0.9999$ $0.9999$ $0.9999$ $0.9999$ $0.9999$ $0.3750$ $0.0324*$ $0.9947$ $0.9990$ $0.6794$ $0.0720$ $0.9995$ $0.9990$ $0.0299*$ $0.9879$ $0.9947$ $0.9990$ $0.6794$ $0.7920$ $0.9995$ $0.9990$ $0.0299*$ $0.9879$ $0.9990$ $0.6794$ $0.9995$ $0.9990$ $0.9990$ $0.9990$ $0.000***$ $0.9970$ $0.9990$ $0.0762$ $0.9986$ $0.9985$ $0.0990$ $0.0990$ $0.077**$ $0.2375$ $0.1701$ $1.0000$ $0.1811$ $0.2200$ $0.1181$ $0.2200$ $0.1139$ $1.0000$ $0.001***$ $0.0645*$ $0.1230$ $0.9996$ $0.1594$ $0.0766*$ $0.9995$ $0.9995$ $0.9995$ $0.008**$ $0.011**$ $0.0121**$ $0.1330$ $0.9997$ $0.0769*$ $0.0102*$ $0.9995$ $0.9995$	10 %		0.6426	0.9912	1.0000	0.9433	0.6705	0.9895	1.0000	0.9537	
0.5657 $0.0323**$ $0.4141$ $0.9999$ $0.2982$ $0.6511*$ $0.4678$ $0.9999$ $0.9999$ $0.3750$ $0.0342**$ $0.1561$ $0.9988$ $0.0760*$ $0.051**$ $0.9970$ $0.9970$ $0.3750$ $0.0342**$ $0.1561$ $0.9988$ $0.0760*$ $0.1907$ $0.9970$ $0.9970$ $0.9175$ $0.8099$ $0.9947$ $0.9980$ $0.9970$ $0.9970$ $0.9970$ $0.9970$ $0.9970$ $0.9970$ $0.9995$ $0.9995$ $0.9990$ $0.9990$ $0.9995$ $0.9990$ $0.9990$ $0.9996$ $0.9990$ $0.9990$ $0.9996$ $0.9990$ $0.0000$ $0.9986$ $0.9996$ $0.1000$ $0.9986$ $0.9996$ $0.1000$ $0.9986$ $0.9996$ $0.1000$ $0.0996$ $0.0000$ $0.0996$ $0.0000$ $0.0996$ $0.0000$ $0.0996$ $0.0000$ $0.0996$ $0.0000$ $0.0996$ $0.0000$ $0.0996$ $0.0000$ $0.0996$ $0.0000$ $0.0136$ $0.0000$ $0.0.$	% 06		$0.0151^{**}$	0.3049	1.0000	0.2985	0.0399**	0.3711	1.0000	0.3123	
$0.3750$ $0.0342**$ $0.1561$ $0.9988$ $0.0760^*$ $0.0251**$ $0.1907$ $0.9970$ $0.9970$ $1.1000$ $0.0315$ $0.1007$ $0.1907$ $0.9970$ $0.9970$ $0.9970$ $0.9970$ $0.9970$ $0.9970$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.0990$ $0.9990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0113$ $0.0139$ $0.0139$ $0.0000$ $0.0990$ $0.0180$ $0.0139$ $0.0139$ $0.0990$ $0.0180$ $0.01390$ $0.0990$ $0.0180$ $0.01390$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$	95 %		0.0323**	0.4141	0.9999	0.2982	$0.0511^{*}$	0.4678	0.9999	0.4351	
One-sided Independent of VaR $0.9175$ $0.8099$ $0.9947$ $0.9920$ $0.9995$ $0.9995$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9995$ $0.9990$ $0.9990$ $0.9995$ $0.9990$ $0.000$ $0.9984$ $0.99969$ $0.0990$ $0.0000$ $0.01139$ $0.0000$ $0.01139$ $0.0000$ $0.01139$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0100$ $0.01220$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.0990$ $0.01000$ $0.01702$ $0.0990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$ $0.9990$	% 66		0.0342**	0.1561	0.9988	0.0760*	$0.0251^{**}$	0.1907	0.9970	0.0753*	
0.9175 $0.8099$ $0.947$ $0.9900$ $0.6794$ $0.7920$ $0.9955$ $0.9990$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.99000$ $0.990000$ $0.990000$ $0.990000000000000000000000000000000000$					One-s	ided Independent of	f VaR				
0.0299**         0.9879         0.9889         1.0000         0.9762         0.9866         0.9885         1.00000         1.00	1 %		0.8099	0.9947		0.6794		0.9995	0.9990	0.7706	
0.0000***         0.9993         0.9970         1.0000         0.9886         0.9984         0.9969         1.0000         1.0000           0.078***         0.2375         0.1701         1.0000         0.181         0.2200         0.1139         1.0000         1.0000           0.001***         0.0645*         0.2270         0.9996         0.1594         0.0796*         0.1702         0.9995         1.0000           0.008***         0.0121**         0.1330         0.9997         0.0769*         0.0162**         0.9995         1.0000	5 %		0.9879	0.9889	1.0000	0.9762	0.9866	0.9885	1.0000	0.9713	
0.0078***         0.2375         0.1701         1.0000         0.1181         0.2200         0.1139         1.0000         1.0000           0.0001***         0.0645*         0.2270         0.9996         0.1594         0.0796*         0.1702         0.9995         0.0995         0.9995         0.0995         0.9995         0.0995         0.99	10 %		0.9993	0.9970	1.0000	0.9886	0.9984	0.9969	1.0000	0.9879	
0.0001***         0.0645*         0.2270         0.9996         0.1594         0.0766*         0.1702         0.9995           0.0080***         0.0121**         0.1330         0.9997         0.0769*         0.0105**         0.1625         0.9991	90 % 06		0.2375	0.1701	1.0000	0.1181	0.2200	0.1139	1.0000	0.0759*	
0.0080*** 0.0121** 0.1330 0.9997 0.0769* 0.0105** 0.1625 0.9991	95 %		0.0645*	0.2270	0.9996	0.1594	0.0796*	0.1702	0.9995	0.1235	
	% 66		$0.0121^{**}$	0.1330	0.9997	0.0769*	$0.0105^{**}$	0.1625	0.9991	0.0824*	

Table E18: ES test results for coal futures on NYMEX

					Me	Monthly electricity - EEX	EX			
Twe-sided Dependent on YaR           Twe-sided Dependent on YaR           0.9212         0.4639         0.3357         0.0302**         0.04502         0.0357         0.0041**           0.9212         0.3144         0.1835         0.0302**         0.0352**         0.1985         0.04612         0.1461         0.001**           0.8318         0.1644         0.8349         0.0302**         0.0355*         0.1985         0.0355*         0.1665         0.1645         0.0355*           0.6553         0.1644         0.8349         0.0325*         0.0355*         0.2355         0.2355         0.2355         0.2355         0.0355*         0.035**         0.035**		EWQR	Garch Normal	Garch Student t	Garch GED	Garch Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
$0.5715$ $0.4639$ $0.3357$ $0.0001^{**}$ $0.032^{**}$ $0.0461^{*}$ $0.021^{**}$ $0.0041^{**}$ $0.0021^{**}$ $0.0218^{**}$ $0.0021^{**}$ $0.0021^{**}$ $0.0021^{**}$ $0.0021^{**}$ $0.0021^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.0022^{**}$ $0.00022^{**}$ $0.00022^{**}$					Two-	sided Dependent on	VaR			
$0.3212$ $0.114$ $0.1835$ $0.023^{**}_{}$ $0.033^{**}_{}$ $0.1643$ $0.0265^{**}_{}$ $0.1643$ $0.021^{**}_{}$ $0.021^{**}_{}$ $0.021^{**}_{}$ $0.021^{**}_{}$ $0.021^{**}_{$	1 %	0.5715	0.4639	0.3357	0.3007	$0.0302^{**}$	0.4262	0.3357	0.0941*	$0.0104^{**}$
0.3817 $0.2259$ $0.487$ $0.032.$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0387$ $0.0387$ $0.0387$ $0.0387$ $0.0387$ $0.0387$ $0.0387$ $0.0387$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0368$ $0.0382$ $0.0382$ $0.0382$ $0.0382$ $0.0382$ $0.0368$ $0.0382$ $0.0382$ $0.0368$ $0.0382$ $0.0382$ $0.0368$	5 %	0.9212	0.3174	0.1835	$0.0278^{**}$	$0.0088^{***}$	0.1662	0.1461	$0.0211^{**}$	$0.0075^{***}$
0.8318         0.1644         0.8349         0.1931         0.6612         0.2116         0.7351         0.2187         0.0239         0.0239         0.0239         0.0239         0.0239         0.00239         0.00239         0.00239         0.00149         0.00129 <t< td=""><td>10 %</td><td>0.7817</td><td>0.2629</td><td>0.4487</td><td><math>0.0302^{**}</math></td><td>0.0355**</td><td>0.1985</td><td>0.4058</td><td>0.0365**</td><td><math>0.0293^{**}</math></td></t<>	10 %	0.7817	0.2629	0.4487	$0.0302^{**}$	0.0355**	0.1985	0.4058	0.0365**	$0.0293^{**}$
0.6581         0.1904         0.9737         0.0964*         0.5175         0.2163         0.7255         0.0684*         0.330           0.6553         0.1870         0.421         0.23078         0.2315         0.5365         0.064*         0.330           0.6553         0.1870         0.241         0.075*         0.075*         0.075*         0.034*         0.330           0.0007***         0.0349*         0.0382**         0.075**         0.074*         0.047**         0.042**         0.042**           0.007***         0.016**         0.016**         0.075**         0.041**         0.042***         0.042***         0.042***           0.075**         0.016**         0.016**         0.016**         0.014**         0.042***         0.007***         0.007***           0.1769*         0.016**         0.016**         0.014**         0.026*         0.006***         0.006***         0.006***         0.000***           0.1769*         0.168**         0.2355         0.026**         0.016**         0.006***         0.006***         0.006***         0.006***         0.006***         0.006***         0.006***         0.006***         0.006***         0.006***         0.006***         0.006***         0.006***	% 06	0.8318	0.1644	0.8349	0.1931	0.6612	0.2116	0.7581	0.2187	0.6850
0.6533         0.1870         0.4212         0.2255         0.2078         0.2471         0.5495         0.330           Two-sided Independent of NA           0.066**         0.073**         0.073**         0.0439*         0.0439**         0.0439**         0.0439**           0.076**         0.0349**         0.0075**         0.0075**         0.0439**         0.0439**         0.0439**         0.0439**           0.0754*         0.0349**         0.006***         0.0075**         0.0439**         0.0439**         0.0439**         0.0439**         0.0007***           0.0774*         0.0216**         0.006**         0.006***         0.006***         0.007**         0.0439**         0.0007***         0.0007***           0.0774*         0.0216**         0.006***         0.006***         0.006***         0.006***         0.006***         0.006***         0.006***         0.006***         0.006***         0.0007***         0.0007***         0.0007***         0.0007***         0.0007***         0.0007***         0.0007***         0.0006***         0.0006***         0.0006***         0.0006***         0.0006***         0.0006***         0.0006***         0.0006***         0.0006***         0.0006***         0.0006***         0.0006***         0.0006***<	95 %	0.6581	0.1904	0.9737	0.0960*	0.5175	0.2163	0.7225	0.0684*	0.3663
Two-sided Independent of VaR           0.05362         0.0734*         0.0734*         0.0734*         0.0732**         0.0305**         0.00002***           0.0776*         0.0216**         0.0316**         0.0003***         0.0131**         0.0002***         0.00002***         0.0002*** <th< td=""><td>% 66</td><td>0.6553</td><td>0.1870</td><td>0.4212</td><td>0.2255</td><td>0.2078</td><td>0.2471</td><td>0.5495</td><td>0.3530</td><td>0.3330</td></th<>	% 66	0.6553	0.1870	0.4212	0.2255	0.2078	0.2471	0.5495	0.3530	0.3330
0.086%         0.6362         0.074%         0.074%         0.074%         0.043%         0.043%         0.0433%         0.0433%         0.0433%         0.0433%         0.0433%         0.0433%         0.0433%         0.0433%         0.0433%         0.0433%         0.0002***         0.00000***         0.0000***<					Two-s	ided Independent o	f VaR			
0.0007***         0.0349**         0.0382**         0.0066***         0.0043**         0.0489**         0.0048**         0.0002***           0.0778*         0.016**         0.016**         0.006***         0.000***         0.000***         0.000***           0.0774*         0.0216**         0.006***         0.000***         0.000***         0.000***         0.000***           0.0724*         0.2268         0.006***         0.006***         0.014**         0.0708*         0.000***           0.1759         0.1684*         0.2335         0.2036         0.006***         0.014**         0.000***         0.000***           0.1759         0.1684*         0.2335         0.2030         0.7229         0.7031         0.2305         0.000***         0.7064           0.1759         0.1664*         0.7029         0.7029         0.7029         0.7064         0.7064           0.1769         0.7029         0.7029         0.7029         0.7029         0.7064           0.3557         0.0704*         0.7029         0.7029         0.7064         0.7029           0.3566         0.0704*         0.7029         0.7029         0.7064         0.7029         0.7064           0.3567         0.7031	1 %	0.0868*	0.6362	0.0745*	0.0745*	0.079*		0.0974	0.0423**	0.0771*
$0.0760^{*}$ $0.016^{**}$ $0.016^{**}$ $0.016^{**}$ $0.016^{**}$ $0.006^{**}$ $0.006^{**}$ $0.000^{**}$	5 %	$0.0007^{***}$	0.0349**	0.0382**	$0.0006^{***}$	$0.0035^{***}$	0.0489*	$0.0418^{**}$	$0.0002^{***}$	$0.0037^{***}$
$0.0778^{*}$ $0.0216^{**}$ $0.0961^{*}$ $0.0345^{**}$ $0.0141^{**}$ $0.0708^{*}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.006^{**$	10 %	$0.0760^{*}$	$0.0010^{***}$	$0.0168^{**}$	$0.0000^{***}$	0.0009***	$0.0021^{***}$	0.0265**	$0.0000^{***}$	$0.0020^{***}$
$0.0724^{*}$ $0.2628$ $0.2036$ $0.0066^{***}$ $0.61^{*}$ $0.1317$ $0.0013^{***}$ $0.0013^{***}$ $0.1769$ $0.1684$ $0.2335$ $0.2537$ $0.02064$ $0.2064$ $0.2064$ $0.1769$ $0.1684$ $0.2335$ $0.2535$ $0.2357$ $0.02064$ $0.2064$	% 06	0.0778*	$0.0216^{**}$	0.0961*	$0.0023^{***}$	0.0345**	$0.0141^{**}$	0.0708*	0.0009***	$0.0243^{**}$
0.1769 $0.1684$ $0.2335$ $0.2577$ $0.1090$ $0.2979$ $0.3005$ $0.2064$ $0.2064$ $0.77298$ $0.1490$ $0.7029$ $0.7029$ $0.9061$ $0.7029$ $0.9061$ $0.2078$ $0.7378$ $0.1490$ $0.7029$ $0.7029$ $0.9061$ $0.7029$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9061$ $0.9063$	95 %	0.0724*	0.2628	0.2036	$0.0066^{***}$	$0.061^{*}$	0.2106	0.1317	$0.0013^{***}$	$0.0465^{**}$
<b>One-sided Dependent on Var</b> 0.2738 <b>One-sided Dependent on Var</b> $0.2738$ $0.1490$ $0.7029$ $0.7031$ $0.9772$ $0.0961*$ $0.7029$ $0.9061$ $0.4582$ $0.0864*$ $0.8437$ $0.9722$ $0.9912$ $0.0207**$ $0.7609$ $0.9789$ $0.3857$ $0.0704*$ $0.7359$ $0.9722$ $0.9912$ $0.0207**$ $0.7510$ $0.9659$ $0.9789$ $0.3857$ $0.0704*$ $0.7326$ $0.9648$ $0.0436**$ $0.7330$ $0.9635$ $0.9963$ $0.9780$ $0.9635$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9963$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9780$ $0.9632$ $0.9991$ $0.9780$ $0.9632$ $0.9991$ $0.9622$ $0.9992$ $0.9992$ $0.9922$ $0.9922$ $0.9922$ $0.9922$ <	% 66	0.1769	0.1684	0.2535	0.2577	0.1090	0.2979	0.3005	0.2064	0.208
0.2798 $0.1490$ $0.7029$ $0.7031$ $0.9772$ $0.9061*$ $0.7029$ $0.9061$ $0.9061$ $0.4582$ $0.0864*$ $0.8437$ $0.9722$ $0.9912$ $0.0207**$ $0.7029$ $0.9789$ $0.9789$ $0.4582$ $0.0704*$ $0.7359$ $0.9722$ $0.9912$ $0.9027**$ $0.8695$ $0.9789$ $0.9789$ $0.3857$ $0.0704*$ $0.7359$ $0.9729$ $0.9648$ $0.0207**$ $0.7510$ $0.9653$ $0.99789$ $0.3966$ $0.0228**$ $0.7325$ $0.9054$ $0.9648$ $0.041**$ $0.7510$ $0.9653$ $0.307**$ $0.0397**$ $0.7449$ $0.6308$ $0.041**$ $0.7510$ $0.9635$ $0.9319$ $0.3060$ $0.022**$ $0.7323$ $0.8099$ $0.8170$ $0.641*$ $0.7049$ $0.6839$ $0.3060$ $0.0659*$ $0.7233$ $0.8099$ $0.8170$ $0.0641*$ $0.7049$ $0.6839$ $0.3060$ $0.022**$ $0.9232$ $0.9916$ $0.9071$ $0.9072$ $0.9097$ $0.9097$ $0.000$ $0.9653$ $0.9916$ $0.9923$ $0.9972$ $0.9972$ $0.9972$ $0.9972$ $0.000$ $0.9533$ $0.9925$ $0.9972$ $0.9972$ $0.9972$ $0.9972$ $0.9972$ $0.000$ $0.9824$ $0.9944$ $0.9952$ $0.9972$ $0.9972$ $0.9972$ $0.9972$ $0.000$ $0.9924$ $0.9952$ $0.9723$ $0.9723$ $0.9972$ $0.9992$ $0.000$ $0.9924$ $0.9952$ $0.9723$ $0.9723$					One-	sided Dependent on				
0.4582 $0.0864*$ $0.8437$ $0.9722$ $0.9912$ $0.0207**$ $0.8695$ $0.9789$ $0.9789$ $0.9789$ $0.9789$ $0.9789$ $0.9789$ $0.9789$ $0.9789$ $0.9789$ $0.9789$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9318*$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9319$ $0.8252$ $0.9235$ $0.021**$ $0.704*$ $0.7049$ $0.6839$ $0.6839$ $0.6839$ $0.6839$ $0.9232$ $0.9924$ $0.9021*$ $0.9021$ $0.9232$ $0.9021*$ $0.9021$ $0.9232$ $0.9021$ $0.9021$ $0.9022$ $0.9021$ $0.9022$ $0.9021$ $0.9022$ <th< td=""><td>1 %</td><td>0.2798</td><td>0.1490</td><td>0.7029</td><td>0.7031</td><td>0.9772</td><td>0.0961*</td><td>0.7029</td><td>0.9061</td><td>0.9903</td></th<>	1 %	0.2798	0.1490	0.7029	0.7031	0.9772	0.0961*	0.7029	0.9061	0.9903
0.3857 $0.0704*$ $0.7359$ $0.7369$ $0.7610$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.9635$ $0.8252$ $0.8252$ $0.8252$ $0.8252$ $0.8252$ $0.8252$ $0.8252$ $0.8252$ $0.8252$ $0.8252$ $0.8269$ $0.641*$ $0.5349$ $0.8252$ $0.8252$ $0.8252$ $0.8252$ $0.8252$ $0.8252$ $0.6839$ $0.8252$ $0.6839$ $0.8252$ $0.6839$ $0.8252$ $0.6839$ $0.8839$ $0.8839$ $0.8839$ $0.6839$ $0.8839$ $0.6939$ $0.6939$ $0.6939$	5 %	0.4582	0.0864*	0.8437	0.9722	0.9912	0.0207 **	0.8695	0.9789	0.9925
0.3966 $0.0228*$ $0.3825$ $0.8449$ $0.6308$ $0.031*$ $0.3820$ $0.8252$ $0.8252$ $0.3063$ $0.037*$ $0.4745$ $0.9054$ $0.636$ $0.3380$ $0.8259$ $0.8259$ $0.3063$ $0.037*$ $0.4745$ $0.9054$ $0.6936$ $0.041*$ $0.5949$ $0.9319$ $0.3060$ $0.0657*$ $0.7733$ $0.8009$ $0.8170$ $0.6041*$ $0.5349$ $0.9319$ $0.3060$ $0.0657*$ $0.7733$ $0.7049$ $0.5339$ $0.6839$ $0.6639$ $0.000***$ $0.2836$ $0.9332$ $0.9332$ $0.9235$ $0.1182$ $0.7049$ $0.6639$ $0.000***$ $0.9990$ $0.9332$ $0.9953$ $0.9997$ $0.9997$ $0.9997$ $0.9977$ $0.9977$ $0.9977$ $0.9977$ $0.9973$ $0.9973$ $0.9991$ $0.9972$ $0.9973$ $0.9991$ $0.9972$ $0.9973$ $0.9991$ $0.9972$ $0.9973$ $0.9991$ $0.9973$ $0.9973$ $0.$	10 %	0.3857	0.0704*	0.7359	0.9699	0.9648	$0.0436^{**}$	0.7510	0.9635	0.9708
0.3063 $0.307**$ $0.4745$ $0.9054$ $0.6936$ $0.041**$ $0.5349$ $0.319$ $0.319$ $0.3060$ $0.0659*$ $0.7123$ $0.8009$ $0.8170$ $0.041**$ $0.5349$ $0.3319$ $0.6839$ $0.3060$ $0.0654*$ $0.7233$ $0.8009$ $0.8170$ $0.0641*$ $0.7049$ $0.6839$ $0.004***$ $0.2836$ $0.7323$ $0.8109$ $0.8170$ $0.9633$ $0.9623$ $0.7049$ $0.6633$ $0.66339$ $0.000***$ $0.9653$ $0.9235$ $0.9235$ $0.182$ $0.9622$ $0.9622$ $0.9622$ $0.9622$ $0.9992$	% 06	0.3966	0.0228**	0.3825	0.8449	0.6308	0.0391**	0.3380	0.8252	0.6139
0.3060 $0.0659*$ $0.7233$ $0.8009$ $0.8170$ $0.0641*$ $0.7049$ $0.6839$ $0.6839$ $0.0094***$ $0.2836$ $0.7323$ $0.8009$ $0.8170$ $0.0641*$ $0.7049$ $0.6839$ $0.6839$ $0.0094***$ $0.2836$ $0.9332$ $0.9332$ $0.9325$ $0.9097$ $0.9622$ $0.9622$ $0.000***$ $0.9653$ $0.9965$ $0.9232$ $0.9623$ $0.9622$ $0.9992$ $0.9$	95 %	0.3063	0.0397**	0.4745	0.9054	0.6936	$0.041^{**}$	0.5949	0.9319	0.7519
One-sided Independent of VaR           0.0004***         0.2836         0.9332         0.9332         0.9335         0.9653         0.9627         0.9622         0           0.000***         0.9653         0.9618         0.9332         0.9332         0.9332         0.9965         0.9523         0.9097         0.9622         0           0.000***         0.9990         0.9618         0.9944         0.9965         0.9523         0.9633         0.9998         0           0.0218**         0.9990         0.9832         1.0000         0.9991         0.9779         0.9737         1.0000         0           0.032***         0.9784         0.9116         0.9977         0.9656         0.9859         0.9313         0.9991         0           0.003***         0.8119         0.8436         0.9403         0.8405         0.9313         0.9991         0           0.0897*         0.0758*         0.7765         0.7633         0.8405         0.9805         0.9987         0.9987	% 66	0.3060	0.0659*	0.7233	0.8009	0.8170	$0.0641^{*}$	0.7049	0.6839	0.7049
$0.004^{***}$ $0.2836$ $0.9332$ $0.9332$ $0.9332$ $0.9235$ $0.182$ $0.907$ $0.9622$ $0.9622$ $0.9623$ $0.000^{***}$ $0.9653$ $0.9618$ $0.9944$ $0.9965$ $0.9523$ $0.9583$ $0.9988$ $0.9988$ $0.0218^{**}$ $0.9990$ $0.9979$ $0.9737$ $0.9983$ $0.9991$ $0.9979$ $0.9737$ $1.0000$ $0.9991$ $0.0218^{**}$ $0.9990$ $0.9791$ $0.9797$ $0.9737$ $0.9998$ $0.9991$ $0.023^{***}$ $0.9784$ $0.9116$ $0.9977$ $0.9656$ $0.9879$ $0.9737$ $1.0000$ $0.003^{***}$ $0.8119$ $0.8436$ $0.9413$ $0.9403$ $0.8405$ $0.9313$ $0.9991$ $0.9987$ $0.003^{***}$ $0.7765$ $0.7633$ $0.8405$ $0.9313$ $0.9991$ $0.9987$ $0.9987$ $0.9987$ $0.9987$ $0.9987$ $0.087^{**}$ $0.0758^{**}$ $0.7765$ $0.7633$ $0.8945$ $0.0959^{**}$ $0.7101$ $0.8013$ $0.8013$					One-s	ided Independent o	f VaR			
0.000***         0.9653         0.9618         0.9944         0.9965         0.9523         0.9583         0.9998            0.0218**         0.9990         0.9832         1.0000         0.9911         0.977         0.977         1.0000	1 %	0.0094***	0.2836	0.9332	0.9332	0.9235	0.1182	0.9097	0.9622	0.9235
0.0218**         0.9990         0.9832         1.0000         0.991         0.9737         1.0000         1.0000           0.0032***         0.9784         0.9116         0.9977         0.9656         0.9859         0.9313         0.9991         1.0000           0.003***         0.8119         0.8436         0.9934         0.9403         0.8405         0.9313         0.9991         1.0000           0.003***         0.8119         0.8436         0.9934         0.9403         0.8405         0.9987         0.9987         1.9805         0.9987         1.0987         1.0987         1.09877         1.09877         1.09877         1.09877         1.09877         1.09877         1.09877         1.09877         1.09877         1.09877         1.09877         1.09877         1.09877         1.09877         1.09974         1.0111         1.0111         1.0111         1.0111         1.0111         1.0111         1.0111         1.001111         1.	5 %	0.0000***	0.9653	0.9618	0.9994	0.9965	0.9523	0.9583	0.9998	0.9963
0.0032***         0.9784         0.9116         0.9977         0.9656         0.9859         0.9313         0.9991           0.0003***         0.8119         0.8436         0.9934         0.9403         0.8405         0.9313         0.9991           0.0003***         0.8119         0.8436         0.9934         0.9403         0.8405         0.9805         0.9987           0.0897*         0.0758*         0.7765         0.7633         0.8945         0.0959*         0.7101         0.8013	10 %	0.0218**	06660	0.9832	1.0000	1666.0	6266.0	0.9737	1.0000	0.998
0.0003***         0.8119         0.8436         0.9934         0.9403         0.8405         0.8805         0.9987           0.0897*         0.0758*         0.7765         0.7633         0.8945         0.0959*         0.7101         0.8013	% 06	$0.0032^{***}$	0.9784	0.9116	0.9977	0.9656	0.9859	0.9313	0.9991	0.9757
0.0897* 0.0758* 0.7765 0.763 0.8945 0.0959* 0.7101 0.8013	95 %	$0.0003^{***}$	0.8119	0.8436	0.9934	0.9403	0.8405	0.8805	0.9987	0.9535
	% 66		0.0758*	0.7765	0.7633	0.8945	0.0959*	0.7101	0.8013	0.7941

Table E19: ES test results for monthly electricity futures on EEX

Quantue         EWQR           1 %         0.4507           5 %         0.9124           10 %         0.4507           5 %         0.9124           10 %         0.4993           90 %         0.6139           95 %         0.7479           99 %         0.5191           10 %         0.8974           5 %         0.0029***           10 %         0.2337           99 %         0.2337           99 %         0.2337           99 %         0.2337           99 %         0.2337           99 %         0.2337           99 %         0.2337           99 %         0.2337           99 %         0.2336           99 %         0.2337           99 %         0.2338           99 %         0.0841*           99 %         0.1536           90 %         0.1536	Garch Normal           0.5617           0.4918           0.4918           0.6228           0.05058           0.0296**           0.0177**           0.3768           0.0345**           0.0171**           0.0171**	Garch Student t 0.1111 0.0447** 0.0192** 0.0864* 0.1215 0.1215	Garch GED Two-s 0.1111	D Garch Skew t G Two-sided Dependent on VaR	GJR Normal	GJR Student t	GJR GED	GJR Skew t
	0.5617 0.4918 0.6228 0.0296** 0.0296** 0.0296** 0.1583 0.1583 0.1583 0.1583 0.1583 0.1583	0.1111 0.0447** 0.0192** 0.0864* 0.1215	`  _	sided Dependent on				
	0.5617 0.4918 0.4918 0.0296** 0.0296** 0.0296** 0.1583 0.1583 0.1583 0.1583 0.1583 0.1583 0.1768 0.0345**	0.1111 0.0447** 0.0192** 0.0864* 0.1215	0.1111	I	VaR			
	0.4918 0.6228 0.0296** 0.0417** 0.1583 0.1583 0.3768 0.3768 0.0345** 0.0345**	0.0447** 0.0192** 0.0864* 0.1215		0.5046	0.5617	0.2206	0.1111	0.5046
	0.6228 0.0296** 0.0417** 0.1583 0.1583 0.1583 0.1583 0.0345** 0.0345**	0.0192** 0.0864* 0.1215	$0.0000^{***}$	0.3840	0.6432	0.0667*	$0.0000^{***}$	0066.0
	0.0296** 0.0417** 0.1583 0.1583 0.3768 0.0345** 0.1928 0.1928	0.0864* 0.1215	$0.0000^{***}$	0.0588*	0.5643	$0.0196^{**}$	$0.0000^{***}$	0.1266
	0.0417** 0.1583 0.1583 0.3768 0.0345** 0.0171** 0.1928	0.1215	$0.0000^{***}$	0.0985	0.0274**	0.0885*	$0.0000^{***}$	0.1226
	0.1583 0.3768 0.0345** 0.0171** 0.1928		$0.0000^{***}$	0.1430	0.0426**	0.1289	$0.0000^{***}$	0.1325
	0.3768 0.0345** 0.0171** 0.1928	0.4940	$0.0025^{***}$	0.5148	0.1326	0.5304	$0.0036^{***}$	0.5110
	0.3768 0.0345** 0.0171** 0.1928		Two-si	<b>Two-sided Independent of VaR</b>				
	0.0345** 0.0171** 0.1928	0.0250**	$0.0017^{***}$	0.4574	0.4509	0.0353**	$0.0108^{**}$	0.6986
	0.0171** 0.1928	0.0076***	$0.0000^{***}$	0.0673*	0.0525*	$0.0120^{**}$	$0.0000^{***}$	0.4293
	0.1928	0.0141**	$0.0000^{***}$	$0.0681^{*}$	0.0291**	0.0239**	$0.0000^{***}$	0.2387
		0.2370	$0.0000^{***}$	0.2230	0.1909	0.2386	$0.0001^{***}$	0.2064
	0.1190	0.1928	$0.0010^{***}$	0.1725	0.1220	0.1969	$0.0008^{***}$	0.1710
	0.3373	0.3654	$0.0122^{**}$	0.3688	0.3194	0.3654	$0.0105^{**}$	0.3688
			One-s	<b>One-sided Dependent on VaR</b>	VaR			
	0.2646	0.9275	0.9275	0.7450	0.2646	0.8180	0.9275	0.2496
	0.7171	0.9573	1.0000	0.7835	0.6490	0.9399	1.0000	0.4938
10 % 0.7395	0.6704	0.9820	1.0000	0.9564	0.6893	0.9818	1.0000	0.9139
90 % 0.6768	$0.0020^{***}$	$0.0194^{**}$	1.0000	$0.0253^{**}$	$0.0012^{***}$	$0.0202^{**}$	1.0000	$0.0307^{**}$
95 % 0.3682	$0.0007^{***}$	$0.0243^{**}$	1.0000	$0.0344^{**}$	0.0008***	$0.0279^{**}$	1.0000	$0.0304^{**}$
99 % 0.2505	$0.0245^{**}$	0.2055	0.9975	0.2165	$0.0187^{**}$	0.2275	0.9964	0.2162
			One-si	<b>One-sided Independent of VaR</b>	f VaR			
1 % 0.5456	0.7887	0.9886	0.9989	0.7270	0.7525	0.9886	0.9895	0.3198
5 % 0.0000***	0.9670	0.9924	1.0000	0.9428	0.9528	0.9880	1.0000	0.7553
10 % 0.0860*	0.9841	0.9868	1.0000	0.9471	0.9737	0.9787	1.0000	0.8591
90 % 0.0729*	0.0372**	0.0606*	1.0000	$0.0546^{*}$	$0.0364^{**}$	$0.0611^{*}$	0.9999	$0.0457^{**}$
95 % 0.0003***	$0.0007^{***}$	$0.0127^{**}$	0.9990	$0.0100^{**}$	$0.0009^{***}$	$0.0158^{**}$	0.9992	$0.0102^{**}$
99 % 0.0440**	$0.0179^{**}$	0.0323**	0.9995	$0.0323^{**}$	0.0179**	$0.0323^{**}$	0.9994	$0.0323^{**}$

Table E20: ES test results for yearly electricity futures on EEX

	:				W	Monthly electricity - ICE	CE									
Two-sided Dependent on YaR           Nan         Nan         Nan         Nan         Nan         Nan         Nan           0.9200         0.5217         0.6419         0.0009**         0.3625         0.0004***         0.000***           0.4809         0.22112         0.0419         0.0009***         0.3133         0.0009***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.01111         0.2201         0.0000***         0.01111         0.2201         0.0111**         0.0000***         0.0111**         0.0000***         0.01111         0.2201         0.0111**         0.0000***         0.0111**         0.0000***         0.0111**         0.0000***         0.0111**         0.0121**         0.0111**         0.0111**         0.0111**         0.0111**         0.0111**         0.0111**         0.0111**         0.0111**         0.0111**         0.0111**         0.0111**         0.0111**         0.0111**         0.0111**         0.0100***         0.0111**         0.0100***         0.0111**         0.0111**         0.0100***         0.0101***	Quantile	EWQR	Garch Normal	Garch Student t	Garch GED	Garch Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t						
Nak         Nak <th></th> <th></th> <th></th> <th></th> <th>Two-</th> <th>sided Dependent on</th> <th>VaR</th> <th></th> <th></th> <th></th>					Two-	sided Dependent on	VaR									
$0.920$ $0.3217$ $0.064^{++}$ $0.000^{+++}$	1 %		NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN						
0.4800         0.2112         0.0035***         0.0001***         0.0001***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0111         0.0113**         0.0000***         0.0111*         0.0101***         0.0101***	5 %		0.5217	0.0541*	0.0000***	0.0003***	0.3625	0.0244**	$0.0000^{***}$	0.0002***						
04400         0.1520         0.2360         0.000 <sup>***</sup> 0.2133         0.2039 <sup>**</sup> 0.2110         0.0334 <sup>**</sup> 0.000 <sup>***</sup> 0.000 <sup>***</sup> 0.9586         0.332         0.3320         0.0100 <sup>***</sup> 0.3231         0.111         0.2210         0.0334 <sup>**</sup> 0.0100 <sup>***</sup> 0.000 <sup>***</sup> 0.000 <sup>***</sup> 0.0100 <sup>***</sup> 0.0000 <sup>***</sup> 0.0000 <sup>***</sup> 0.0000 <sup>***</sup> 0.0000 <sup>***</sup> 0.0010 <sup>***</sup> 0.0010 <sup>***</sup> 0.0010 <sup>***</sup> 0.011 <sup>**</sup> 0.0010 <sup>***</sup> 0.0011 <sup>***</sup> 0.0010 <sup>***</sup> <	10 %		0.2712	0.0015***	$0.0000^{***}$	$0.0001^{***}$	0.2882	0.0014***	$0.0000^{***}$	$0.0000^{***}$						
0.9986         0.0360*         0.3520         0.000***         0.2410         0.0334*         0.4116         0.000***           0.3386         0.3932         0.3330         0.3330         0.1111         0.2221         0.2033         0.111           0.3586         0.3355         0.3365         0.088**         0.003***         0.012**         0.011**         0.111           0.3556         0.3365         0.068**         0.000***         0.000***         0.000***         0.000***           0.3554         0.000***         0.000***         0.000***         0.000***         0.000***         0.000***           0.3593         0.0354*         0.000***         0.000***         0.000***         0.000***         0.000***           0.3593         0.7518         0.000***         0.000***         0.000***         0.000***         0.000***           0.3593         0.7518         0.000***         0.000***         0.015**         0.000***         0.000***           0.3593         0.7518         0.000***         0.015**         0.016***         0.000***         0.000***           0.3593         0.7518         0.015**         0.7678         0.016***         0.000***           0.3514         0.7518	% 06		0.1520	0.2369	0.0000***	0.3133	0.2039	0.4139	$0.0000^{***}$	0.2822						
0.3386         0.3330         0.111         0.221         0.2603         0.111         0.111           A         A         0.013**         0.0221         0.021         0.111         0.111           A         A         0.013**         0.021         0.010***         0.011           0.350         0.000***         0.000***         0.000***         0.000***         0.000***         0.000***           0.052**         0.000***         0.000***         0.000***         0.000***         0.000***         0.000***           0.052**         0.000***         0.000***         0.000***         0.000***         0.000***         0.000***           0.559*         0.052**         0.000***         0.000***         0.000***         0.000***         0.000***           0.589%         0.052**         0.000***         0.000***         0.000***         0.000***         0.000***           0.589%         0.158         0.052**         0.000***         0.000***         0.000***         0.000***           0.589%         0.158         0.053**         0.158         0.158**         0.158**         0.000***           0.581         0.999%         0.053** <td< td=""><td>95 %</td><td></td><td>0.0260**</td><td>0.3620</td><td><math>0.0000^{***}</math></td><td>0.2410</td><td>0.0394**</td><td>0.4116</td><td><math>0.0000^{***}</math></td><td>0.3082</td></td<>	95 %		0.0260**	0.3620	$0.0000^{***}$	0.2410	0.0394**	0.4116	$0.0000^{***}$	0.3082						
Two-sided Independent of VaR           0.3365         0.0005***         0.012***         0.012***         0.012***         0.010***         0.010***         0.010***         0.010***         0.010***         0.010***         0.010***         0.010***         0.0100***         0.000***         0.0134**         0.0134**         0.0134**         0.0134**         0.0134**         0.0134**         0.0134**         0.0134**         0.0134**         0.0134**         0.0134**         0.0134**         0.0134** <th <<="" colspa="5" td=""><td>% 66</td><td></td><td>0.3932</td><td>0.3330</td><td>0.1111</td><td>0.2221</td><td>0.2603</td><td>0.2221</td><td>0.1111</td><td>0.2221</td></th>	<td>% 66</td> <td></td> <td>0.3932</td> <td>0.3330</td> <td>0.1111</td> <td>0.2221</td> <td>0.2603</td> <td>0.2221</td> <td>0.1111</td> <td>0.2221</td>	% 66		0.3932	0.3330	0.1111	0.2221	0.2603	0.2221	0.1111	0.2221					
0.3356 $0.3365$ $0.081*$ $0.003**$ $0.013**$ $0.001**$ $0.001**$ $0.000***$ $0.011**$ $0.000***$ $0.011**$ $0.000***$ $0.000***$ $0.000***$ $0.011**$ $0.000****$ $0.011**$ $0.000****$					Two-s	sided Independent o	f VaR									
0.0002***         0.0002***         0.0002***         0.0000***         <	1 %		0.3365	0.0681*	0.0033***	0.013**		0.012**	$0.0017^{***}$	$0.0116^{**}$						
0.0051***         0.000***         0.015*         0.015**         0.015**         0.015**         0.015**         0.015**         0.015**         0.010***         0.000***         0.000***         0.000***         0.000***         0.000***         0.000***         0.000***         0.000***         0.015**         0.015**         0.015**         0.015**         0.015	5 %		0.0002***		$0.0000^{***}$	$0.0000^{***}$	0.0008***	$0.0000^{***}$	$0.0000^{***}$	$0.0000^{***}$						
$0.5921$ $0.0546*$ $0.0202**$ $0.0000***$ $0.0140*$ $0.0140^{**}$ $0.0046^{**}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.015^{**}$ $0.010^{**}$ $0.010^{**}$ $0.010^{**}$ $0.010^{**}$ $0.010^{**}$ $0.010^{**}$ $0.010^{**}$ $0.010^{**}$ $0.010^{**}$ $0.010^{**}$ $0.015^{**}$ $0.016^{**}$ $0.0116^{**}$ $0.0116^{**}$ $0.0116^{**}$ $0.0116^{**}$ $0.0116^{**}$ $0.0116^{**}$ $0.0116^{**}$ <	10 %		$0.0000^{***}$		0.0000***	$0.0000^{***}$	0.0000***	$0.0000^{***}$	$0.0000^{***}$	$0.0000^{***}$						
$0.589$ $0.7918$ $0.0528$ $0.0000^{**}$ $0.0165$ $0.0466^{**}$ $0.000^{**}$ $0.000^{**}$ $0.0104^{**}$ $0.123$ $0.0123$ $0.0183^{**}$ $0.0165^{**}$ $0.0015^{**}$ $0.0015^{**}$ $0.0115^{**}$ $NaN$ NaN	% 06		0.0546*	0.0202**	$0.0000^{***}$	0.0072	$0.0476^{**}$	$0.0140^{**}$	$0.0000^{***}$	0.0048						
0.0104**         0.1259         0.0833*         0.0149**         0.1652         0.0833*         0.0115**           NaN	95 %		0.7918	0.0528*	$0.0000^{***}$	0.0213**	0.7678	0.0466**	$0.0000^{***}$	$0.0190^{**}$						
Main         Nan         Nan <th <="" colspan="6" th=""><th>% 66</th><th></th><th>0.1259</th><th>0.0893*</th><th><math>0.0149^{**}</math></th><th>0.0893*</th><th>0.1652</th><th>0.0893*</th><th><math>0.0115^{**}</math></th><th>0.0847*</th></th>	<th>% 66</th> <th></th> <th>0.1259</th> <th>0.0893*</th> <th><math>0.0149^{**}</math></th> <th>0.0893*</th> <th>0.1652</th> <th>0.0893*</th> <th><math>0.0115^{**}</math></th> <th>0.0847*</th>						% 66		0.1259	0.0893*	$0.0149^{**}$	0.0893*	0.1652	0.0893*	$0.0115^{**}$	0.0847*
NaNN					One-	sided Dependent on	VaR									
0.4722 $0.6552$ $0.9459$ $1.0000$ $0.9977$ $0.6655$ $0.9756$ $1.0000$ $1.0000$ $0.7405$ $0.7715$ $0.985$ $1.0000$ $0.985$ $0.9986$ $1.0000$ $1.0000$ $0.7432$ $0.0512*$ $0.985$ $0.9857$ $0.9999$ $0.8088$ $0.9986$ $1.0000$ $1.0000$ $0.7638$ $0.0512*$ $0.98549$ $1.0000$ $0.8194$ $0.7715$ $1.0000$ $1.0000$ $0.7638$ $0.0512*$ $0.95216$ $0.9275$ $0.9621$ $0.7715$ $1.0000$ $1.0000$ $0.2094$ $0.1761$ $0.9521$ $0.9275$ $0.9621$ $0.7705$ $1.0000$ $0.9275$ $0.2094$ $0.0781*$ $0.9275$ $0.9621$ $0.7705$ $0.9275$ $0.9275$ $0.2094$ $0.0781*$ $0.9621$ $0.0781*$ $0.9275$ $0.9275$ $0.000**$ $0.0992$ $0.9274$ $0.99275$ $0.9877$ $0.9275$ $0.99275$ $0.000**$ $0.9998$ $0.9324$ $0.9972$ $0.9877$ $0.9697$ $0.9988$ $0.9928$ $0.000**$ $0.9998$ $0.9992$ $0.0987$ $0.9988$ $0.9986$ $0.9988$ $0.9988$ $0.9988$ $0.000**$ $0.9917$ $0.9992$ $0.9920$ $0.9992$ $0.9988$ $0.9988$ $0.9988$ $0.9988$ $0.000**$ $0.9920$ $0.9930$ $0.9912$ $0.9912$ $0.9912$ $0.9912$ $0.9988$ $0.9988$ $0.000**$ $0.9920$ $0.9912$ $0.9912$ $0.9613$ $0.9872$ $0.9912$ <td>1 %</td> <td></td> <td>NaN</td> <td>NaN</td> <td>NaN</td> <td>NaN</td> <td>NaN</td> <td>NaN</td> <td>NaN</td> <td>NaN</td>	1 %		NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN						
$0.7405$ $0.7970$ $0.9985$ $1.0000$ $0.9996$ $0.0006$ $1.0000$ $0.0006$ $0.7638$ $0.0512$ $0.8549$ $1.0000$ $0.8194$ $0.7715$ $1.0000$ $1.0000$ $0.7638$ $0.0512$ $0.8549$ $1.0000$ $0.8194$ $0.7715$ $1.0000$ $1.0000$ $0.4832$ $0.016$ $0.8549$ $1.0000$ $0.8515$ $0.006$ $0.7703$ $1.0000$ $1.0000$ $0.2094$ $0.1761$ $0.9275$ $0.9621$ $0.9275$ $0.9621$ $0.7703$ $1.0000$ $0.2094$ $0.1761$ $0.9274$ $0.9817$ $0.9621$ $0.9275$ $0.9927$ $0.9927$ $0.9927$ $0.000^{***}$ $0.9998$ $0.0930$ $0.9877$ $0.9987$ $0.9987$ $0.9987$ $0.9987$ $0.0000^{***}$ $0.99992$ $0.0000$ $0.9992$ $0.0990$ $0.9987$ $0.9987$ $0.9987$ $0.0000^{***}$ $0.9992$ $0.9877$ $0.9877$ $0.9987$ $0.99987$	5 %		0.6552	0.9459	1.0000	0.9997	0.6655	0.9756	1.0000	0.9998						
$0.7638$ $0.0512*$ $0.8549$ $1.0000$ $0.8194$ $0.078*$ $0.715$ $1.0000$ $1.000$ $0.4832$ $0.0016^{***}$ $0.7986$ $1.0000$ $0.8515$ $0.0062^{***}$ $0.7703$ $1.0000$ $1.0000$ $0.4832$ $0.1761$ $0.9621$ $0.8515$ $0.062^{***}$ $0.7703$ $1.0000$ $1.0000$ $0.2094$ $0.1761$ $0.9621$ $0.9621$ $0.9621$ $0.7703$ $0.9275$ $0.9275$ $0.2094$ $0.1761$ $0.9224$ $0.9275$ $0.9621$ $0.9621$ $0.9275$ $0.9275$ $0.9275$ $0.9275$ $0.9985$ $0.9985$ $0.9992$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9985$ $0.9992$ $0.9985$ $0.9992$ $0.9985$ $0.9992$ $0.9985$ $0.9992$ $0.9985$ $0.9985$ $0.9992$ $0.099$	10 %		0.7970	0.9985	1.0000	0.9999	0.8088	0.9986	1.0000	1.0000						
$0.4832$ $0.0016^{***}$ $0.7986$ $1.0000$ $0.8515$ $0.0062^{***}$ $0.7703$ $1.0000$ $1.0000$ $0.2094$ $0.1761$ $0.9621$ $0.9275$ $0.9621$ $0.9275$ $0.9285$ $0.9285$ $0.9285$ $0.9285$ $0.9988$ $0.00000$ $0.0000$ $0.0000$	% 06		0.0512*	0.8549	1.0000	0.8194	0.0781*	0.7715	1.0000	0.8343						
0.2094 $0.1761$ $0.9621$ $0.0621$ $0.1125$ $0.9621$ $0.9275$ $0.275$ $0.275$ $0.275$ $0.275$ $0.275$ $0.275$ $0.275$ $0.275$ $0.275$ $0.275$ $0.275$ $0.275$ $0.275$ $0.275$ $0.275$ $0.278$ $0.278$ $0.278$ $0.2988$ $0.2992$ $0.2988$ $0.2988$ $0.2988$ $0.2988$ $0.2972$ $0.2988$ $0.2972$ $0.2000$ $0.2000$ $0.2987$ $0.2000$ $0.2000$ $0.2000$ $0.2987$ $0.2000$ $0.2987$ $0.2000$ $0.2987$ $0.2000$ $0.2987$ $0.2000$ $0.2987$ $0.2000$ $0.2987$ $0.2000$ $0.2000$ $0.2000$ $0.207$ $0.207$	95 %		$0.0016^{***}$	0.7986	1.0000	0.8515	$0.0062^{***}$	0.7703	1.0000	0.8268						
One-sided Independent of VaR $0.6699$ $0.6699$ $0.9324$ $0.9972$ $0.9877$ $0.6699$ $0.9885$ $0.9886$ $0.9992$ $1.0000$ $1.0000$ $1.0000$ $1.0000$ $1.0000$ $0.9992$ $0.0986$ $0.0900$ $0.09886$ $0.9887$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09807$ $0.09872$ $0.0000$ $0.09807$ $0.09872$ $0.0000$ $0.09807$ $0.09807$ $0.09807$ $0.09807$ $0.09807$ $0.09807$ $0.09807$ $0.09807$ $0.09807$ $0.09807$ $0.09807$ $0.09807$ $0.09807$ $0.09807$	% 66		0.1761	0.9621	0.9275	0.9621	0.1125	0.9621	0.9275	0.9621						
0.6699 $0.6699$ $0.9324$ $0.9972$ $0.8877$ $0.6899$ $0.9885$ $0.988$ $0.9988$ $0.0000$ $0.9992$ $0.0000$ $0.9887$ $0.0900$ $0.9992$ $0.0000$ $0.0987$ $0.0000$ $0.9872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.0000$ $0.09872$ $0.00000$ $0.09807$ $0.09807$					One-s	vided Independent o	f VaR									
0.000***         0.9998         1.0000         1.0000         0.9992         1.00000         1.00	1 %		0.6699	0.9324	0.9972	0.9877	0.6699	0.9885	0.9988	0.9891						
0.000***         1.00000         1.00	5 %		0.9998	1.0000	1.0000	1.0000	0.9992	1.0000	1.0000	1.0000						
0.2746         0.9572         0.9817         1.0000         0.9330         0.9613         0.9872         1.0000         1.0000           0.6907         0.5855         0.9570         1.0000         0.9802         0.5975         0.9607         1.0000         1.0000           0.009***         0.0637*         0.9207         0.9207         0.9207         0.9207         0.9895         1.0000	10 %		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000						
0.6907         0.5855         0.9570         1.0000         0.9802         0.5975         0.9607         1.0000           0.009***         0.0637*         0.9207         0.9856         0.9207         0.989         0.989	% 06		0.9572	0.9817	1.0000	0.9930	0.9613	0.9872	1.0000	0.9952						
0.0099*** 0.0637* 0.9207 0.9856 0.9207 0.9207 0.989	95 %		0.5855	0.9570	1.0000	0.9802	0.5975	0.9607	1.0000	0.9819						
	% 66		0.0637*	0.9207	0.9856	0.9207	0.0760*	0.9207	0.989	0.9207						

Table E21: ES test results for monthly electricity futures on ICE

				Mon	Monthly electricity- NYMEX	MEX			
Quantile	EWQR	Garch Normal	Garch Student t	Garch GED	Garch Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
				Two-	<b>Two-sided Dependent on VaR</b>	VaR			
1 %	0.4860	0.0476**	0.3441	$0.0002^{***}$	0.2241	0.0493**	0.2391	$0.0010^{***}$	0.1296
5 %	0.0774*	$0.0306^{**}$	0.8746	$0.0000^{***}$	0.2154	$0.0263^{**}$	0.8893	$0.0001^{***}$	0.2324
10 %	0.1763	0.0204**	0.3577	0.0006***	0.1194	$0.0226^{**}$	0.5994	$0.0002^{***}$	0.2113
% 06	0.9719	0.0059***	0.7254	$0.0000^{***}$	0.9809	$0.0040^{***}$	0.4447	$0.0000^{***}$	0.2214
95 %	0.7973	$0.0280^{**}$	0.2489	$0.0000^{***}$	0.4766	$0.0081^{***}$	0.7583	$0.0000^{***}$	0.7845
% 66	0.9396	0.1091	0.0086***	$0.0016^{***}$	$0.0164^{**}$	0.0342**	0.0003***	$0.0004^{***}$	0.0005***
				Two-s	<b>Two-sided Independent of VaR</b>	f VaR			
1 %	0.1091	0.0056***	0.8378	0.0420**	0.0898*	$0.0137^{**}$	0.7876	0.0127**	$0.0382^{**}$
5 %	0.0366**	0.0082***	0.1498	$0.0008^{***}$	0.0258**	$0.0107^{**}$	0.2326	$0.0002^{***}$	$0.0308^{**}$
10 %	0.0881*	$0.0307^{**}$	0.0992*	$0.0017^{***}$	0.0333**	0.0385**	0.1660	$0.0000^{***}$	$0.0496^{**}$
% 06	0.0142**	0.9336	0.5449	$0.0000^{***}$	0.9531	0.4149	0.9984	$0.0000^{***}$	0.6344
95 %	0.4197	0.0749*	0.2931	$0.0000^{***}$	0.7812	0.0212**	0.7747	$0.000^{***}$	0.7471
% 66		0.0064***	0.0124**	$0.012^{**}$	0.0713*	$0.0039^{***}$	0.0232**	$0.0377^{**}$	$0.011^{**}$
				One-	<b>One-sided Dependent on VaR</b>	VaR		•	
1 %	0.2123	0.0031***	0.8029	0.9999	0.1017	0.0119**	0.8539	0.9993	0.0986
5 %		$0.0028^{***}$	0.4266	1.0000	0.0856*	$0.0023^{***}$	0.5375	0.9999	0.0864*
10 %	0.0697*	0.0011***	0.1496	0.9994	0.0319**	$0.0019^{***}$	0.2773	0.9998	0.0749*
% 06	0.5090	$0.0001^{***}$	0.6305	1.0000	0.4872	***9000'0	0.2097	1.0000	0.0958*
95 %	0.3853	0.0032***	0.8542	1.0000	0.7372	$0.0015^{***}$	0.6123	1.0000	0.3835
% 66	0.5379	0.0533*	0.9921	1.0000	0.9837	$0.0126^{**}$	0.9997	0.9996	0.9996
				One-s	<b>One-sided Independent of VaR</b>	f VaR			
1 %	$0.0064^{***}$	0.0021***	0.4271	0.9896	0.0794*	$0.013^{**}$	0.3992	0.9881	$0.0361^{**}$
5 %	0.0077***	0.0002***	0.0568*	0.9992	$0.0036^{***}$	***1000'0	0.0958*	0.9998	$0.0031^{***}$
10 %	0.0265**	0.0044***	$0.0252^{**}$	0.9983	$0.0042^{***}$	$0.0065^{***}$	0.0556*	1.0000	$0.0092^{***}$
90 %	$0.0011^{***}$	0.4622	0.7193	1.0000	0.5271	0.1918	0.4852	1.0000	0.3052
95 %	0.1919	0.0220**	0.8274	1.0000	0.5895	$0.0058^{***}$	0.6056	1.0000	0.3649
96 %	0.0293**	0.0042***	0.9888	0.9995	0.9294	$0.0007^{***}$	0.9771	0.9631	0.9896

Table E22: ES test results for monthly electricity futures on NYMEX

					Gas - ICE				
Quantile	EWQR	Garch Normal	Garch Student t	Garch GED	Garch Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
				Two-	<b>Two-sided Dependent on VaR</b>	VaR			
1 %	0.4348	0.5523	0.0862*	$0.0151^{**}$	0.0757*	0.5104	$0.0862^{*}$	$0.0151^{**}$	0.0828*
5 %	0.8993	0.1696	0.1699	$0.0002^{***}$	$0.0047^{***}$	0.1918	0.2676	$0.0001^{***}$	0.0097***
10 %	0.4819	0.3865	0.0424**	$0.0000^{***}$	$0.0092^{***}$	0.6476	$0.0486^{**}$	$0.0000^{***}$	$0.0094^{***}$
% 06	0.5718	0.1860	0.2339	$0.0199^{**}$	0.3241	0.1243	0.2402	$0.0204^{**}$	0.3886
95 %	0.8168	0.2662	0.4577	$0.0429^{**}$	0.6845	0.2106	0.4317	$0.0240^{**}$	0.6520
% 66	0.5927	0.3642	0.6559	0.4049	0.6211	0.3690	0.6497	0.4005	0.6243
				Two-s	<b>Two-sided Independent of VaR</b>	f VaR			
1 %	0.7722	0.6972	0.0440**	$0.0137^{**}$	0.0136**	0.5113	0.0473**	$0.0137^{**}$	0.0167**
5 %	0.5063	0.0460**	0.0877*	$0.0000^{***}$	$0.0097^{***}$	0.0551*	0.1023	$0.000^{***}$	$0.0104^{**}$
10 %	0.9604	$0.0025^{***}$	0.3413	$0.0000^{***}$	0.0613*	$0.0058^{***}$	0.3705	$0.000^{***}$	0.0636*
% 06	0.2607	0.4462	0.2000	0.3356	0.225	0.3459	0.1956	0.3646	0.2195
95 %	0.4446	0.3453	0.3120	0.3446	0.3336	0.322	0.3078	0.3558	0.3263
% 66	0.3835	0.3835	0.3869	0.8434	0.4063	0.3835	0.3869	0.8511	0.4063
				One-	<b>One-sided Dependent on VaR</b>	VaR			
1 %	0.7962	0.2267	0.9248	0.9926	0.9353	0.1898	0.9248	0.9926	0.9282
5 %	0.5393	0.0452**	0.8842	0.9998	0.9953	0.0593*	0.8389	0.9999	0.9903
10 %	0.7351	0.1604	0.9626	1.0000	0.9909	0.3036	0.9578	1.0000	0.9907
<b>06</b>	0.1972	$0.0030^{***}$	0.0565*	0.9801	0.1062	$0.0004^{***}$	0.0646*	0.9796	0.1462
95 %	0.5514	$0.0106^{**}$	0.1673	0.9571	0.2955	0.0035***	0.1537	0.9760	0.2788
0% 66	0.2292	$0.0207^{**}$	0.2796	0.6709	0.2720	$0.0217^{**}$	0.2812	0.6709	0.2718
				One-s.	<b>One-sided Independent of VaR</b>	f VaR			
1 %	0.6002	0.3177	0.9670	0.9888	0.9974	0.1907	0.9637	0.9888	0.9943
5 %	0.2285	0.9596	0.9334	1.0000	0.9903	0.9551	0.9248	1.0000	0.9896
10 %	0.4686	0.9975	0.8002	1.0000	0.9481	0.9943	0.7907	1.0000	0.9468
90 %	0.0075***	0.1213	$0.0021^{***}$	0.7113	$0.0052^{***}$	$0.0564^{*}$	$0.0018^{***}$	0.7037	$0.0048^{***}$
95 %	0.0982*	$0.0191^{**}$	$0.0078^{***}$	0.6744	$0.0168^{**}$	$0.0066^{***}$	$0.0070^{***}$	0.6680	$0.0145^{**}$
99 %	0.0610*	0.0610*	0.0644*	0.5497	0.0838*	0.0610*	$0.0644^{*}$	0.5391	0.0838*

The table presents the results for onesided and twosided ES-tests dependent on VaR and independent of VaR. \*, \*\* and \*\*\* denotes significance at the 10%, 5% and 1% respectively.

# Table E23: ES test results for natural gas futures on ICE

$ \begin{array}{                                     $	- Litter C					Gas - NYMEX					
Two-sided Dependent on VaR           0.3575         0.3546         0.3546         0.3546         0.3546         0.3546         0.3546         0.3546         0.3546         0.3546         0.3546         0.3546         0.0104**         0.0000***         0.0000***         0.0000***         0.0104**         0.0000***         0.0104**         0.0000***         0.0100***         0.0100***         0.0000***          0.0000*** <th colspa="&lt;/th"><th></th><th>EWQR</th><th>Garch Normal</th><th>Garch Student t</th><th>Garch GED</th><th>Garch Skew t</th><th>GJR Normal</th><th>GJR Student t</th><th>GJR GED</th><th>GJR Skew t</th></th>	<th></th> <th>EWQR</th> <th>Garch Normal</th> <th>Garch Student t</th> <th>Garch GED</th> <th>Garch Skew t</th> <th>GJR Normal</th> <th>GJR Student t</th> <th>GJR GED</th> <th>GJR Skew t</th>		EWQR	Garch Normal	Garch Student t	Garch GED	Garch Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
0.1084         0.2211         0.5046         NaN         0.5046         0.5046         0.5046         0.5046           0.2373         0.0053*         0.014**         0.0000***         0.0000***         0.0317         0.0564*         0.0000***           0.2375         0.0053*         0.0114**         0.0000***         0.0001***         0.0001***         0.0000***         0.0001***         0.0000***         0.0001***         0.0000***         0.0001***         0.0000***         0.0001***         0.0000***         0.0001***         0.0000***         0.00					Two-	sided Dependent on	VaR				
0.373 $0.073*$ $0.014**$ $0.000**$	1 %		0.2221	0.5046	NaN	0.5046	0.3357	0.5046	0.5046	0.5046	
$0.2325$ $0.063^{+}$ $0.001^{+}$ $0.001^{+}$ $0.001^{+}$ $0.000^{+}$	5 %		0.0728*	0.0114**	$0.0000^{***}$	$0.0010^{***}$	0.3137	0.0054***	$0.000^{***}$	$0.0008^{***}$	
$0.6975$ $0.2180$ $0.7312$ $0.000^{++-}$ $0.000^{++-}$ $0.000^{++}$ $0.4371$ $0.11230$ $0.7316$ $0.000^{++}$ $0.3959$ $0.000^{++}$ $0.000^{++$	10 %		0.0693*	$0.0014^{***}$	$0.000^{***}$	0.0000 ***	$0.0931^{*}$	$0.0015^{***}$	$0.0000^{***}$	$0.0001^{***}$	
0.3791         0.1230         0.7316         0.000 <sup>444</sup> 0.7316         0.000 <sup>445</sup> 0.7305         0.000 <sup>444</sup> 0.000 <sup>445</sup> 0.0144         0.0144         0.0144	%06		0.2180	0.7312	$0.000^{***}$	0.9592	0.2125	0.5017	$0.0000^{***}$	0.6784	
$0.4737$ $0.118$ $0.4786$ $0.036$ $0.0367$ $0.0367$ $0.0367$ $0.0367$ $0.0367$ $0.0016^{***}$ $0.0016^{***}$ $0.0016^{***}$ $0.0016^{***}$ $0.0016^{***}$ $0.0016^{***}$ $0.0016^{***}$ $0.0016^{***}$ $0.0016^{***}$ $0.0016^{***}$ $0.0016^{***}$ $0.0016^{***}$ $0.000^{***$	95 %		0.1230	0.7316	$0.0001^{***}$	0.7955	0.1315	0.3959	$0.0000^{***}$	0.5333	
Two-sided Independent of VaR           0.0904*         0.0124*         0.0104**         0.0104**         0.0104**         0.0104**         0.0104**         0.0104**         0.0104**         0.0104**         0.0104**         0.0104**         0.0100***         0.0100***         0.0100***         0.0100***         0.0100***         0.0100***         0.0000***         0.0100***         0.0000***         0.0100***	% 66		0.1188	0.4786	$0.0036^{***}$	0.5941	0.0920*	0.3567	$0.0036^{***}$	0.4292	
$0.1215$ $0.0904*$ $0.012^{**}$ $0.0012^{**}$ $0.0012^{**}$ $0.0012^{**}$ $0.0012^{**}$ $0.0012^{**}$ $0.000^{***}$ $0.003^{**}$ $0.000^{***}$ $0.003^{**}$ $0.000^{***}$					Two-s	ided Independent o	f VaR				
$0.1194$ $0.0140^{**}$ $0.0016^{***}$ $0.000^{***$	1 %		0.0904*	0.0122**	$0.0017^{***}$	$0.0116^{**}$	$0.0704^{*}$	0.0098***	$0.0017^{***}$	0.0215**	
0.1797 $0.0106*$ $0.0047*$ $0.00047*$ $0.0000*$ $0.000*$ $0.000*$ $0.000*$ $0.000*$ $0.000*$ $0.000*$ $0.0000*$ $0.0000*$ $0.$	5 %		$0.0140^{**}$	$0.0015^{***}$	$0.0000^{***}$	$0.0000^{***}$	$0.0135^{**}$	0.0008***	$0.0000^{***}$	$0.0001^{***}$	
$0.5905$ $0.3330$ $0.4815$ $0.0000^{***}$ $0.6571$ $0.3459$ $0.4652$ $0.000^{***}$ $0.000^{***}$ $0.7165$ $0.2117$ $0.5552$ $0.000^{***}$ $0.7254$ $0.1613$ $0.4588$ $0.000^{***}$ $0.3114$ $0.0533^{**}$ $0.2752$ $0.020^{***}$ $0.7258$ $0.000^{***}$ $0.024^{***}$ $0.024^{***}$ $0.7450$ $0.024^{***}$ $0.024^{***}$ $0.0799^{**}$ $0.7450$ $0.024^{***}$ $0.0748^{***}$ $0.024^{***}$ $0.0748^{***}$ $0.0748^{***}$ $0.0748^{***}$ $0.0748^{***}$ $0.0748^{***}$ $0.0748^{***}$ $0.0748^{***}$ $0.0748^{***}$ $0.0748^{***}$ $0.000^{****}$ $0.000^{****}$ $0.000^{****}$ $0.000^{***}$ $0.000^{***}$ $0.000^{****}$ $0.0748^{***}$ $0.000^{***}$ $0.000^{***}$ $0.0748^{**}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.0248^{**}$ $0.000^{***}$ $0.000^{***}$ $0.024^{**}$ $0.000^{***}$ $0.000^{***}$ $0.000^{**}$ $0.000^{***}$ $0.000^{*$	10 %		$0.0106^{**}$	$0.0047^{***}$	$0.0000^{***}$	0.0009***	0.0079***	0.0039***	$0.0000^{***}$	0.0005***	
$0.165$ $0.2117$ $0.5552$ $0.000^{444}$ $0.060^{444}$ $0.000^{444}$ $0.3114$ $0.0533^{4}$ $0.2552$ $0.0256^{444}$ $0.1743$ $0.0248^{444}$ $0.3114$ $0.0533^{4}$ $0.2752$ $0.0225^{444}$ $0.3508$ $0.01743$ $0.0248^{444}$ $0.3114$ $0.0533^{4}$ $0.2752$ $0.0225^{444}$ $0.3176$ $0.0248^{444}$ $0.0248^{444}$ $0.07450$ $0.7600$ $0.7450$ $0.71000$ $0.77000$ $0.7760$	% 06		0.3739	0.4815	$0.0000^{***}$	0.6571	0.3459	0.4652	$0.0000^{***}$	0.6393	
$0.3114$ $0.0533$ $0.2752$ $0.0225$ $0.0312^{**}$ $0.1743$ $0.0248^{**}$ $IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII$	95 %		0.2117	0.5552	$0.0000^{***}$	0.7254	0.1613	0.4588	$0.0000^{***}$	0.6047	
<b>One-sided Dependent on XaR One-sided Dependent on XaR</b> 0.0622*         0.9621         0.7450         NaN         0.7450         0.7000         0.7450         0.7000         0.7450         0.7000         0.7450         0.7000         0.7470         0.7470         0.7470 <t< td=""><td>% 66</td><td></td><td>0.0533*</td><td>0.2752</td><td><math>0.0225^{**}</math></td><td>0.3508</td><td><math>0.0312^{**}</math></td><td>0.1743</td><td><math>0.0248^{**}</math></td><td>0.1799</td></t<>	% 66		0.0533*	0.2752	$0.0225^{**}$	0.3508	$0.0312^{**}$	0.1743	$0.0248^{**}$	0.1799	
0.062* $0.961$ $0.7450$ $NaN$ $0.7450$ $0.7000$ $0.7000$ $0.7000$ $0.9381$ $0.00247*$ $0.00000$ $0.0000$ $0.00000$ $0.00000$ $0.00000$ $0.00000$ $0.00000$ $0.00000$ $0.00000$ $0.00000$ $0.00000$ $0.00000$ $0.00000$ $0.00000$ $0.00000$ $0.00000$ $0.000000$ $0.000000$ $0.000000$ $0.000000$ $0.0000000$ $0.00000000000000000000000000000000000$					One-	sided Dependent on	VaR				
0.1654 $0.9378$ $0.9886$ $1.0000$ $0.9900$ $0.8201$ $0.947$ $1.0000$ $1.0000$ $0.2591$ $0.9481$ $0.9481$ $0.9866$ $1.0000$ $1.0000$ $0.9381$ $0.9986$ $1.0000$ $1.0000$ $0.5381$ $0.0481$ $0.9481$ $0.9386$ $1.0000$ $0.9381$ $0.9986$ $1.0000$ $1.0000$ $0.5371$ $0.0453*$ $0.3407$ $0.9999$ $0.3715$ $0.0724*$ $0.2176$ $1.0000$ $0.1797$ $0.0453*$ $0.2307$ $0.9993$ $0.2750$ $0.0278*$ $0.1568$ $0.0983$ $0.1797$ $0.0453*$ $0.2307$ $0.9993$ $0.2750$ $0.0278*$ $0.1668$ $0.9983$ $0.1797$ $0.0453*$ $0.2307$ $0.9983$ $0.2750$ $0.026*$ $0.9983$ $0.9983$ $0.0630*$ $0.9210$ $0.9992$ $0.9983$ $0.2760$ $0.056*$ $0.9983$ $0.9983$ $0.0630*$ $0.9992$ $0.9983$ $0.9983$ $0.9647$ $0.9992$ $0.9983$ $0.0630*$ $0.9982$ $0.9983$ $0.9873$ $0.9976$ $0.9988$ $0.9988$ $0.0638*$ $0.9990$ $0.9983$ $0.9987$ $0.9992$ $0.9992$ $0.9988$ $0.9988$ $0.0688*$ $0.9980$ $0.9983$ $0.9983$ $0.9976$ $0.9988$ $0.9988$ $0.0688*$ $0.9980$ $0.9983$ $0.9972$ $0.9992$ $0.9992$ $0.0000$ $0.0688*$ $0.9980$ $0.9983$ $0.9923$ $0.9961$ $0.0000$ $0.0000$ $0.$	1 %		0.9621	0.7450		0.7450		0.7450	0.7450	0.7450	
0.2591 $0.9481$ $0.9986$ $1.0000$ $1.0000$ $0.9381$ $0.9986$ $1.0000$ $1.0000$ $0.6381$ $0.0709*$ $0.3451$ $1.0000$ $0.4613$ $0.0724*$ $0.2176$ $1.0000$ $1.0000$ $0.1535$ $0.074*$ $0.3407$ $0.3407$ $0.9999$ $0.3715$ $0.0724*$ $0.2176$ $1.0000$ $1.0000$ $0.1535$ $0.0247*$ $0.3407$ $0.9999$ $0.3715$ $0.0724*$ $0.1568$ $1.0000$ $1.0000$ $0.1797$ $0.0453*$ $0.2307$ $0.9983$ $0.2750$ $0.0756*$ $0.1655$ $0.9983$ $0.9983$ $0.1797$ $0.0256*$ $0.0256*$ $0.1655$ $0.9983$ $0.9983$ $0.9647$ $0.9983$ $0.9983$ $0.053*$ $0.9210$ $0.9922$ $0.9983$ $0.9833$ $0.9647$ $0.9976$ $0.9983$ $0.9983$ $0.058*$ $0.9986$ $0.9988$ $0.9883$ $0.9893$ $0.9647$ $0.9976$ $0.9988$ $0.9988$ $0.0688*$ $0.9990$ $0.9991$ $0.9923$ $0.9992$ $0.9992$ $0.9992$ $0.9992$ $0.9988$ $0.688*$ $0.9986$ $0.9991$ $0.9923$ $0.9992$ $0.9992$ $0.9988$ $0.9988$ $0.9933$ $0.9992$ $0.0991$ $0.9992$ $0.6845$ $0.1509$ $0.2060$ $0.0000$ $0.9923$ $0.9992$ $0.9992$ $0.0000$ $0.0000$ $0.3373$ $0.0680*$ $0.2486$ $0.0000$ $0.3387$ $0.0447**$ $0.1980$ $0.0900$ $0.9856$ $0.9856$	5 %		0.9378	0.9886	1.0000	0.9990	0.8201	0.9947	1.0000	0.9992	
$0.6381$ $0.0709^{*}$ $0.3451$ $1.0000$ $0.4613$ $0.0724^{*}$ $0.2176$ $1.0000$ $1.0000$ $0.1535$ $0.0247^{**}$ $0.3407$ $0.9999$ $0.3715$ $0.0724^{**}$ $0.1568$ $1.0000$ $1.0000$ $0.1757$ $0.0278^{**}$ $0.1568$ $0.1000$ $1.0000$ $0.9833$ $0.2750$ $0.0278^{**}$ $0.1658$ $0.9983$ $0.1797$ $0.0457^{**}$ $0.2307$ $0.9983$ $0.2750$ $0.0256^{**}$ $0.1658$ $0.9983$ $0.9983$ $0.0630^{**}$ $0.9210$ $0.9922$ $0.9988$ $0.9893$ $0.9647$ $0.9766$ $0.9988$ $0.9983$ $0.0537^{**}$ $0.9910$ $0.9647$ $0.9976$ $0.9988$ $0.9983$ $0.9976$ $0.9988$ $0.9988$ $0.0688^{**}$ $0.9982$ $0.9883$ $0.9893$ $0.9647$ $0.9976$ $0.9988$ $0.9988$ $0.0688^{**}$ $0.9992$ $0.9983$ $0.9961$ $0.9992$ $0.9988$ $0.9988$ $0.9992$ $0.9992$ $0.9992$ $0.9992$ $0.0688^{**}$ $0.9986$ $0.9883$ $0.9961$ $0.9992$ $0.9992$ $0.9992$ $0.9992$ $0.9992$ $0.9992$ $0.0000$ $0.6945$ $0.1509$ $0.2266$ $0.0991$ $0.9923$ $0.9961$ $0.0000$ $0.0000$ $0.9933$ $0.9961$ $0.0000$ $0.0000$ $0.0580^{**}$ $0.0680^{**}$ $0.22486$ $0.0991$ $0.9923$ $0.9961$ $0.0000$ $0.0000$ $0.0984$ $0.0984$ $0.0986$ $0.0986$ $0.0984$ <td>10 %</td> <td></td> <td>0.9481</td> <td>0.9986</td> <td>1.0000</td> <td>1.0000</td> <td>0.9381</td> <td>0.9986</td> <td>1.0000</td> <td>0.9999</td>	10 %		0.9481	0.9986	1.0000	1.0000	0.9381	0.9986	1.0000	0.9999	
0.1535 $0.0247**$ $0.3407$ $0.9999$ $0.3715$ $0.0278**$ $0.1568$ $1.0000$ $1.0000$ $0.1797$ $0.0453**$ $0.2307$ $0.9983$ $0.2750$ $0.0256**$ $0.1655$ $0.9983$ $0.9983$ $0.175$ $0.0453*$ $0.2307$ $0.9983$ $0.2750$ $0.056*$ $0.9983$ $0.9983$ $0.0630*$ $0.9210$ $0.9992$ $0.9988$ $0.9893$ $0.9647$ $0.9976$ $0.9988$ $0.9988$ $0.9976$ $0.9988$ $0.9988$ $0.9976$ $0.9988$ $0.9988$ $0.99976$ $0.9988$ $0.9988$ $0.99961$ $0.9988$ $0.99961$ $0.9988$ $0.9998$ $0.09988$ $0.99961$ $0.0998$ $0.09988$ $0.99961$ $0.0998$ $0.0000$ $0.99961$ $0.0000$ $0.09988$ $0.09988$ $0.09988$ $0.09988$ $0.09988$ $0.0000$ $0.09988$ $0.09988$ $0.00000$ $0.09988$ $0.09988$ $0.09988$ $0.00000$ $0.09988$ $0.00000$ $0.09886$ $0.09986$	90 %		0.0709*	0.3451	1.0000	0.4613	0.0724*	0.2176	1.0000	0.3161	
0.1797 $0.0453*$ $0.2307$ $0.983$ $0.2750$ $0.026*$ $0.1655$ $0.9833$ $0.9833$ $0.9833$ $0.9637$ $0.9933$ $0.9936$ $0.9938$ $0.9976$ $0.9988$ $0.9976$ $0.9988$ $0.9647$ $0.9976$ $0.9988$ $0.9647$ $0.9976$ $0.9883$ $0.06373*$ $0.9976$ $0.9988$ $0.9976$ $0.9988$ $0.9647$ $0.9976$ $0.9988$ $0.9647$ $0.9976$ $0.9988$ $0.9983$ $0.9976$ $0.9988$ $0.9983$	95 %		0.0247**	0.3407	0.9999	0.3715	0.0278**	0.1568	1.0000	0.2310	
One-sided Independent of VaR $0.0630^{*}$ $0.9210$ $0.9992$ $0.9888$ $0.9893$ $0.976$ $0.9888$ $0.976$ $0.9888$ $0.975$ $0.9976$ $0.9888$ $0.975$ $0.9976$ $0.9888$ $0.9647$ $0.9976$ $0.9888$ $0.9688^{*}$ $0.9976$ $0.9888$ $0.9976$ $0.9888$ $0.0000$ $0.9976$ $0.9988$ $0.0000$ $0.9975$ $0.9988$ $0.9986$ $0.9988$ $0.9987$ $0.9992$ $0.0988$ $0.09923$ $0.9992$ $0.0000$ $0.99923$ $0.09921$ $0.0000$ $0.00961$ $0.0000$ $0.0000$ $0.0000$ $0.0000$ $0.0000$ $0.0000$ $0.0000$ $0.0000$ $0.0000$ $0.0000$ $0.0000$ $0.0000$ $0.0000$ $0.0000$ $0.0875^{*}$ $0.0856$ $0.0856$	% 66		0.0453**	0.2307	0.9983	0.2750	$0.0256^{**}$	0.1655	0.9983	0.2039	
0.0630*         0.9210         0.9992         0.9883         0.9647         0.976         0.988         0.9976         0.988         0.988         0.988         0.988         0.9976         0.9988         0.9988         0.9988         0.9976         0.9988         0.9988         0.9976         0.9988         0.9988         0.9976         0.9988         0.9983         0.9983         0.9983         0.9983         0.9983         0.9983         0.9983         0.9983         0.9983         0.9983         0.9983         0.9983         0.9983         0.9983         0.9983         0.9983         0.9984         0.9983         0.9984         0.9984         0.9983         0.9984         0.9983					One-s	ided Independent of	f VaR				
0.0373**         0.9862         0.9985         1.0000         1.0000         0.9873         0.9992         1.0000         1.0000           0.0688*         0.9900         0.9953         1.0000         0.9911         0.9923         1.0000         1.0000           0.6945         0.1509         0.2060         1.0000         0.3046         0.1406         0.2049         1.0000         1.0000           0.6313         0.0680*         0.2486         1.0000         0.3387         0.0447**         0.1980         1.0000	1 %		0.9210	0.9992	0.9988	0.9893	0.9647	0.9976	0.9988	0.9904	
0.0688*         0.9900         0.9953         1.0000         0.9991         0.9233         0.9661         1.0000         1.0000           0.6945         0.1509         0.2060         1.0000         0.3046         0.1406         0.2049         1.0000         1.0000           0.3373         0.0680*         0.2486         1.0000         0.3387         0.0447**         0.1980         1.0000         1.0000           0.1068         0.0354**         0.1604         0.9879         0.1967         0.0875*         0.9856         1	5 %		0.9862	0.9985	1.0000	1.0000	0.9873	0.9992	1.0000	0.9999	
0.6945         0.1509         0.2060         1.0000         0.3046         0.1406         0.2049         1.0000         1.0000           0.3373         0.0680*         0.2486         1.0000         0.3387         0.0447**         0.1980         1.0000 <td>10 %</td> <td></td> <td>0.9900</td> <td>0.9953</td> <td>1.0000</td> <td>0.9991</td> <td>0.9923</td> <td>0.9961</td> <td>1.0000</td> <td>0.9995</td>	10 %		0.9900	0.9953	1.0000	0.9991	0.9923	0.9961	1.0000	0.9995	
0.3373         0.0680*         0.2486         1.0000         0.3387         0.0447**         0.1980         1.0000           0.1068         0.0354**         0.1604         0.9879         0.1967         0.009***         0.9875*         0.9856	06 %		0.1509	0.2060	1.0000	0.3046	0.1406	0.2049	1.0000	0.2992	
0.1068 0.0354** 0.1604 0.9879 0.1967 0.009*** 0.0875* 0.9856 0.0000	95 %		0.0680*	0.2486	1.0000	0.3387	$0.0447^{**}$	0.1980	1.0000	0.2735	
	% 66		$0.0354^{**}$	0.1604	0.9879	0.1967	***6600.0	0.0875*	0.9856	0.0875*	

Table E24: ES test results for natural gas futures on NYMEX

Quantife     EWQR     Garci       1 %     0.6172     0       5 %     0.6942     0       90 %     0.6942     0       90 %     0.6942     0       90 %     0.9820     0       97 %     0.3715     0       99 %     0.5046     0       1 %     0.5367     0       90 %     0.5367     0       90 %     0.5367     0       90 %     0.5367     0       90 %     0.7522     0       91 %     0.7522     0       92 %     0.1479     0       93 %     0.2972     0       90 %     0.2972     0       90 %     0.2972     0       90 %     0.2550     0	Garch Normal 0.2646 0.8017 0.9186 0.6583 0.5046 0.5046	Garch Student t 0.5046 0.2829 0.3185 0.3185 0.0758* 0.0879* 0.5046	Garch GED	Garch Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
0.6172 0.6942 0.0281** 0.0281** 0.0281** 0.03820 0.3715 0.5367 0.5367 0.0356** 0.0149** 0.1479 0.1479 0.1479 0.1479 0.1479 0.07566 0.2550 0.07566 0.02550 0.255 0.255 0.255 0.255 0.255 0.255 0.255 0.255 0.255 0.255 0.255 0.255 0.255 0.25 0.2	).2646 ).8017 ).9186 ).6583 ).3148 ).3148	0.5046 0.2829 0.3185 0.0758* 0.0879* 0.5046						
0.6172 0.6942 0.6942 0.6942 0.9820 0.9820 0.3715 0.3715 0.3715 0.3715 0.3715 0.3715 0.3756* 0.0149** 0.0149** 0.0149** 0.0149** 0.0149** 0.0149* 0.01479 0.7522 0.2992 0.2992 0.2952 0.2952 0.2952 0.2952 0.2550 0.255 0.	).2646 ).8017 ).9186 ).9186 ).6583 ).3148 ).3148	0.5046 0.2829 0.3185 0.0758* 0.0758* 0.0879*	Two-s	<b>Fwo-sided Dependent on VaR</b>	VaR			
0.6942 0.09820 0.9820 0.9820 0.3715 0.3715 0.3715 0.3715 0.3715 0.3715 0.3567 0.0356** 0.0149** 0.1479 0.1479 0.1479 0.7522 0.2972 0.2972 0.2922 0.37666 0.0.4651 0.37566 0.0.2550 0.255 0.25 0.2	).8017 ).9186 ).6583 ).3148 ).5046	0.2829 0.3185 0.0758* 0.0879* 0.5046	0.5046	0.5046	0.6200	0.5046	0.5046	0.5046
0.0281**           0.9820           0.3715           0.3715           0.3715           0.3715           0.3715           0.3715           0.3715           0.3715           0.5367           0.5367           0.5367           0.0356**           0.0149**           0.1479           0.1479           0.7522           0.2972           0.2972           0.2972           0.2550           0.2550	0.9186 0.6583 0.3148 0.5046	0.3185 0.0758* 0.0879* 0.08746	$0.0000^{***}$	0.0229**	0.9507	0.1600	$0.000^{***}$	$0.0433^{**}$
0.9820 0.3715 0.3715 0.5046 0.5367 0.5367 0.0366** 0.0356** 0.0149** 0.1479 0.1479 0.1479 0.7522 0.7522 0.2972 0.2972 0.2952 0.2952 0.2550 0.2550 0.2550 0.2550	).6583 ).3148 ).5046	0.0758* 0.0879* 0.5046	$0.0000^{***}$	0.2906	0.7459	0.3464	$0.0000^{***}$	0.1925
0.3715 0.5046 0.5046 0.5367 0.0090*** 0.0356** 0.0356** 0.0479 0.1479 0.1479 0.1479 0.1479 0.2522 0.2972 0.2972 0.2972 0.2972 0.2550 0.2550	).3148 ).5046	0.0879* 0 5046	$0.0000^{***}$	0.2015	0.5942	0.1096	$0.0000^{***}$	0.2952
0.5046 0.5367 0.090%*** 0.0356** 0.0356** 0.0149** 0.1479 0.1479 0.1479 0.7522 0.2972 0.2922 0.2972 0.2950 0.9770 0.4651 0.2550 0.2550 0.2550	).5046	0 5046	$0.0000^{***}$	0.1518	0.4243	0.0928*	$0.0000^{***}$	0.2820
0.5367 0.0090**** 0.0356** 0.0149** 0.1479 0.7522 0.7522 0.2972 0.2972 0.2972 0.2666 0.4651 0.7666 0.2550			0.5046	0.5046	0.5046	0.5046	0.5046	0.5046
0.5367 0.0090*** 0.0356** 0.1479 0.1479 0.7522 0.7522 0.2972 0.2922 0.2972 0.2950 0.4651 0.4651 0.2550			Two-si	<b>Two-sided Independent of VaR</b>	f VaR			
0.0090*** 0.0356** 0.0356** 0.1479 0.1479 0.7522 0.7522 0.2972 0.2922 0.9770 0.4651 0.7566 0.2550 0.2550	0.1666	0.0372**	$0.0017^{***}$	0.0753*	0.3084	0.033	$0.0017^{***}$	0.0355**
0.0356**           0.0149**           0.11479           0.1479           0.7522           0.7522           0.7522           0.7522           0.7522           0.7522           0.7522           0.7522           0.7556           0.75550	0.0251**	$0.0020^{***}$	$0.0000^{***}$	0.6220	$0.0336^{**}$	0.0042***	$0.0000^{***}$	0.4205
0.0149** 0.1479 0.1479 0.7522 0.7522 0.2972 0.2922 0.9770 0.4651 0.7566 0.2550 0.2550	$0.004^{***}$	0.0009***	$0.0000^{***}$	0.1368	$0.0055^{***}$	0.0031***	$0.0000^{***}$	0.1802
0.1479 0.7522 0.7522 0.2972 0.2922 0.9770 0.4651 0.4651 0.7566 0.2550	0.3693	0.1496	$0.0000^{***}$	0.5593	0.3164	0.1348	$0.0000^{***}$	0.5390
0.7522 0.2972 0.2992 0.9770 0.4651 0.7566 0.2550	0.3504	$0.0731^{*}$	$0.0000^{***}$	0.2156	0.3022	0.0781*	$0.0000^{***}$	0.2357
0.2972 0.2992 0.9770 0.4651 0.7566 0.2550	0.4726	0.0887*	$0.0134^{**}$	0.1323	0.4627	0.0935*	$0.0122^{**}$	0.2641
0.2972 0.2992 0.9770 0.4651 0.7566 0.2550			One-s	<b>One-sided Dependent on VaR</b>	VaR			
0.2992 0.9770 0.4651 0.7566 0.2550	0.8130	0.7450	0.745	0.2550	0.6903	0.7504	0.7504	0.2550
0.9770 0.4651 0.7566 0.2550	0.3860	0.8270	1.0000	$0.0014^{***}$	0.5051	0.8846	1.0000	$0.0029^{***}$
0.4651 0.7566 0.2550	0.4473	0.8260	1.0000	0.1275	0.3603	0.8051	1.0000	0.0731*
0.7566 0.2550	0.6560	0.9429	1.0000	0.8779	0.6796	0.9204	1.0000	0.8203
0.2550	0.7907	0.9149	1.0000	0.8752	0.7353	0.9087	1.0000	0.7963
	0.2550	0.7504	0.7504	0.2550	0.2550	0.2550	0.7504	0.2550
			One-si	<b>One-sided Independent of VaR</b>	f VaR			
1 % 0.2660 0.	0.9446	0.9984	0.9995	0.0659*	0.8546	0.9856	0.9997	$0.0146^{**}$
5 % 0.9910 0.	0.9807	0.9980	1.0000	0.2996	0.9725	0.9958	1.0000	0.1878
10 % 0.9693 0.	0.9961	0.9991	1.0000	0.9177	0.9952	0.9969	1.0000	0.8907
90 % 0.986 0.	0.7935	0.9044	1.0000	0.7028	0.8173	0.9093	1.0000	0.7100
95 % 0.870 0.	0.7751	0.9273	1.0000	0.8419	0.7987	0.9227	1.0000	0.8317
99 % 0.3366 0.	0.7338	0.9228	0.9871	0.9228	0.7417	0.9214	0.9883	0.7906

Table E25: ES test results for brent crude oil futures on ICE

	Garch Normal 0.7190							
	0.7190	Garch Student t	Garch GED	Garch Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
	0.7190		Two-	<b>Two-sided Dependent on VaR</b>	VaR			
		0.1111	0.1111	0.5046	0.5908	0.3357	0.0151**	0.5046
	0.2116	0.0316**	$0.0000^{***}$	$0.0417^{**}$	0.5617	0.0259**	$0.000^{***}$	$0.0318^{**}$
	0.9993	0.0278**	$0.0000^{***}$	0.5618	0.9687	0.2166	$0.000^{***}$	0.3137
	0.3978	0.1272	$0.0000^{***}$	0.1743	0.2575	0.0676*	$0.000^{***}$	0.1147
	0.6296	0.9253	0.0225**	0.9002	0.6438	0.7258	0.0292**	0.9416
	0.5591	0.5046	0.5046	0.5591	0.5591	NaN	NaN	0.5046
			Two-s	<b>Two-sided Independent of VaR</b>	f VaR			
	0.3397	0.0078***	$0.0082^{***}$	0.0738*	0.7870	$0.0127^{**}$	0.0115**	0.0227**
	0.1360	$0.0058^{***}$	$0.0000^{***}$	0.3217	0.2323	$0.0108^{**}$	$0.000^{***}$	0.2317
	0.1192	0.0123**	$0.0000^{***}$	0.6027	0.1821	0.0172**	$0.000^{***}$	0.7333
	0.1323	0.0600*	$0.0000^{***}$	0.1250	0.0963*	0.0527*	$0.0000^{***}$	0.1116
	0.2466	0.1303	$0.0005^{***}$	0.2004	0.2268	0.1183	$0.0000^{***}$	0.1819
	0.8058	0.5799	0.0800*	0.6650	0.8844	0.5244	$0.0814^{*}$	0.5982
			One-s	<b>One-sided Dependent on VaR</b>	VaR			
	0.6592	0.9275	0.9654	0.2550	0.3192	0.7029	0.9918	0.2550
186/.0 0% C	0.8583	0.9706	1.0000	$0.0052^{***}$	0.6964	0.9757	1.0000	$0.0032^{***}$
10 % 0.8355	0.4908	0.9760	1.0000	0.2650	0.4722	0.8689	1.0000	0.1345
90 % 0.6413	0.7110	0.8735	1.0000	0.8319	0.7682	0.9324	1.0000	0.8857
95 % 0.3899	0.2531	0.4018	0.9775	0.3951	0.2709	0.5870	0.9708	0.4145
99 % 0.2550	0.2606	0.2550	0.7504	0.2606	0.2606	NaN	NaN	0.2550
			One-si	<b>One-sided Independent of VaR</b>	f VaR			
1 % 0.9735	0.8693	0.9979	0.9988	$0.0676^{*}$	0.6332	0.9932	0.9989	$0.0174^{**}$
5 % 0.9868	0.8940	0.9942	1.0000	0.1400	0.8384	0.9894	1.0000	0.0893*
10 % 0.9982	0.9125	0.9884	1.0000	0.6762	0.8787	0.9843	1.0000	0.6192
90 % 0.9520	0.8739	0.9400	1.0000	0.8818	0.9054	0.9474	1.0000	0.8906
95 % 0.7760	0.7668	0.8698	0.9995	0.8060	0.7761	0.8817	1.0000	0.8187
99 % 0.2796	0.3639	0.6635	0.9207	0.6372	0.5192	0.6635	0.9191	0.6619

Table E26: ES test results for light crude oil futures on NYMEX

$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$						Gasoline - NYMEX				
Two-sided Dependent on YaR           Two-sided Dependent on YaR $0.4373$ $0.2474$ $0.7725$ $0.0075^{$	Quantile	EWQR	Garch Normal	Garch Student t	Garch GED	Garch Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
0.9580         0.2434         0.7725         0.000***         0.1004         0.000***         0.					Two-	sided Dependent on	VaR			
$0.413$ $0.2440$ $0.3643$ $0.000^{***}$	1 %		0.2474	0.7725	0.0017***	0.1004	0.1520	0.2161	$0.0017^{***}$	0.0122**
$0.236$ $0.1919$ $0.4009$ $0.000 \text{cm}$ $0.1331$ $0.2053$ $0.0000 \text{cm}$ $0.0000 \text{cm}$ $0.2113$ $0.0653^{\circ}$ $0.0007^{\circ}$ $0.4027$ $0.0362^{\circ}$ $0.0000 \text{cm}$ $0.0000 \text{cm}$ $0.2143$ $0.4965$ $0.0007^{\circ}$ $0.5779$ $0.5862$ $0.0000^{\circ}$ $0.5046$ <td>5 %</td> <td></td> <td>0.2240</td> <td>0.3643</td> <td><math>0.0000^{***}</math></td> <td><math>0.0003^{***}</math></td> <td>0.2853</td> <td>0.3915</td> <td><math>0.000^{***}</math></td> <td><math>0.0021^{***}</math></td>	5 %		0.2240	0.3643	$0.0000^{***}$	$0.0003^{***}$	0.2853	0.3915	$0.000^{***}$	$0.0021^{***}$
	10 %		0.1919	0.4009	$0.0000^{***}$	0.0031***	0.1383	0.2161	$0.000^{***}$	$0.0023^{***}$
09241         0.4969         0.2659         0.000***         0.2105         0.1653         0.016**         0.000***           0.8779         0.8495         Nax         Nax         0.5779         0.5046         0.5046         0.5046         0.5046           0.7751         0.2445         0.7113         0.017***         0.0197**         0.7139         0.5046         0.5046         0.5046           0.7251         0.0487         0.713         0.0197**         0.1469         0.5379         0.000***           0.7251         0.04876         0.1617         0.000***         0.01599         0.5179         0.000***           0.0357*         0.3048         0.2049         0.1617         0.000***         0.1590         0.000***           0.0357*         0.3047         0.0278**         0.000***         0.1590         0.1466         0.000***           0.935*         0.3017         0.2371         0.0189*         0.1466         0.1466         0.000***           0.935*         0.3017         0.2374         0.0186*         0.1466         0.1466         0.000***           0.9313         0.3017         0.2371         0.1266         0.1466         0.1466         0.000***           0	% 06		0.0652*	0.0362**	$0.0000^{***}$	0.4027	0.0635*	0.0242**	$0.000^{***}$	0.1025
$0.8797$ $0.5395$ NaN         NaN $0.5779$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.5046$ $0.000^{***}$ $0.01751$ $0.0436$ $0.000^{***}$ <td>95 %</td> <td></td> <td>0.4969</td> <td>0.2659</td> <td><math>0.0000^{***}</math></td> <td>0.3201</td> <td>0.5862</td> <td>0.1763</td> <td><math>0.0000^{***}</math></td> <td>0.3661</td>	95 %		0.4969	0.2659	$0.0000^{***}$	0.3201	0.5862	0.1763	$0.0000^{***}$	0.3661
Two-sided Independent of VaR           0.0445         0.01713         0.0007***         0.0175**         0.0175**         0.0175**         0.0175**         0.0175**         0.0175**         0.0107***         0.0107***         0.0107***         0.0107***         0.0107***         0.0107***         0.0107***         0.0107***         0.0107***         0.0107***         0.0107***         0.01007***         0.01007***         0.01007***         0.0000***         0.0000***         0.01007***         0.01007***         0.01007***         0.01007***         0.01007***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0000***         0.0106***         0.0106***         0.0106***         0.0000***         0.0106***         0.0106***         0.0106***         0.0106***         0.0106***         0.0106***         0.0106***         0.0106***         0.0106***         0.0106**         0.0106**	% 66		0.5495	NaN	NaN	0.5779	0.5046	0.5046	0.5046	0.5046
$0.4456$ $0.2445$ $0.7713$ $0.001^{***}$ $0.0197^{**}$ $0.1469$ $0.2380$ $0.000^{***}$ $0.010^{***}$ $0.000^{***}$ $0.010^{***}$ $0.010^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.000^{***}$ $0.010^{***}$ $0.010^{***}$ $0.010^{***}$ $0.010^{***}$ $0.010^{***}$ $0.010^{***}$ $0.010^{***}$ $0.010^{***}$ $0.010^{***}$ $0.010^{***}$					Two-s	ided Independent of	f VaR			
$0.7251$ $0.6487$ $0.3908$ $0.000^{\text{mes}}$ $0.0637^{\text{mes}}$ $0.0637^{\text{mes}}$ $0.000^{\text{mes}}$ $0.01248$ $0.000^{\text{mes}}$ $0.0174^{\text{mes}}$ $0.000^{\text{mes}}$ $0.0114^{\text{mes}}$ $0.000^{\text{mes}}$ $0.000^{\text$	1 %		0.2445	0.7713	0.0017***	0.0197**	0.1469	0.2380	$0.0017^{***}$	0.0017***
0.093* $0.2046$ $0.1617$ $0.003*$ $0.1569$ $0.1348$ $0.000**$ $0.000**$ $0.1012$ $0.0395*$ $0.0284*$ $0.000**$ $0.4172$ $0.015**$ $0.000***$ $0.000***$ $0.1012$ $0.0395*$ $0.0278*$ $0.000***$	5 %		0.6487	0.3908	$0.0000^{***}$	0.0002***	0.7439	0.5571	$0.0000^{***}$	$0.0001^{***}$
0.1012 $0.035**$ $0.0284*$ $0.006***$ $0.017*$ $0.016**$ $0.006***$ $0.006***$ $0.006***$ $0.006***$ $0.006***$ $0.006***$ $0.006***$ $0.006***$ $0.006***$ $0.006***$ $0.006***$ $0.006***$ $0.0174*$ $0.000***$ $0.000***$ $0.0017**$ $0.000***$ $0.000***$ $0.0174*$ $0.000***$ $0.000***$ $0.0174*$ $0.000***$ $0.000***$ $0.0174*$ $0.000***$ $0.000***$ $0.0174*$ $0.000***$ $0.000***$ $0.0117*$ $0.010***$ $0.000***$ $0.0117*$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.0995$ $0.010***$ $0.010***$ $0.010***$ $0.0995$ $0.010***$ $0.010***$ $0.0995$ $0.010***$ $0.010***$ $0.0995$ $0.010***$ $0.010***$ $0.0995$ $0.010***$ $0.0995$ $0.010***$ $0.0995$ $0.010***$ $0.0995$ $0.010***$ $0.0995$ $0.010***$ $0.0995$ $0.010***$ $0.0995$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.0995$ $0.010***$ $0.0995$ $0.010***$ $0.010***$ $0.010***$ $0.0995$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$ $0.010***$	10 %		0.2046	0.1617	$0.0000^{***}$	0.0653*	0.1569	0.1348	$0.0000^{***}$	0.1041
$0.028*$ $0.049^{**}$ $0.0278*$ $0.007*$ $0.017^{**}$ $0.017^{**}$ $0.017^{**}$ $0.000^{***}$ $0.9133$ $0.3617$ $0.2971$ $0.2971$ $0.0278*$ $0.0132*$ $0.0114^{**}$ $0.0017^{**}$ $0.000^{***}$ $0.9133$ $0.3617$ $0.2971$ $0.2971$ $0.017^{**}$ $0.0108^{**}$ $0.0108^{**}$ $0.0108^{**}$ $0.0108^{**}$ $0.0108^{**}$ $0.0108^{**}$ $0.0108^{**}$ $0.0108^{**}$ $0.0108^{**}$ $0.0108^{**}$ $0.0108^{**}$ $0.0008^{**}$ $0.0147^{**}$ $0.0992^{**}$ $0.0992^{**}$ $0.0907^{**}$ $0.9992^{**}$ $0.0907^{**}$ $0.9992^{**}$ $0.0907^{**}$ $0.0900^{**}$ $0.0900^{**}$ $0.0745^{*}$ $0.0900^{**}$ $0.0246^{**}$ $0.017^{**}$ $0.0900^{**}$ $0.0745^{*}$ $0.000^{**}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$ $0.0745^{*}$	% 06		0.0395**	0.0284**	$0.0000^{***}$	0.4172	$0.0189^{**}$	0.0162**	$0.000^{***}$	0.2980
0.9133 $0.3617$ $0.2971$ $0.0017$ *** $0.4953$ $0.4953$ $0.4953$ $0.2406$ $0.2126$ $0.010$ *** $1.000$ $A876$ $0.1373$ $0.3292$ $0.3995$ $0.0387$ ** $0.0147$ ** $0.033$ *** $0.9992$ $1.0000$ $0.4876$ $0.1373$ $0.3928$ $0.9995$ $0.0387$ ** $0.0147$ ** $0.9992$ $1.0000$ $0.4876$ $0.1373$ $0.5909$ $1.0000$ $0.000$ *** $0.1196$ $0.1766$ $1.0000$ $1.0000$ $0.6721$ $0.0682$ * $0.1757$ $1.0000$ $0.000$ *** $0.1196$ $0.1766$ $1.0000$ $1.0000$ $0.6721$ $0.0682$ * $0.1757$ $0.1049$ ** $0.1766$ $1.0000$ $1.0000$ $1.0000$ $0.6721$ $0.0682$ * $0.1767$ $0.0307$ ** $0.9444$ $0.9781$ $1.0000$ $1.0000$ $0.4250$ $0.71130$ $0.8220$ $0.0449$ ** $0.2494$ $0.7857$ $1.0000$ $1.0000$ $0.4250$ $0.71130$ $0.8220$ $0.0904$ $0.6539$ $0.745$ $1.0000$ $0.775$ $0.1258$ $0.7126$ $0.02494$ $0.6539$ $0.745$ $0.775$ $1.0000$ $0.1533$ $0.6888$ $0.3920$ $0.9924$ $0.0316$ ** $0.0316$ ** $0.775$ $0.775$ $0.1558$ $0.9926$ $0.9946$ $0.0716$ ** $0.0716$ ** $0.7926$ $0.7992$ $0.7926$ $0.1658$ $0.9226$ $0.9946$ $0.0916$ ** $0.9046$ $0.9168$ $0.7926$ $0.9992$ $0.1659$ $0.9216$ </td <td>95 %</td> <td></td> <td>0.0492**</td> <td>0.0278**</td> <td><math>0.0000^{***}</math></td> <td>0.2875</td> <td><math>0.0328^{**}</math></td> <td>0.0174**</td> <td><math>0.0000^{***}</math></td> <td>0.2756</td>	95 %		0.0492**	0.0278**	$0.0000^{***}$	0.2875	$0.0328^{**}$	0.0174**	$0.0000^{***}$	0.2756
<b>One-sided Dependent on YaR</b> $0.4876$ $0.1373$ $0.3928$ $0.9955$ $0.0387*$ $0.0147*$ $0.033**$ $0.9992$ $0$ $0.4876$ $0.1373$ $0.3928$ $0.9955$ $0.0387*$ $0.033**$ $0.9992$ $0$ $0.2488$ $0.0851*$ $0.1570$ $1.0000$ $0.000***$ $0.01196$ $0.1766$ $1.0000$ $0.6721$ $0.987*$ $0.1757$ $1.0000$ $0.000***$ $0.0449*$ $0.9781$ $1.0000$ $0.6721$ $0.9471$ $0.9677$ $1.0000$ $0.0449*$ $0.9781$ $1.0000$ $0.0000**$ $0.6720$ $0.7130$ $0.8220$ $1.0000$ $0.8004$ $0.6559$ $0.9781$ $1.0000$ $0.745$ $0.7130$ $0.7130$ $0.8220$ $1.0000$ $0.8004$ $0.6559$ $0.745$ $1.0000$ $0.73350$ $0.7130$ $0.8220$ $1.0000$ $0.6839$ $0.2496$ $0.745$ $1.0000$ $0.73350$ $0.7130$ $0.3228$ $0.9922$ $0.007**$ $0.7455$ $0.745$ $0.745$ $0.1558$ $0.1373$ $0.3228$ $0.9922$ $0.000**$ $0.0316*$ $0.717*$ $0.9995$ $0.1558$ $0.1373$ $0.7822$ $0.9920$ $0.000**$ $0.016*$ $0.717*$ $0.9995$ $0.9529$ $0.9641$ $0.9720$ $0.000**$ $0.016*$ $0.017*$ $0.9995$ $0.9995$ $0.9529$ $0.9641$ $0.9724$ $0.0916*$ $0.9158$ $0.0995$ $0.09046$ $0.9926$ $0.0996$ $0.9513$ $0.9724$ <	% 66		0.3617	0.2971	0.0017***	0.4953	0.2406	0.2126	$0.0108^{**}$	0.3830
0.4876 $0.1373$ $0.3928$ $0.995$ $0.0387*$ $0.0147*$ $0.0387*$ $0.992$ $0.992$ $0.992$ $0.2488$ $0.0851*$ $0.1590$ $1.0000$ $0.000$ ** $0.01196$ $0.1766$ $1.0000$ $1.0000$ $0.6721$ $0.082*$ $0.1577$ $1.0000$ $0.000$ ** $0.0149*$ $0.0307*$ $1.0000$ $1.0000$ $0.6721$ $0.0682*$ $0.1757$ $1.0000$ $0.000$ ** $0.0449*$ $0.0807*$ $1.0000$ $0.8550$ $0.9471$ $0.9577$ $1.0000$ $0.000$ ** $0.0449*$ $0.781$ $1.0000$ $0.8550$ $0.7130$ $0.8220$ $1.0000$ $0.8004$ $0.5599$ $0.781$ $1.0000$ $0.7250$ $0.7149$ $0.745$ $1.0000$ $0.745$ $1.0000$ $0.745$ $0.1578$ $0.7049$ $NaN$ $NaN$ $NaN$ $0.6839$ $0.2496$ $0.745$ $1.0000$ $0.1578$ $0.7049$ $NaN$ $NaN$ $NaN$ $0.6839$ $0.745$ $0.745$ $1.0000$ $0.1578$ $0.1373$ $0.3288$ $0.3928$ $0.9922$ $0.007**$ $0.745$ $0.745$ $0.745$ $0.1588$ $0.1373$ $0.7882$ $0.9922$ $0.000**$ $0.016*$ $0.717*$ $0.9955$ $0.9995$ $0.05829$ $0.9920$ $0.900**$ $0.016*$ $0.016*$ $0.016*$ $0.017*$ $0.9995$ $0.9995$ $0.05829$ $0.9920$ $0.000**$ $0.000**$ $0.016*$ $0.016*$ $0.017*$ $0.0995$ $0.9995$ $0$					One-t	sided Dependent on	VaR			
0.2488 $0.0851*$ $0.1590$ $1.0000$ $0.000***$ $0.1166$ $1.0000$ $1.0000$ $0.6721$ $0.0682*$ $0.1757$ $1.0000$ $0.060***$ $0.1765$ $0.1766$ $1.0000$ $1.0000$ $0.6721$ $0.0682*$ $0.1757$ $1.0000$ $0.060***$ $0.0449**$ $0.807*$ $1.0000$ $1.0000$ $0.8962$ $0.9471$ $0.9677$ $1.0000$ $0.7659$ $0.9781$ $1.0000$ $1.0000$ $0.8350$ $0.7130$ $0.8220$ $1.0000$ $0.8004$ $0.6559$ $0.8557$ $1.0000$ $0.4250$ $0.7130$ $0.8220$ $1.0000$ $0.8004$ $0.6559$ $0.745$ $0.745$ $0.4250$ $0.7049$ $0.8220$ $0.9922$ $0.0874$ $0.2496$ $0.745$ $0.745$ $0.1538$ $0.1373$ $0.3228$ $0.9922$ $0.007***$ $0.0316*$ $0.745$ $0.745$ $0.1558$ $0.1373$ $0.3288$ $0.9922$ $0.000***$ $0.0166*$ $0.7768$ $0.7952$ $0.1558$ $0.1379$ $0.7822$ $0.9040$ $0.717*$ $0.9995$ $0.9995$ $0.1259$ $0.8825$ $0.9040$ $0.0216**$ $0.916*$ $0.917*$ $0.9995$ $0.9293$ $0.9641$ $0.9724$ $0.0000***$ $0.9046$ $0.9168$ $0.9844$ $0.0000$ $0.9293$ $0.9916*$ $0.9916*$ $0.9926$ $0.9916*$ $0.9994$ $0.9994$ $0.9994$	1 %		0.1373	0.3928	0.9995	0.0387**	$0.0147^{**}$	$0.0338^{**}$	0.9992	$0.0114^{**}$
0.6721 $0.0682*$ $0.1757$ $1.0000$ $0.0000***$ $0.0449**$ $0.0807*$ $1.0000$ $1.0000$ $0.8962$ $0.9471$ $0.9677$ $1.0000$ $0.7755$ $0.9494$ $0.9781$ $1.0000$ $1.0000$ $0.8350$ $0.7130$ $0.8220$ $1.0000$ $0.7765$ $0.9494$ $0.9781$ $1.0000$ $1.0000$ $0.5350$ $0.7130$ $0.8220$ $1.0000$ $0.8004$ $0.6559$ $0.7857$ $1.0000$ $1.0000$ $0.4250$ $0.7130$ $0.8220$ $1.0000$ $0.8399$ $0.2496$ $0.745$ $0.745$ $0.745$ $0.1558$ $0.1373$ $0.3928$ $0.9992$ $0.0007***$ $0.0316*$ $0.745$ $0.745$ $0.745$ $0.1558$ $0.1373$ $0.3282$ $0.9992$ $0.0007***$ $0.0316*$ $0.745$ $0.9995$ $0.745$ $0.1558$ $0.1373$ $0.7892$ $0.9992$ $0.0007**$ $0.0316*$ $0.776*$ $0.9995$ $0.9995$ $0.1000$ $0.0000**$ $0.0000**$ $0.0316*$ $0.717*$ $0.7995$ $0.9995$ $0.9995$ $0.9293$ $0.9641$ $0.9724$ $0.0000**$ $0.0216**$ $0.9166$ $0.91000$ $0.0995$ $0.9995$ $0.9818$ $0.9529$ $0.9724$ $0.0000$ $0.0216**$ $0.9916$ $0.9926$ $0.0996$ $0.9994$ $0.9994$ $0.9717$ $0.9724$ $0.9990$ $0.9016$ $0.9016$ $0.9916$ $0.9994$ $0.9994$ $0.9994$	5 %		0.0851*	0.1590	1.0000	$0.0000^{***}$	0.1196	0.1766	1.0000	$0.0000^{***}$
0.8962 $0.9471$ $0.9677$ $1.0000$ $0.7765$ $0.9494$ $0.9781$ $1.0000$ $1.0000$ $0.5350$ $0.7130$ $0.8220$ $0.8220$ $1.0000$ $0.8004$ $0.6559$ $0.8557$ $1.0000$ $1.0000$ $0.4250$ $0.7130$ $0.8220$ $1.0000$ $0.8004$ $0.6559$ $0.8557$ $1.0000$ $1.0000$ $0.4250$ $0.7130$ $0.8220$ $1.0000$ $0.6839$ $0.2496$ $0.745$ $0.745$ $0.745$ $0.1578$ $0.1373$ $0.3928$ $0.9922$ $0.0007***$ $0.0316**$ $0.745$ $0.9955$ $0.745$ $0.1558$ $0.1373$ $0.3928$ $0.9922$ $0.0007***$ $0.0316**$ $0.7017*$ $0.9995$ $0.745$ $0.1573$ $0.6688$ $0.7892$ $0.9922$ $0.0007***$ $0.0316**$ $0.7017*$ $0.9995$ $0.9995$ $0.9297$ $0.8825$ $0.9046$ $0.7082$ $0.9168$ $0.7082$ $0.9995$ $0.9995$ $0.9293$ $0.9641$ $0.9724$ $0.0000**$ $0.7611$ $0.9818$ $0.9916$ $0.9000$ $0.9818$ $0.9529$ $0.9724$ $0.0000$ $0.9816$ $0.9826$ $0.0900$ $0.9994$ $0.9994$ $0.5173$ $0.6791$ $0.7966$ $0.7966$ $0.9994$ $0.9994$ $0.9994$ $0.9994$	10 %		0.0682*	0.1757	1.0000	$0.0000^{***}$	$0.0449^{**}$	0.0807*	1.0000	$0.0000^{***}$
$0.5350$ $0.7130$ $0.8220$ $1.0000$ $0.8004$ $0.6559$ $0.8557$ $1.0000$ $1.0000$ $0.4250$ $0.7130$ $0.7130$ $NaN$ $NaN$ $NaN$ $0.6839$ $0.6539$ $0.745$ $1.0000$ $0.745$ $0.1558$ $0.7049$ $NaN$ $0.9922$ $0.6839$ $0.2496$ $0.745$ $0.745$ $0.745$ $0.1558$ $0.1373$ $0.3288$ $0.9922$ $0.0097^{***}$ $0.0316^{**}$ $0.7082$ $1.0000$ $0.6153$ $0.6688$ $0.7892$ $1.0000$ $0.000^{***}$ $0.6168$ $0.7082$ $1.0000$ $0.9297$ $0.8825$ $0.9040$ $1.0000$ $0.0216^{**}$ $0.9046$ $0.9158$ $1.0000$ $0.9293$ $0.9641$ $0.9730$ $1.0000$ $0.7611$ $0.9168$ $0.9164$ $1.0000$ $0.9293$ $0.9641$ $0.9724$ $1.0000$ $0.7611$ $0.9818$ $0.9826$ $1.0000$ $0.9818$ $0.9529$ $0.9724$ $1.0000$ $0.8025$ $0.9675$ $0.9826$ $1.0000$ $0.5173$ $0.6711$ $0.7966$ $0.7966$ $0.9994$ $0.9994$ $0.9994$	%06		0.9471	0.9677	1.0000	0.7765	0.9494	0.9781	1.0000	0.9307
$0.4250$ $0.7049$ NaN         NaN $0.6839$ $0.2496$ $0.745$ $0.9955$ $0.9952$ $0.9952$ $0.9992$ $0.000^{***}$ $0.0168$ $0.0708$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9995$ $0.9994$ $0.9994$ $0.9994$ $0.9994$	95 %		0.7130	0.8220	1.0000	0.8004	0.6559	0.8557	1.0000	0.7654
One-sided Independent of VaR           0.1558         0.1373         0.3928         0.9992         0.0005***         0.0316**         0.0717*         0.9995 $0$ 0.6153         0.6688         0.7892         1.0000         0.0000***         0.6168         0.9995         10000           0.9297         0.8825         0.9040         1.0000         0.0010***         0.6168         0.7082         1.0000         10000           0.9293         0.9641         0.9730         1.0000         0.7611         0.9818         0.9158         1.0000         1.0000           0.9218         0.9529         0.9724         1.0000         0.7611         0.9818         0.9826         1.0000         1.0000         0.9675         0.9826         1.0000         0.9936         0.9934         1.0000         0.9951         0.9926         0.9994	96 %		0.7049	NaN	NaN	0.6839	0.2496	0.745	0.745	0.2496
$0.1558$ $0.1373$ $0.3928$ $0.9992$ $0.0007^{***}$ $0.0316^{**}$ $0.0717^{*}$ $0.9955$ $0.9955$ $0.6153$ $0.6688$ $0.7892$ $1.0000$ $0.0000^{***}$ $0.6168$ $0.7082$ $1.0000$ $1.0000$ $0.9297$ $0.8825$ $0.9040$ $1.0000$ $0.0016^{***}$ $0.6168$ $0.7082$ $1.0000$ $1.0000$ $0.9293$ $0.9641$ $0.9730$ $1.0000$ $0.0216^{**}$ $0.9046$ $0.9158$ $1.0000$ $1.0000$ $0.9218$ $0.9529$ $0.9724$ $1.0000$ $0.7611$ $0.9818$ $0.9844$ $1.0000$ $1.0000$ $0.9818$ $0.9724$ $1.0000$ $0.8025$ $0.9675$ $0.9826$ $1.0000$ $1.0000$ $0.5173$ $0.6791$ $0.7796$ $0.7966$ $0.9994$ $1.0000$					One-s.	ided Independent of	f VaR			
$0.6153$ $0.6688$ $0.7892$ $1.0000$ $0.000^{***}$ $0.6168$ $0.7082$ $1.0000$ $1.0000$ $0.9297$ $0.8825$ $0.9040$ $1.0000$ $0.0216^{**}$ $0.9158$ $1.0000$ $1.0000$ $0.9293$ $0.9641$ $0.9730$ $1.0000$ $0.7611$ $0.9188$ $0.9158$ $1.0000$ $0.92818$ $0.9529$ $0.9724$ $1.0000$ $0.8025$ $0.9675$ $0.9844$ $1.0000$ $0.9818$ $0.9724$ $1.0000$ $0.8025$ $0.9675$ $0.9826$ $1.0000$ $0.5173$ $0.6791$ $0.7093$ $0.9990$ $0.6775$ $0.7966$ $0.9994$	1 %		0.1373	0.3928	0.9992	0.0097***	$0.0316^{**}$	$0.0717^{*}$	0.9995	$0.0007^{***}$
$0.9297$ $0.8825$ $0.9040$ $1.0000$ $0.0216^{**}$ $0.9046$ $0.9158$ $1.0000$ $1.0000$ $0.9293$ $0.9641$ $0.9730$ $1.0000$ $0.7611$ $0.9818$ $0.9844$ $1.0000$ $0.9818$ $0.9529$ $0.9724$ $1.0000$ $0.8025$ $0.9675$ $0.9826$ $1.0000$ $0.5173$ $0.6791$ $0.7093$ $0.9990$ $0.6775$ $0.7966$ $0.9944$ $1.0000$	5 %		0.6688	0.7892	1.0000	$0.0000^{***}$	0.6168	0.7082	1.0000	$0.0000^{***}$
0.9293         0.9641         0.9730         1.0000         0.7611         0.9818         0.9844         1.0000         1.0000           0.9818         0.9529         0.9724         1.0000         0.8025         0.9675         0.9826         1.0000         1.0000           0.5173         0.6791         0.7093         0.9990         0.6775         0.7966         0.9994         0.9994	10 %		0.8825	0.9040	1.0000	$0.0216^{**}$	0.9046	0.9158	1.0000	$0.0338^{**}$
0.9818         0.9529         0.9724         1.0000         0.8025         0.9675         0.9826         1.0000         1.0000           0.5173         0.6791         0.7093         0.9990         0.6775         0.7966         0.7966         0.9994	90 %		0.9641	0.9730	1.0000	0.7611	0.9818	0.9844	1.0000	0.8238
0.5173 0.6791 0.7093 0.9990 0.6775 0.7966 0.7966 0.9994	95 %		0.9529	0.9724	1.0000	0.8025	0.9675	0.9826	1.0000	0.8072
	% 66		0.6791	0.7093	06660	0.6775	0.7966	0.7966	0.9994	0.7124

Table E27: ES test results for gasonline futures on NYMEX

					H	Heating Oil - NYMEX	X			
Two-sided Dependent on VaR           Nask in NaN	Quantile	EWQR	Garch Normal	Garch Student t	Garch GED	Garch Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
0.5046         NaN         NaN         NaN         NaN         NaN         NaN         NaN $0.10269$ $0.2031$ $0.0035$ $0.000563$ $0.000563$ $0.000563$ $0.000563$ $0.000666$ $0.000666$ $0.0006666$ $0.0006666$ $0.00066666$ $0.00066666$ $0.00066666$ $0.00066666$ $0.000666666$ $0.000666666$ $0.000666666666666666666666666666666666$					Two-	-sided Dependent or	ı VaR			
	1 %		NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
0.086         0.053;         0.066;*         0.053;*         0.015;         0.006;*         0.000;*         0	5 %		0.2031	$0.0012^{***}$	$0.0000^{***}$	$0.0001^{***}$	0.3374	$0.0012^{***}$	$0.0000^{***}$	$0.0001^{***}$
	10 %		0.5276	0.0563*	$0.0000^{***}$	$0.018^{**}$	0.5191	$0.0551^{*}$	$0.0000^{***}$	$0.0174^{**}$
	% 06		0.1912	0.0087***	$0.0000^{***}$	0.015**	0.2428	0.0077***	$0.0000^{***}$	0.0069***
	95 %		0.1005	$0.0032^{***}$	$0.0000^{***}$	0.0051***	0.085	$0.0036^{***}$	$0.0000^{***}$	0.0055***
Two-sided Independent of VaR           0.0594*         0.0115**         0.0116**         0.0116**         0.0116**         0.0116**         0.0116**         0.0116**         0.0116**         0.0116**         0.0116**         0.0116**         0.0116**         0.0116**         0.0100***         0.000***         0.0000*	% 66		NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
					Two-	sided Independent (	of VaR			
	1 %		0.0115**	$0.0017^{***}$	$0.0017^{***}$	0.0029***	0.0115**	$0.0017^{***}$	$0.0110^{**}$	0.0128**
0.001***         0.042**         0.060***         0.0018***         0.0418**         0.002***         0.000***         0.000***           0.0254**         0.0145**         0.005***         0.000***         0.000***         0.000***         0.000***           0.0254**         0.0145**         0.005***         0.000***         0.000***         0.000***         0.000***           0.0254*         0.0145*         0.006***         0.000***         0.000***         0.000***         0.000***           0.593         0.017**         0.000***         0.000***         0.000***         0.000***         0.000***           0.593         0.0017**         0.000***         0.000***         0.000***         0.000***         0.000***           0.593         0.0017**         0.000**         0.000**         0.000***         0.000***         0.000***           0.7571         0.8909         0.9973         1.0000         0.9987         0.7385         0.9992         1.0000           0.7271         0.9412         0.9428         1.0000         0.9887         0.9993         1.0000           0.7271         0.9402         0.9010         0.9993         0.7385         0.9993         1.0000           0.7271	5 %		$0.0136^{**}$	$0.0000^{***}$	$0.0000^{***}$	$0.0000^{***}$	$0.0156^{**}$	$0.0002^{***}$	$0.000^{***}$	$0.0000^{***}$
	10 %		0.0429**	$0.0058^{***}$	$0.0000^{***}$	$0.0015^{***}$	$0.0418^{**}$	0.0059***	$0.0000^{***}$	0.0013***
0.0263* $0.006$ /res $0.006$ /res $0.0007$ /res	% 06		0.0145**	$0.0059^{***}$	$0.0000^{***}$	0.0029***	$0.0112^{**}$	$0.0045^{***}$	$0.000^{***}$	0.0027***
$0.5943$ $0.0017^{stac}$ $0.0208^{st}$ $0.018^{stac}$ $0.0017^{stac}$ $0.0017^{stac}$ $0.0017^{stac}$ $IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII$	95 %		0.0096***	$0.0006^{***}$	$0.0000^{***}$	$0.0003^{***}$	0.0074***	0.0007***	$0.0000^{***}$	$0.0004^{***}$
<b>One-sided Dependent on Var</b> $0.7450$ NavNavNavNavNavNavNav $0.7450$ NavNavNavNavNavNavNav $0.7450$ 0.89090.99921.00000.99990.82560.99921.0000 $0.912$ 0.73550.96781.00000.98770.73850.96811.0000 $0.9217$ 0.99221.00000.98930.86870.99731.0000 $0.7271$ 0.94020.99771.00000.95880.94810.99731.0000 $0.7271$ 0.94020.99771.00000.99580.99731.0000 $0.7271$ 0.94020.99170.99730.99731.0000 $0.7271$ 0.99910.99830.99330.99930.9993 $0.9990$ 0.99920.99930.99930.99930.9993 $0.9992$ 0.99431.00000.99890.99740.99930.9993 $0.9992$ 0.99431.00000.99890.99730.99931.0000 $0.9992$ 0.99430.99890.99740.99930.99931.0000 $0.9992$ 0.99430.99890.99930.99931.0000 $0.9992$ 0.99430.99890.99930.99931.0000 $0.9992$ 0.99430.99890.99930.99931.0000 $0.9993$ 0.99930.99930.99930.99931.0000 $0.9993$ 0.99930.99930.99930.9993 <th>% 66</th> <th></th> <th><math>0.0017^{***}</math></th> <th>0.0208**</th> <th><math>0.0017^{***}</math></th> <th>0.0208</th> <th><math>0.011^{**}</math></th> <th><math>0.0208^{**}</math></th> <th><math>0.0017^{***}</math></th> <th><math>0.0208^{**}</math></th>	% 66		$0.0017^{***}$	0.0208**	$0.0017^{***}$	0.0208	$0.011^{**}$	$0.0208^{**}$	$0.0017^{***}$	$0.0208^{**}$
0.7450NaN					One-	sided Dependent or	l VaR			
0.9232 $0.8909$ $0.9992$ $1.0000$ $0.9972$ $1.0000$ $1.0000$ $1.0000$ $0.912$ $0.7355$ $0.9678$ $0.9678$ $0.9877$ $0.7385$ $0.9681$ $1.0000$ $1.0000$ $0.8227$ $0.8223$ $0.9972$ $1.0000$ $0.9877$ $0.7385$ $0.9681$ $1.0000$ $1.0000$ $0.8227$ $0.8923$ $0.9977$ $1.0000$ $0.9893$ $0.8687$ $0.9938$ $1.0000$ $1.0000$ $0.7271$ $0.9402$ $0.9977$ $1.0000$ $0.9958$ $0.9481$ $0.9973$ $1.0000$ $1.0000$ $0.6652$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $0.6652$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $0.6652$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $0.6652$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $0.9990$ $0.9991$ $0.9993$ $0.9993$ $0.9993$ $0.9993$ $0.9993$ $0.9993$ $0.9920$ $0.9923$ $0.9993$ </td <td>1 %</td> <td></td> <td>NaN</td> <td>NaN</td> <td>NaN</td> <td>NaN</td> <td>NaN</td> <td>NaN</td> <td>NaN</td> <td>NaN</td>	1 %		NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
0.9412 $0.7355$ $0.9678$ $1.0000$ $0.9877$ $0.7385$ $0.9681$ $1.0000$ $1.0000$ $0.8227$ $0.8923$ $0.9923$ $0.9932$ $1.0000$ $0.9893$ $0.8687$ $0.9938$ $1.0000$ $1.0000$ $0.7271$ $0.9402$ $0.9973$ $1.0000$ $0.9893$ $0.8687$ $0.9938$ $1.0000$ $1.0000$ $0.7271$ $0.9402$ $0.9973$ $1.0000$ $0.9973$ $0.9973$ $1.0000$ $NaN$ $0.6652$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $0.9896$ $0.9911$ $0.9988$ $0.9933$ $0.9933$ $0.9933$ $0.9933$ $0.9933$ $0.9933$ $0.9990$ $0.9926$ $0.9993$ $0.9993$ $0.9890$ $0.9933$ $0.9993$ $0.9993$ $0.9993$ $0.9993$ $0.9922$ $0.9725$ $0.9929$ $0.9993$ $0.9989$ $0.9714$ $0.9993$	5 %		0.8909	0.9992	1.0000	0.9999	0.8256	0.9992	1.0000	0.9999
0.8227 $0.8923$ $0.9932$ $1.0000$ $0.9893$ $0.8687$ $0.9038$ $1.0000$ $1.0000$ $0.7271$ $0.9402$ $0.9977$ $0.9977$ $1.0000$ $0.973$ $1.0000$ $1.0000$ $0.7271$ $0.9402$ $0.9977$ $0.9973$ $0.9973$ $1.0000$ $NaN$ $0.6652$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $NaN$ $0.6652$ $0.9991$ $0.9912$ $0.9923$ $0.9933$ $0.9481$ $0.9933$ $0.9933$ $0.9990$ $0.9912$ $0.9988$ $0.9933$ $0.9993$ $0.9933$ $0.9993$ $0.9993$ $0.9993$ $0.9992$ $0.9926$ $1.0000$ $1.0000$ $0.9889$ $0.9933$ $0.9993$ $0.9993$ $0.9993$ $0.9993$ $0.9926$ $0.9929$ $0.9943$ $1.0000$ $0.9974$ $0.9966$ $0.9993$ $1.0000$ $0.9886$ $0.9943$ $1.0000$ $0.9974$ $0.9966$ $0.9956$ $1.0000$ $0.9993$ $0.9923$ $0.9926$ $0.9993$ $0.9956$ $0.0000$ $0.9993$ $0.9993$ $0.9993$ $0.9993$ $0.9993$ $0.9993$ $0.9993$	10 %		0.7355	0.9678	1.0000	0.9877	0.7385	0.9681	1.0000	0.9880
0.7271 $0.9402$ $0.9977$ $1.0000$ $0.9958$ $0.9481$ $0.9073$ $1.0000$ $1.0000$ $0.6652$ NaNNaNNaNNaNNaNNaNNaNNaN $0.6652$ NaNNaNNaNNaNNaNNaNNaNNaN $0.6652$ NaNNaNNaNNaNNaNNaNNaNNaN $0.6652$ 0.99910.99880.99930.99930.99930.99930.99930.9993 $0.9992$ 0.97591.00001.00000.99890.97310.99931.00001.0000 $0.9928$ 0.99431.00000.99890.97310.99591.00001.0000 $0.9806$ 0.99120.99431.00000.99740.99661.00001.0000 $0.9806$ 0.99120.99431.00000.99740.99660.99561.0000 $0.9931$ 0.99330.99320.99930.99931.00000.99931.0000	% 06		0.8923	0.9932	1.0000	0.9893	0.8687	0.9938	1.0000	0.9942
0.6652NaNNaNNaNNaNNaNNaNNaNNaNNaN $1.6652$ NaNNaNNaNNaNNaNNaNNaNNaNNaN $1.71$ $1.71$ $1.616$ $0.9983$ $0.9934$ $0.9934$ $0.9934$ $0.9934$ $0.9934$ $0.9934$ $0.9934$ $0.9934$ $0.9934$ $0.9934$ $0.9933$ $0.9933$ $0.9933$ $0.9993$ <t< td=""><td>95 %</td><td></td><td>0.9402</td><td>0.9977</td><td>1.0000</td><td>0.9958</td><td>0.9481</td><td>0.9973</td><td>1.0000</td><td>0.9952</td></t<>	95 %		0.9402	0.9977	1.0000	0.9958	0.9481	0.9973	1.0000	0.9952
One-sided Independent of VaR           0.9896         0.9991         0.9988         0.9993         0.9000         0.9956         0.0000         0.9956         0.0000         0.9956         0.0000         0.9956         0.0000         0.9993         0.0000         0.9993         0.0000         0.9993         0.0000         0.9993         0.0000         0.9993         0.0993         0.0993         0.0993         0.9993         0.	% 66		NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
					One-s	sided Independent o	of VaR			
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1 %		0.9991	0.9988	0.9993	0.9993	0.9989	0.9993	0.9993	0.9975
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	5 %		0.9896	1.0000	1.0000	1.0000	0.9873	0.9998	1.0000	1.0000
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	10 %		0.9725	0.9959	1.0000	0.9989	0.9731	0.9959	1.0000	0.999
0.9806         0.9912         0.9934         1.0000         0.997         0.9931         0.9933         1.0000           0.6699         0.9993         0.9892         0.9892         0.9892         0.9990         0.9993         0.9993	06 %		0.9868	0.9943	1.0000	0.9974	0.9906	0.9956	1.0000	0.9974
0.6699   $0.9993$   $0.9892$   $0.9992$   $0.9892$   $0.9990$   $0.9892$   $0.9990$   $0.9892$   $0.9993$	95 %		0.9912	0.9994	1.0000	0.9997	0.9931	0.9993	1.0000	0.9996
	% 66		0.9993	0.9892	0.9992	0.9892	0.9990	0.9892	0.9993	0.9892

Table E28: ES test results for heating oil futures on NYMEX

Total	16	29	27	29	23	25	37	16	26	16	33	17	25	18		13	27	25	26	16	24	32	11	18	10	32	13	20	12															
Number of breaches		2	2	3	7	1	5	5	8	9	1	4	5	9		10	13	11	13	12	10	12	8	12	8	14	12	14	10		3	14	14	13	4	14	20	3	6	2	18	1	6	2
LC Oil	0	0	0	0	0	0	1	0	0	0	0	0	0	0		ю	-	2	-	4	2	-	1	0	-	0	2	0	1		-	0	-	0	-	0	0	0	1	0		0	2	0
Heating Oil	1	0	1	0	2	0	0	0	0	0	0	0	0	0		0	2	0	2	1	1	2	0	0	0	2	0	0	0		0	0	0	0	2	0	0	0	0	0	0	0	0	0
Gasoline	0		0	2	1	0	0	0	-	0	0	0	0	1		1	-	1	2	1	2	1	2	2	-		1	1	0		0	0	0	0	0	0	0	0	0	0	1	0	1	
Oil ICE	0	0	0	0	2	1	1	1		1	0	0	0	0			0		0	2	0	1	1	1	-	0	1	1	1		-	0	0	0	1	0	0	0	0	0	1	0	0	0
Gas Nymex	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	1	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas ICE	0	-	0	0	0	0	0	1	-	0	0	1	1	1		0	-	2	-	0	1	1	1	0	-	2	1	0	1		0	-	-	0	0	1	2	0	0	0	2	0	0	0
EI Y EEX	0	0	0	0	0	0	1	0	0	0	0	0	0	0		0	2	0	2	2	1	0	0	1	0	0	0	0	0		0	0	0	-	0	0	1	0	0	0	1	0	0	0
El M Nymex	_	0	0	0	0	0	0	0	0	0	0	0	1	0		0		0		1	0	0	0	0	0	1	0	0	0		0	2	3	0	0	2	2	0	0	0	1	0	0	0
EI M ICE	0	0	0	0	0	0	0	1	-	2	0	2	1	2		1	0	0	-	0	0	1	1	2	2	2	2	3	2		1	4	4	4	0	4	4	1	2	0	3	0	1	0
EI M EEX		0	0	0	0	0	0	1	0	1	0	-	0	1		1	.0		2	0	0	0	1	2	1	0	1	2	1		0	-	3	3	0	4	4	1	2	1	4	1	2	
Coal Nymex	0	0	1	0	0	0	0	0	2	0	0	0	1	0		2		2	0	1	1	1	0	0	0	1	0	0	0		0	2	0	-	0	1	1	0	0	0	1	0	0	0
Coal ICE	0	0	0	-	1	0	0	1	0	1	0	0	0	0		0			0	0	0	0	0	1	0	1	2	2	3		0	0	0	0	0	0	4	1	1	1	2	0	0	0
CO2 Nasdaq	0	0	0	0	1	0	1	0	2	0		0	0	0		0	0	0	0	0	0	2	0	-	1		1	4	1		0	-	0	-	0	0		0	0	0	0	0	0	0
CO2 EEX	0	0	0	0	0	0	1	0	0	1	0	0	1	1		1	0		-1	0	2	2	1	1	0	3	1	1	0		0	m	2	ω	0	2	1	0	0	0	1	0	0	0
10 %	EWQR	CAViaR1	CAViaR2	CAViaR3	CAViaR4	CAViaR5	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	5 %	EWQR	CAViaR1	CAViaR2	CAViaR3	CAViaR4	CAViaR5	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	1 %	EWQR	CAViaR1	CAViaR2	CAViaR3	CAViaR4	CAViaR5	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t

Table E29: Total VaR test results for the unconditional coverage test

Total	21	26	23	22	19	17	26	18	23	19	25	17	20	18		18	21	17	19	12	15	22	13	16	13	20	15	16	14															
Number of breaches	3	5	9	3	7	2	4	5	7	9	5	2	4	4		8	6	12	10	9	10	8	8	8	8	11	11	9	6		10	12	5	9	6	5	14	5	8	5	9	4	7	5
LC Oil	1	0	0	0	-	0	0	0	0	0	0	0	0	0		-	1	2	1	1	1	1	0	1	1	-	_	0	_		2	0	0	0	2	0	0	1	0	0	0	0	_	0
Heating Oil	1	1	1	0	1	0	1	0	1	0	0	0	1	0		-	-	_	-	0	1	1	1	1	1	0	-	1	_		0	0	0	0	2	0	0	0	0	0	0	0	0	0
Gasoline	0	0	0	0	2	1	0	0	0	0	0	0	0	0		0	-	_	-	0	0	0	1	0	0	-	_	-	0		0	0	0	0	0	0	1	0	1	1	0	0	0	
Oil ICE	0	0	0	0	0	0	0	0	0	0	0	0	0	0		-	0	2	0	-	2	1	1	-	1	1	-	1	_		1	2	0	2	-	0	1	1	1	1	-	-		
Gas Nymex	0	0	0	0	1	0	0	0	1	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas ICE	0	-	0	1	0	1	0	2	0	1	-	1	0	2		0	2	2	-	0	0	1	0	1	0	-	0		0		0	0	0	-	0	1	2	0	0	0	2	0	0	0
EI Y EEX	0	-	1	1	-	0	0	1	1	-	0	1	1	1		0	-	0	2		1	0	1	0	1	2	-	0	_		0	0	0	0	0	0	2	0	1	0	0	0		0
El M Nymex	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	-	-	0	-	1	0	0	0	0	2	0	0	0		0	-	2	0	0	1	1	0	0	0	0	0	0	0
EI M ICE	0	0	0	0	0	0	0	0	1	1	0	0	0	1		0	0	0	0	0	0	1	2	-	2	2	3	2	2		3	2	1	-	0	0	2	0	1	0	2	0	0	0
EI M EEX	1	0	1	0	0	0	0	0	1	1	0	0	0	0		-	0	-	2	1	0	0	1	0	0	0	0	1	0		0	2	1	-	0	3	2	1	2	1	2	-	2	-
Coal Nymex	0	0	1	0	0	0	1	1	0	1	0	0	0	0		2	0	0	-	-	1	0	1	-	1	0	2	1	2		2	e	0	3	-	0	2	1	2	1	2		2	-
Coal ICE	0	-	0	1	-	0	0	0	0	0	1	0	0	0		-	1	-	0	0	1	0	0	1	1	0	-		-		2	0	0	0	0	0	1	1	0	1	0		0	1
CO2 Nasdaq	0	1	2	0	0	0	1	1	1	1	1	0	1	0		-	0	0	0	0	0	2	0	1	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 EEX	0	0	0	0	0	0	1	0	1	0	2	0	-	0		0	-	-	-	0	2	1	0	0	0	-	0	0	0		0	2	-	-	0	0	0	0	0	0	0	0	0	0
10 %	EWQR	CAViaR1	CAViaR2	CAViaR3	CAViaR4	CAViaR5	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	5 %	EWOR	CAViaR1	CAViaR2	CAViaR3	CAViaR4	CAViaR5	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	1 %	EWQR	CAViaR1	CAViaR2	CAViaR3	CAViaR4	CAViaR5	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t

Table E30: Total VaR test results for the conditional coverage test

Total	40	28	34	26	37	30	26	38	35	39	34	39	36	40	
Τ															
LC Oil	-	3	2	3	1	2	3	3	3	3	3	3	3	3	
Gasoline Heating Oil LC Oil	3	ę	3	3	2	ю	3	3	3	3	4	3	ę	3	
	3	2	2	1	3	3	2	2	2	2	2	2	2	2	
Oil ICE	2	-	1	1	1	1	1	1	1	1	1	1	-	_	
Nymex EI M EEX EI M ICE EI M Nymex EI Y EEX Gas ICE Gas Nymex Oil ICE	4	e,	3	3	3	3	3	4	3	3	3	3	с,	3	
Gas ICE	5	2	2	2	3	3	1	4	3	4	2	4	3	4	
EI Y EEX	5	ę	4	2	3	3	2	3	3	3	2	3	ę	3	
El M Nymex	5	3	3	4	4	3	2	3	3	3	3	4	4	4	
EI M ICE	1	0	0	0	3	0	0	1	1	2	0	1	1	2	
EI M EEX	3	-	1	0	2	0	0	1	1	2	0	2	0	2	
Coal Nymex	1	1	4	0	1	2	3	3	2	3	3	2	2	2	
Coal ICE	1	1	3	3	4	3	0	2	2	1	3	1	2	1	
CO2 EEX CO2 Nasdaq Coal ICE Coal	3	4	5	3	ю	4	3	4	4	5	5	5	5	5	
CO2 EEX	3	1	1	1	4	0	3	4	4	4	3	5	4	5	
	EWQR	CAViaR1	CAViaR2	CAViaR3	CAViaR4	CAViaR5	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	

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The table gives the number of quantiles for each model and futures series that pass the dynamic quantile test at 5% significanse.

Total	46	30	20	25	44	22	34	23	21	20	28	23	21	21		39	22	17	22	35	14	23	18	14	15	25	15	16	15															
Number of breaches	7	8	3	3	9	8	11	5	7	5	3	8	5	9		10	15	9	15	14	5	7	6	5	9	7	9	5	5		29	7	11	7	21	6	16	9	9	9	18	6	11	10
LC Oil	1	1	0	0	1	0	1	0	0	0	0	1	0	0		2	0	0	0	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heating Oil	0	0	0	1	0	2	1	0	0	0	1	0	0	0		0	0	0	-	-	0	0	-		-	0	1		-		0	0	0	0	1	0		0	0	0	0	0	0	0
Gasoline	2	0	0	1	0	0	1	0	1	0	0	0	0	0		0	-	0	0	-	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	1	0	0	0	0
Oil ICE	0	1		0	0	1	1	1	1	1	0	0	0	0		-	2		2	ę	0	0	0		-	-	1	0	-		0	0	0	0	1	0		1	0	0	0	0	1	0
Gas Nymex	0	1	-	0	0	1	0	0	0	0	0	1	1	1		1	0	1	-	0	0	0	0	0	0	0	0	0	0		-	0	0	0	1	0	0	0	0	0	0	0	0	0
Gas ICE	-	0	0	0	1	1	0	1	1	1	0	1	1	2		1	2	0	-	0	0	2	7	0	1	-		0			-	0	2	1	0	1		0	0	0	2	0	0	0
EI Y EEX	-	0	0	0	0	0	1	1	0	1	1	1	0	0		2	2	2	2	2	-	0	1	2	-	0	-	2	-		2	0	0	1	2	0	-	0	0	0	-	0	0	0
El M Nymex	0	-	0	1	0	1	1	0	1	0	0	0	0	0		2	2	0		2	0	1	1	0	-	-	0	0	0		2	1	3	0	2	2		0	0	0	-	0	0	0
EI M ICE	0	0	0	0	2	0	0	0	1	1	0	1	1	1			_	0		-	0	1	2		0	-	-		0		4	3	4	3	2	4	3	1	1	2	2	1	1	1
EI M EEX	-	2	1	0	1	1	1	0	0	0	0	0	1	0		0	0	0	2	0	2	1	1	0	0	0	0	0	0		5	0	0	0	3	0	2	1	2	1	4	1	2	2
Coal Nymex	0	0	0	0	1	0	0	0	0	1	0	1	0	0		0	e	0	3	0	0	2	-	0	-	2	0	0	-		5	0	0	1	3	0	2	3	4	2	2	3	4	3
Coal ICE	0	2	0	0	1	0	2	0	1	0	0	2	0	2		0	0	7	0	-	1	0	0	0	0	-	0	1	0		4	0	1	0	2	1	-1	1	0	1	2	1	0	1
CO2 Nasdaq	-	0	0	0	0	0	2	2	1	0	0	0	1	0		0	0	0	-	-	-	0	0	0	0	0	-	0	0		3	2	1	1	1	1	2	1	1	1	2	1	1	1
CO2 EEX	0	0	0	0	2	1	0	0	0	0	1	0	0	0		0	2	0	0	-	0	0	0	0	0	0	0	0	0		2	1	0	0	3	0	-	1	-	1	2	2	2	2
10 %	EWQR	CAViaR1	CAViaR2	CAViaR3	CAViaR4	CAViaR5	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	5 %	EWQR	CAViaR1	CAViaR2	CAViaR3	CAViaR4	CAViaR5	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	1 %	EWQR	CAViaR1	CAViaR2	CAViaR3	CAViaR4	CAViaR5	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t

Table E32: Total VaR test results for the dynamic quantile test

al	4	13	22	64	23	13	23	67	23		-	8	16	62	18	7	15	65	19										
Total																													
Number of breaches	3	5	9	2	5	9	8	2	4		1	2	6	7	7	5	2	6	6		0	1	7	55	11	2	8	56	13
LC Oil	0	0	0	0	0	0	1	0	0		0	0	2	1	1	0	1	2	1		0	0	0	3	0	0	0	3	0
Heating Oil	1	0	1	0	0	0	1	0	0		0	0	0	0	2	0	0	0	1		0	0	3	4	2	0	3	4	3
Gasoline	0	1	0	0	0	1	0	0	0		0	0	1	0	0	0	1	0	1		0	0	0	5	2	0	0	5	2
Oil ICE	0	0	2	0	0	0	1	0	0		-	0	0	0	1	0	0	0	1		0	0	0	4	0	0	0	4	0
Coal Nymex	1	1	0	0	1	1	0	0	2		0	0	0	0	0	0	2	0	0		0	0	1	5	0	0	0	5	0
Coal ICE	0	1	0	1	0	1	1	0	0		0	0	0	0	0	0	0	-	0		0	0	0	4	0	0	0	5	0
Gas Nymex	0	2	0	0	0	2	0	0	0		0	0	1	0	0	0	0	0	0		0	0	1	5	2	0	2	5	2
Gas ICE	0	0	1	0	1	0	1	0	1		0	0	1	3	0	0	1	3	0		0	0	0	2	2	0	0	2	2
EI Y EEX	0	0	1	0	1	0	2	0	0		0	2	2	0	0	2	1	0	0		0	0	0	5	0	0	0	5	0
EI M EEX	0	0	0	1	0	0	0	2	0		0	0	0	2	2	0	0	2	2		0	0	0	0	1	0	0	0	-
EL M ICE	0	0	1	0	0	0	0	0	0		0		0	0	0	1	1	0	0		0	0	1	4	2	0	1	4	2
El M Nymex	1	0	0	0	0	0	0	0	0		0	4	0	0	1	2	0	0	0		0	1	1	9	0	2	1	6	_
CO2 Nasdaq El M Nymex	0	0	0	0	1	1	1	0	0		0	0	2	1	0	0	0	-	0		0	0	0	4	0	0	1	4	0
CO2 EEX	0	0	0	0	1	0	0	0	1		0	0	0	0	0	0	0	0	0		0	0	0	4	0	0	0	4	0
10 %	EWQR	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	5 %	EWQR	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	1 %	EWQR	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t

Table E33: Total results for the twosided ES-test dependent on VaR

	31	37	46	80	38	38	43	78	34	I	20	29	34	75	26	30	34	74	30										
Total																													
Number of breaches	11	8	12	5	12	8	6	4	4		11	17	18	6	11	20	20	15	17		6	12	16	66	15	10	14	59	13
LC Oil	1	0	1	1	1	1	1	1	0		2	0	1	0	0	0	3	1	1		1	0	2	5	0	0	0	4	0
Heating Oil	-	0	0	0	0	0	0	0	0		2	4	1	0	1	5	1	1	2		2	2	5	6	5	1	5	5	4
Gasoline	-	0	0	0	1	0	0	0	0		-	2	2	0	1	2	2	1	0		0	0	0	6	1	0	0	5	2
Oil ICE	0	0	2	0	1	0	2	0	0		2	1	1	1	0	1	0	1	1		1	1	2	5	0	1	2	5	0
Coal Nymex	-	1	0	0	0	1	0	0	0		-	1	2	1	1	1	2	1	2		-	1	1	5	1	1	1	5	0
Coal ICE	0	1	0	1	0	0	1	1	0		0	0	0	1	0	0	0	1	0		0	1	0	4	0	1	0	3	0
Gas Nymex	0	2	0	0	0	1	0	0	0		0	2	1	1	1	2	0	1	1		0	0	2	5	2	1	3	5	2
Gas ICE	0	0	1	0	1	1	0	0	1		0	1	1	1	1	0	1	1	2		0	1	0	2	1	1	0	2	0
EI Y EEX	1	0	0	0	2	1	0	0	0		0	2	2	0	0	1	3	2	0		1	0	1	6	0	0	0	4	0
EI M EEX	4	0	2	1	2	1	1	0	1		0	2	2	0	1	1	2	1	2		1	1	0	4	2	1	0	4	2
EL M ICE	0	-	3	0	1	0	-	0	1		-	0	1	1	2	1	3	1	2		2	2	2	5	3	2	2	5	9
El M Nymex	1	1	1	0	2	0	0	0	0		2	1	1	2	2	4	1	2	4		0	3	0	4	0	1	0	4	0
CO2 Nasdaq	1	2	1	1	1	2	2	2	0		0	0	3	1	0	1	1	0	0		0	0	0	4	0	0	1	4	0
CO2 EEX	0	0	1	1	0	0	1	0	1		0	1	0	0	1	1	1	1	0		0	0	1	5	0	0	0	4	0
10 %	EWQR	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	5 %	EWQR	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	1 %	EWQR	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t

Table E34: Total results for the twosided ES-test independent of VaR

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	З	35	3	0	13	38	5	0	12		-	21	2	0	10	30	3	0	7										
Total																													
Number of breaches	2	14	1	0	3	8	2	0	5		1	11	2	0	5	20	3	0	3		0	10	0	0	5	10	0	0	4
LC Oil	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0		0	0	0	0	1	0	0	0	1
Heating Oil	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0
Gasoline	0	2	0	0	0	0	-	0	0		0	0	0	0	1	2	1	0	1		0	0	0	0	2	0	0	0	2
Oil ICE	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0		0	0	0	0	1	0	0	0	-
Coal Nymex	0	0	0	0	1	1	0	0	1		0	e,	0	0	0	2	0	0	0		0	0	0	0	0	0	0	0	0
Coal ICE	0	3	0	0	0	1	0	0	0		0	0	0	0	0	4	0	0	0		0	1	0	0	0	1	0	0	0
Gas Nymex	_	1	0	0	0	1	0	0	0	r.	0	2	0	0	0	2	0	0	0		0	0	0	0	0	0	0	0	0
Gas ICE	0	0	1	0	0	1	1	0	0	r.	0	3	0	0	0	1	0	0	0		0	1	0	0	0	2	0	0	0
EI Y EEX	0	0	0	0	0	0	0	0	0		0	1	2	0	2	1	2	0	2		0	2	0	0	0	2	0	0	0
EI M EEX	0	3	0	0	0	2	0	0	0		0	2	0	0	0	4	0	0	0		0	0	0	0	0	0	0	0	0
EL M ICE	0	1	0	0	0	1	0	0	0		0	0	0	0	0	0	0	0	0		0	1	0	0	0	1	0	0	0
El M Nymex	-	1	0	0	1	0	0	0	3		1	0	0	0	1	2	0	0	0		0	5	0	0	0	4	0	0	0
CO2 Nasdaq El M Nymex	0	2	0	0	0	1	0	0	0		0	0	0	0	1	2	0	0	0		0	0	0	0	0	0	0	0	0
CO2 EEX	0	1	0	0	1	0	0	0	0		0	0	0	0	0	0	0	0	0		0	0	0	0		0	0	0	0
10 %	EWQR	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	5 %	EWQR	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	1 %	EWQR	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t

## Table E35: Total results for the onesided ES-test dependent on VaR

	2	9	6	0	20	20	Ξ	0	22	I	4	Ξ	5	0	13	14	5	0	16	I									
Total		1					1								1														
Number of breaches	8	5	4	0	7	6	9	0	6		7	9	3	0	6	7	3	0	10		17	5	2	0	7	7	2	0	9
LC Oil	0	0	0	0	1	0	0	0	1		0	0	0	0	0	0	0	0	-		0	0	0	0	0	0	0	0	0
Heating Oil	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0
Gasoline	0	0	0	0	0	0	1	0	0		0	0	0	0	1	1	0	0	-		0	0	0	0	2	0	0	0	2
Oil ICE	0	0	0	0	1	0	0	0	0		0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0
Coal Nymex	0	1	0	0	-	1	0	0	2		-	1	0	0	0	1	0	0	0		4	0	0	0	0	0	0	0	0
Coal ICE	0	0	1	0	0	0	0	0	0		0	0	0	0	1	1	1	0	1		0	0	0	0	0	0	0	0	0
Gas Nymex	2	1	0	0	0	0	1	0	1		-	1	0	0	0	1	0	0	0		0	0	0	0	0	1	0	0	0
Gas ICE	2	1	1	0	1	2	1	0	1		0	1	0	0	1	0	0	0	1		1	0	2	0	1	1	2	0	1
EI Y EEX	2	0	1	0	1	0	1	0	0		-	2	2	0	2	2	2	0	3		2	1	0	0	0	1	0	0	0
EI M EEX	1	1	0	0	0	1	0	0	0		-	0	0	0	0	0	0	0	0		4	0	0	0	0	0	0	0	0
EL M ICE	0	1	0	0	0	1	0	0	0		0	0	0	0	0	0	0	0	0		3	0	0	0	0	0	0	0	0
El M Nymex	0	0	1	0	-	0	2	0	0		2	1	1	0	0	1	0	0	1		3	4	0	0	2	4	0	0	2
CO2 Nasdaq El M Nymex	0	0	0	0	-	1	0	0	1		-	0	0	0	1	0	0	0	0		0	0	0	0	0	0	0	0	0
CO2 EEX	1	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	-		0	0	0	0	2	0	0	0	_
10 %	EWQR	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	5 %	EWQR	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t	1 %	EWQR	Garch-N	Garch-t	Garch-GED	Garch-skew t	GJR-Garch-N	GJR-Garch-t	GJR-Garch-GED	GJR-Garch-skew t

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Symmetric Absolute Value CAViaR		Asymmetric Slope CAViaR	Indirect GARCH CAViaR	Adaptive CAViaR	Indirect AR-GARCH CAViaR	GARCH Normal	GARCH Student t	GARCH GED	GARCH Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
0.40		0.40	0.20	0.80	0.00	1.00	0.40	0.40	0.40	0.80	0.40	0.40	0.40
2.00	1	2.60	2.40	4.40	2.80	3.20	4.00	3.60	3.40	3.20	4.00	3.40	3.40
6.60		7.00	6.40	9.40	6.80	7.60	8.80	8.40	8.40	7.20	8.60	8.20	8.20
8.00		8.20	8.20	8.60	6.40	6.20	9.00	8.20	9.40	6.40	9.00	8.20	9.00
2.00		2.40	2.20	3.80	2.20	3.00	3.20	3.00	3.60	3.00	3.20	3.00	3.60
0.80		0.40	0.60	0.00	0.60	0.80	0.60	0.60	0.80	1.00	1.00	0.60	1.00
					З С	CO2 - NASDAQ OMX	XMO (						
Symmetric Absolute Value CAViaR	2	Asymmetric Slope CAViaR	Indirect GARCH CAViaR	Adaptive CAViaR	Indirect AR-GARCH CAViaR	GARCH Normal	GARCH Student t	GARCH GED	GARCH Skew t	GJR Normal	GJR Student t	GJR GED	GJR Skew t
0.00		0.60	0.00	0.60	0.00	0.80	0.40	0.40	0.20	0.80	0.20	0.20	0.20

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4.80 9.20 3.60 1.00

3.60 8.20 3.40 1.00

4.00 9.80 8.80 4.20

3.40 9.40 7.80 2.80

 $4.60 \\ 10.00$ 

 $4.20 \\ 10.00$ 8.60 5.60 0.80

4.60 7.80 8.80 4.20 0.40

 $2.00 \\ 10.60$ 8.60 5.60 0.60

 $4.00 \\ 10.00$ 

9.80 4.60 0.80

 $\begin{array}{r} 2.00 \\ 10.80 \\ 9.80 \\ 4.00 \\ 0.80 \end{array}$ 

10.60 5.20 3.80 9.60

5 % 10 % 90 % 95 %

1.00

% 66

0.80

0.80

8.60 3.60 0.80

6.60 2.80 3.40 7.40

0.80

1.00

Table E37: Hitpercentage for CO2 on EEX and NASDAQ OMX

GJR Skew t	1.00	3.20	8.60	13.20	7.20	1.20		GJR Skew t	0.40
GJR GED	1.00	3.00	6.80	10.80	5.60	1.20		GJR GED	0 10
GJR Student t	1.00	4.00	9.00	13.20	7.20	1.20		GJR Student t	010
GJR Normal	0.80	2.20	2.80	7.20	4.00	1.20		GJR Normal	0.00
GARCH Skew t	1.00	3.60	8.40	14.00	7.00	1.20		GARCH Skew t	010
GARCH GED	1.20	3.00	6.40	10.40	5.80	1.20		GARCH GED	0 10
SARCH GARCH Normal Student t	1.00	4.20	9.00	13.80	00.7	1.20	EX	GARCH Student t	0.10
GARCH Normal	0.80	2.40	2.60	6.40	2.00	0.60	Coal - NYMEX	GARCH Normal	0.00
Indirect AR-GARCH CAViaR	1.00	3.60	10.40	9.40	4.80	1.00		Indirect AR-GARCH CAViaR	0.00
Adaptive CAViaR	0.40	4.60	9.60	8.80	3.40	0.40		Adaptive CAViaR	000
Indirect GARCH CAViaR	1.00	3.40	10.00	7.60	4.80	1.00		Indirect GARCH CAViaR	0.40
Asymmetric Slope CAViaR	0.80	3.60	8.80	7.40	4.40	1.00		Asymmetric Slope CAViaR	0000
Symmetric Absolute Value CAViaR	0.80	3.80	9.40	7.40	4.00	0.60		Symmetric Absolute Value CAViaR	0000
EWQR	0.40	5.60	9.80	9.00	4.20	0.40		EWQR	0.00
Quantile	1 %	5 %	10 %	% 06	95 %	% 66		Quantile	101

NYMEX
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E38:
Table

1.00 $\begin{array}{r} 4.40 \\ 9.40 \\ 111.60 \\ 6.20 \\ 1.00 \end{array}$ 3.20 6.40 8.80 5.00 1.20 3.80 9.00 5.80 1.00 3.40 7.60 5.20 1.00  $\begin{array}{r} 4.40 \\ 9.40 \\ 5.80 \\ 1.00 \\ 1.00 \end{array}$ 1.400.40 $\begin{array}{r} 4.60 \\ 9.00 \\ 10.20 \\ 0.20 \end{array}$ 1.80 7.20 5.60 0.40 0.400.4011.40 7.60 2.20 5%10% 90% 95% 99%

3.20 6.20 8.20 4.80

2.20 7.00 11.40 5.60

3.20 7.80 9.00 4.60

1.80 6.20 9.20 4.40

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Proportion of losses greater than the forecasted VaR for each of the return quantiles. Ideally 1.00 for 1%, 5.00 for 5%, 10.00 for 10%, 10.00 for 90%, 5.00 for 95% and 1.00 for 99%.

4.20 9.20 11.80 6.401.00

3.60 7.60 5.20

1.00	GJR Skew t	1.00
0.80	GJR GED	0.80 3.40
1.00	GJR Student t	1.00 4.40
1.00	GJR Normal	1.00 2.40
1.00	GARCH Skew t	5.00
20.00	GARCH GED	3.40
	GARCH Student t	4.60
	GARCH Normal	2.20
	Indirect AR-GARCH CAViaR	3.80
	Adaptive CAViaR	3.80
	Indirect GARCH CAViaR	3.80
	Asymmetric Slope CAViaR	3.20
	Absolute Value CAViaR	3.20
	EWQR	5.00
	Quantile	5 %

Table E39: Hitpercentage for Gas on ICE and NYMEX

CAViaR	

CAViaR         C-AViaR         Control         C-AViaR         C-AViaR <thc-aviar< th=""> <thc-aviar< th=""> <thc< th=""><th></th><th></th><th></th><th></th><th></th><th></th><th></th></thc<></thc-aviar<></thc-aviar<>							
CAViaR         CaViaR         CaVia		0.40	4.60	10.60	10.00	4.80	1.20
CAViaR		0.40	3.60	9.60	10.00	4.80	1.20
CAViaR		0.40	4.40	10.40	10.00	4.80	1.20
CAViaR         C.AViaR         C.AViaR <thcode< th=""> <thcode< th=""> <thcode< t<="" th=""><th></th><th>0.60</th><th>3.60</th><th>8.60</th><th>9.40</th><th>4.80</th><th>1.40</th></thcode<></thcode<></thcode<>		0.60	3.60	8.60	9.40	4.80	1.40
CAViaR $\cdots$		0.40	4.40	11.20	10.40	5.00	1.20
CAViaR         C. AViaR         A. 200         A. 400         A. 400 <t< th=""><th></th><th>0.20</th><th>4.20</th><th>10.40</th><th>10.20</th><th>4.60</th><th>1.20</th></t<>		0.20	4.20	10.40	10.20	4.60	1.20
CAViaR         Caviar <thcaviar< th=""> <thcaviar< th=""> <thcaviar< th="" th<=""><th></th><th>0.40</th><th>4.20</th><th>10.80</th><th>10.40</th><th>5.20</th><th>1.20</th></thcaviar<></thcaviar<></thcaviar<>		0.40	4.20	10.80	10.40	5.20	1.20
CAViaR         C.AViaR         C.AViaR <thc.aviar< th=""> <thc.aviar< th=""> <thc.< th=""><th></th><th>0.60</th><th>4.20</th><th>8.80</th><th>9.20</th><th>4.40</th><th>1.40</th></thc.<></thc.aviar<></thc.aviar<>		0.60	4.20	8.80	9.20	4.40	1.40
CAViaR         Caviar         Caviar           0.80         0.60         0.40           5.20         3.80         3.80         4.20           10.00         9.20         8.80         10.60           10.00         10.20         10.80         10.40           4.20         5.40         4.80         120           1.20         1.20         1.40         1.20		0.40	4.00	10.20	10.80	5.40	1.20
CAViaR         C.AViaR           0.80         0.60         0.60           5.20         3.80         3.80           10.00         9.20         8.80           10.00         10.20         10.80           4.20         4.20         5.40           1.20         1.20         1.40		1.00	4.00	9.40	9.80	4.80	1.60
CAViaR           0.80         0.60           5.20         3.80           10.00         9.20           10.00         10.20           4.20         4.20           1.20         1.20		0.40	4.20	10.60	10.40	4.80	1.20
0.80 5.20 10.00 10.00 4.20 1.20		0.60	3.80	8.80	10.80	5.40	1.40
	CAViaR	0.60	3.80	9.20	10.20	4.20	1.20
$   \begin{array}{r}     1 \% \\     5 \% \\     10 \% \\     90 \% \\     99 \% \\   \end{array} $		0.80	5.20	10.00	10.00	4.20	1.20
		1 %	5 %	10 %	00 %	95 %	0% 66

Proportion of losses greater than the forecasted VaR for each of the return quantiles. Ideally 1.00 for 1%, 5.00 for 5%, 10.00 for 10%, 10.00 for 90%, 5.00 for 95% and 1.00 for 99%.

	R v t		(	(	0	0	0		
	GJR Skew t	0.20	3.00	7.60	7.60	3.60	0.60		
	GJR GED	0.20	2.40	7.20	7.60	3.20	0.60		
	GJR Student t	0.20	2.80	7.60	7.80	3.80	0.60		
	GJR Normal	0.20	2.60	5.20	00.9	2.80	1.20		
	GARCH Skew t	0.20	3.00	7.60	7.60	3.80	0.60		
	GARCH GED	0.20	2.40	6.60	7.60	3.00	0.60		
ity - ICE	GARCH Student t	0.20	2.60	7.60	8.40	4.00	0.60	- NYMEX	
<b>Monthly Electricity - ICE</b>	GARCH Normal	0.20	2.00	4.80	5.80	2.60	1.40	Monthly Electricity - NYMEX	
Mo	Indirect AR-GARCH CAViaR	0.00	1.00	2.60	2.20	0.80	0.00	Mont	
	Adaptive CAViaR	0.00	4.20	9.60	09.6	0.00	1.00		
	Indirect GARCH CAViaR	0.20	1.00	2.40	3.00	1.00	0.00		
	Asymmetric Slope CAViaR	0.40	0.60	3.80	3.20	0.80	0.00		
	Symmetric Absolute Value CAViaR	0.40	0.60	3.80	3.60	1.00	0.00		Symmetric
	EWQR	0.20	8.60	12.20	10.60	4.20	1.60		
	Quantile	1 %	5 %	10 %	% 06	95 %	0% 66		

Monthly Electricity - NYMEX           EwQR         Symmetric Absolute         Symmetric Signe         Indirect GARCH         Indirect Absolute         Monthly Slope         Indirect GARCH         Indirect GARCH         GARCH	_			_	_	_		
Monthly Electricity - NYMEX           EWQR         Symmetric Absolute         Symmetric Slope         Indirect GARCH         GARCH         GARCH         GARCH         GJR		GJR Skew t	1.20	6.20	11.20	8.40	5.00	1.60
Monthly Electricity - NYMEX           EWQR         Symmetric Absolute         Symmetric Slope         Indirect GARCH         Monthly Electricity - NYMEX           EWQR         Value         Slope         GARCH         Adaptive         Indirect         GARCH         GARCH<		GJR GED	1.60	5.80	10.60	7.80	4.60	1.60
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		GJR Student t	1.60	6.40	11.20	8.40	5.00	1.40
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		GJR Normal	2.40	5.60	00'6	6.40	4.60	2.20
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		GARCH Skew t	1.60	6.20	11.00	9.40	5.20	1.20
EWQR         Symmetric Absolute         Asymmetric Asymmetric         Indirect         Monthly Electricity - Normal           EWQR         Absolute Value         Slope         GARCH         Adaptive         Indirect         GARCH           0         1.60         91.00         88.00         0.00         1.20         2.80         2.60           0         5.20         4.40         4.00         4.20         4.80         9.00         9.00           0         10.20         6.60         1.40         8.40         9.20         8.00         0.00         1.20         2.80         2.60           0         10.20         6.60         1.40         8.40         9.20         8.00         0.00         1.20         2.80         2.60         5.80 <td></td> <td>GARCH GED</td> <td>1.80</td> <td>6.00</td> <td>10.80</td> <td>8.00</td> <td>4.60</td> <td>1.20</td>		GARCH GED	1.80	6.00	10.80	8.00	4.60	1.20
EWQR         Symmetric Absolute         Asymmetric Slope         Indirect GARCH         Adaptive Adaptive         Indirect Adaptive           0         1.60         91.00         88.00         0.00         1.20         2.8           0         1.60         91.00         88.00         0.00         1.20         2.8           0         1.60         91.00         88.00         0.00         1.20         2.8           0         10.20         6.60         1.40         8.40         9.20         8.0           0         10.20         6.60         1.40         8.40         9.20         8.0           0         10.20         5.00         5.20         5.60         4.4         4.4	- NYMEX	GARCH Student t	1.60	6.40	11.20	9.20	5.00	1.00
EWQR         Symmetric Absolute         Asymmetric Slope         Indirect GARCH         Adaptive Adaptive         Indirect Adaptive           0         1.60         91.00         88.00         0.00         1.20         2.8           0         1.60         91.00         88.00         0.00         1.20         2.8           0         1.60         91.00         88.00         0.00         1.20         2.8           0         10.20         6.60         1.40         8.40         9.20         8.0           0         10.20         6.60         1.40         8.40         9.20         8.0           0         10.20         5.00         5.20         5.60         4.4         4.4	hly Electricity		2.60	5.80	00.6	5.80	4.40	1.80
EWQR         Symmetric Absolute         Asymmetric Asymmetric         Indirect Asymmetric         Adaptive Adaptive           EWQR         Absolute Value         Slope         GARCH         Adaptive           0         Ualue         Slope         GARCH         CAViaR         CAViaR           0         0.00         91.00         88.00         0.00         1.20           0         52.0         4.40         4.00         4.20         4.80           0         10.20         6.60         1.40         8.40         9.20           0         5.40         5.00         5.20         5.60         5.60         5.60	Mont	Indirect AR-GARCH CAViaR	2.80	4.40	8.00	9.60	4.60	2.40
EwQR         Symmetric Absolute         Asymmetric Asymmetric           EwQR         Value         Slope           Value         CAViaR         CAViaR           0         1.60         91.00         88.00           5.20         4.40         4.00         1.40           0         10.20         6.60         1.40         5.20           0         5.40         5.00         5.20         5.20			1.20	4.80	9.20	7.20	5.60	0.80
EWQR         Symmetric           EWQR         Absolute           Value         CAViaR           0         1.60         91.00           0         5.20         4.40           0         10.20         6.60           0         12.60         9.40           0         5.00         5.00			0.00	4.20	8.40	9.40	5.60	2.00
EWQR E 5.20 5.20 1.60 1.60 1.20 5.40 5.40 5.40 5.40		Asymmetric Slope CAViaR	88.00	4.00	1.40	8.60	5.20	2.40
		Symmetric Absolute Value CAViaR	91.00	4.40	6.60	9.40	5.00	2.20
Quantile		EWQR		5.20			5.40	1.80
		Quantile	1 %	5 %	10 %	% 06	95 %	% 66

Proportion of losses greater than the forecasted VaR for each of the return quantiles. Ideally 1.00 for 1%, 5.00 for 5%, 10.00 for 10%, 10.00 for 90%, 5.00 for 95% and 1.00 for 99%.

Table E40: Hitpercentage for Monthly Electricity on ICE and NYMEX

								1		
	GJR Skew t	0.40	4.20	10.40	9.40	5.60	1.80			GJR Skew t
	GJR GED	0.60	3.80	9.60	8.60	5.20	1.80			GJR GED
	GJR Student t	0.60	4.20	10.20	9.00	5.40	1.80			GJR Student t
	GJR Normal	0.60	3.80	8.00	8.00	5.20	2.40			GJR Normal
	GARCH Skew t	0.40	4.20	08.6	9.20	5.60	1.80			GARCH Skew t
	GARCH GED	0.60	3.80	9.20	8.80	5.20	2.00			GARCH GED
v - EEX	GARCH Student t	0.60	4.20	9.80	00.6	5.40	1.80		ty - EEX	GARCH Student t
Yearly Electricity - EEX	GARCH Normal	0.60	3.80	7.60	8.20	5.20	2.60		Monthly Electricity - EEX	GARCH Normal
Yes	Indirect AR-GARCH CAViaR	0.40	4.40	11.00	9.20	5.20	2.20		Mor	Indirect AR-GARCH CAViaR
	Adaptive CAViaR	0.20	3.20	8.80	9.40	4.20	0.80			Adaptive CAViaR
	Indirect GARCH CAViaR	0.20	5.20	13.80	8.80	5.60	2.20			Indirect GARCH CAViaR
	Asymmetric Slope CAViaR	0.00	3.60	8.20	0.60	5.80	1.80			Asymmetric Slope CAViaR
	Symmetric Absolute Value CAViaR	0.20	4.00	11.20	9.00	5.00	2.00			Symmetric Absolute Value CAViaR
	EWQR	0.60	6.60	09.6	10.80	5.80	1.20			EWQR
	Quantile	1 %	5 %	10 %	06 %	95 %	% 66			Quantile

Table E41: Hitpercentage for Monthly and Yearly Electricity on EEX

1.00	4.60	7.80	5.80	3.20	0.60
1.00	3.00	5.60	4.60	2.80	0.80
0.60	4.20	7.40	5.80	3.40	0.60
1.00	1.40	2.80	3.20	1.80	0.80
0.80	4.40	7.60	6.20	3.20	0.80
0.80	3.00	5.80	5.20	3.00	1.00
0.60	4.00	7.20	6.40	3.40	0.80
0.80	1.80	3.00	3.00	2.00	0.80
0.60	2.40	5.80	5.60	2.40	0.40
0.80	4.80	10.00	10.20	5.40	1.00
0.20	2.40	5.80	09.9	3.20	0.60
1.00	2.40	6.20	00'9	3.00	0.40
1.80	2.80	6.00	8.00	2.80	0.20
1.80	7.40	10.40	11.40	6.80	1.20
1 %	5 %	10 %	% 06	95 %	% 66

Proportion of losses greater than the forecasted VaR for each of the return quantiles. Ideally 1.00 for 1%, 5.00 for 5%, 10.00 for 10%, 10.00 for 90%, 5.00 for 95% and 1.00 for 99%.

1							
GJR Skew t	0.40	3.60	7.00	10.40	5.00	0.40	
GJR GED	0.40	3.60	7.00	9.60	4.80	0.40	
GJR Student t	0.40	3.80	7.40	10.00	5.00	0.40	
GJR Normal	0.80	3.60	6.60	9.20	4.80	0.40	
GARCH Skew t	0.40	3.40	7.20	10.60	5.20	0.40	
GARCH GED	0.40	3.40	7.00	9.80	4.80	0.40	
GARCH Student t	0.40	3.40	7.40	10.20	4.80	0.40	
GARCH Normal	0.80	3.40	6.80	9.20	5.00	0.40	
Indirect AR-GARCH CAViaR	0.00	3.60	7.60	9.00	4.40	0.40	
Adaptive CAViaR	0.00	2.40	7.60	7.60	3.00	0.20	
Indirect GARCH CAViaR	0.00	3.80	8.20	9.80	4.40	0.40	
Asymmetric Slope CAViaR	0.20	4.00	8.60	11.20	5.00	0.60	
Symmetric Absolute Value CAViaR	0.00	3.80	8.20	10.40	4.80	0.40	
EWQR	1.00	2.20	9.60	6.80	4.40	0.40	
Quantile	1 %	5 %	10 %	% 06	95 %	% 66	
	EWQRSymmetric AbsoluteAsymmetric SolpeIndirect GARCHIndirect AR-GARCHIndirect GARCHGARCH 	EWQRSymmetric AbsoluteAsymmetric SolpeIndirect GARCHIndirect AdaptiveIndirect AR-GARCHIndirect GARCHIndirect GARCHGARCH GARCH<	EWQRSymmetric AbsoluteAsymmetric SolpeIndirect GARCHIndirect AdaptiveIndirect AR-GARCHIndirect GARCHGARCH GARCHGARCH GARCHGARCH GARCHGARCH GARCHGARCH GARCHGJRGJR GJR	EWQR         Symmetric Absolute         Asymmetric Slope         Indirect GARCH         Indirect Absolute         Indirect Slope         Indirect GARCH         CARCH         GARCH         GARCH         GJR         GJR<	EWQR         Symmetric Absolute         Asymmetric Slope         Indirect GARCH         Indirect Absolute         Indirect Slope         Indirect GARCH         CARCH         GARCH         GARCH         GARCH         GJR         GJR	EWQR EWQRSymmetric AbsoluteAsymmetric StopeIndirect GARCHIndirect Adaptive StopeIndirect GARCHIndirect GARCHCARCH GARCHGARCH GARCHGARCH GARCHGARCH GARCHGARCH GARCHGJR 	EWQR EWQRSymmetric Absolute ValueAsymmetric Stope CAViaRIndirect GARCHIndirect<

	GJR Skew t	0.40	3.60	8.20	11.00	3.00	0.40
	GJR GED	0.80	4.20	8.20	10.20	2.40	0.20
	GJR Student t	0.60	4.40	8.20	10.80	3.00	0.20
	GJR Normal	0.80	4.20	8.00	9.40	2.60	0.60
	GARCH Skew t	0.40	3.60	8.40	10.40	3.20	0.60
	GARCH GED	0.60	4.20	8.40	10.00	2.60	0.40
NYMEX	GARCH Student t	0.60	4.20	9.20	10.00	2.80	0.40
Light Crude Oil - NYMEX	GARCH Normal	0.80	4.60	7.80	9.00	2.80	0.60
Ligh	Indirect AR-GARCH CAViaR	0.40	3.20	9.00	8.40	3.00	0.40
	Adaptive CAViaR	0.00	2.80	6.80	7.00	2.60	0.20
	Indirect GARCH CAViaR	0.40	4.20	9.80	8.80	3.20	0.40
	Asymmetric Slope CAViaR	0.60	3.20	8.80	10.40	2.60	0.20
	Symmetric Absolute Value CAViaR	0.40	3.80	9.20	9.60	3.00	0.60
	EWQR	0.40	3.20	7.00	7.20	2.60	0.40
	Quantile	1 %	5 %	10 %	90 %	95 %	% 66

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Table E42: Hitpercentage for Brent Crude Oil on ICE and Light Crude Oil on NYMEX

		_						1	Г
	GJR Skew t	0.80	3.20	6.20	9.80	4.20	0.40		
	GJR GED	1.00	4.00	6.60	9.00	3.20	0.40		
	GJR Student t	1.00	4.00	6.80	9.20	3.60	0.40		
	GJR Normal	1.00	4.00	6.60	8.80	3.20	0.40	•	
	GARCH Skew t	0.80	3.60	7.00	9.60	4.80	0.80	•	
	GARCH GED	1.00	3.80	00'L	09.6	3.40	0.20		
MEX	GARCH Student t	1.00	3.80	7.40	09.6	3.60	0.20		
<b>Gasoline - NYMEX</b>	GARCH Normal	1.00	3.80	00''	9.40	3.60	0.60		
	Indirect AR-GARCH CAViaR	0.20	3.80	8.00	8.60	3.00	1.40		
	Adaptive CAViaR	0.80	3.40	8.00	8.40	3.60	0.20		
	Indirect GARCH CAViaR	0.80	3.40	09''	7.40	3.00	1.00		
	Asymmetric Slope CAViaR	09.0	3.80	7.20	09.6	3.60	1.20		
	Symmetric Absolute Value CAViaR	0.60	3.60	7.60	00.6	3.20	1.80		
	EWQR	1.00	3.80	8.60	9.20	3.20	0.80		
	Quantile	1 %	5 %	10 %	% 06	95 %	% 66		

	GJR Skew t	0.00	4.40	9.00	00.6	3.80	0.00
	GJR GED	0.00	4.00	9.00	8.80	3.80	0.00
	GJR Student t	0.00	4.20	9.00	9.20	4.00	0.00
	GJR Normal	0.20	3.80	8.40	8.00	3.80	0.20
	GARCH Skew t	0.00	4.40	9.00	8.80	3.80	0.00
	GARCH GED	0.00	4.00	9.00	8.80	3.80	0.00
'MEX	GARCH Student t	0.00	4.20	9.00	9.20	4.00	0.00
Heating Oil - NYMEX	GARCH Normal	0.20	4.00	8.40	8.20	3.80	0.20
He	Indirect AR-GARCH CAViaR	0.40	4.40	8.60	8.20	3.20	0.40
	Adaptive CAViaR	0.00	2.20	6.40	7.80	3.40	0.20
	Indirect GARCH CAViaR	0.20	4.60	9.00	8.60	3.20	0.00
	Asymmetric Slope CAViaR	0.60	4.00	9.00	7.80	3.60	0.00
	Symmetric Absolute Value CAViaR	0.20	4.00	00.6	7.40	3.60	0.00
	EWQR	0.40	3.40	8.20	8.20	3.80	0.80
	Quantile	1 %	5 %	10%	% 06	95 %	% 66

Proportion of losses greater than the forecasted VaR for each of the return quantiles. Ideally 1.00 for 1%, 5.00 for 5%, 10.00 for 10%, 10.00 for 90%, 5.00 for 95% and 1.00 for 99%.

Table E43: Hitpercentage for Gasoline and Heating Oil on NYMEX

## **Appendix F: Source Codes**

### F.1 Overview

The source codes for calculating the different VaR and ES models and tests are left in the attached zip-file. EWQR is programmed in EViews since it is relatively easy to perform this kind of quantile regression with it. The other models are implemented in MATLAB. The VaR tests have been implemented in both EViews and MATLAB, for easier VaR testing, while the ES tests have been written only in MATLAB.

The parameters of GARCH and GJR-GARCH are estimated using Kevin Sheppard's "Oxford MFEToolbox", which can be downloaded together with program documentation at <a href="http://www.kevinsheppard.com/wiki/MFE\_Toolbox">http://www.kevinsheppard.com/wiki/MFE\_Toolbox</a>. We found a bug in the file "gedinv.m", which made it produce wrong answers when the input quantiles were all above or below 0.5. We have therefore changed the file to make sure that it works properly. When the input contains quantiles both above and below 0.5, there is no problem using the original file. Another bug was found and corrected for "skewtinv.m". Input values for degrees of freedom that were too high led to the answer NaN, since the function then divided two terms that were infinity. We avoided this by implementing an if-statement that inserts the following limit value when this problem occurs.

$$c = \lim_{v \to \infty} \frac{\Gamma\left(\frac{v+1}{2}\right)}{\sqrt{\pi(v-2)}\Gamma\left(\frac{v}{2}\right)} = \frac{1}{\sqrt{2\pi}}$$

The implementation of CAViaR has been based on the public codes of Engle and Manganelli, found at <u>http://www.simonemanganelli.org/Simone/Research.html</u>, which have been simplified and tailored to this paper. Among the changes made are the exclusion of in-sample testing and the inclusion of the indirect AR-GARCH CAViaR model.

In all programs "theta" refers to the quantiles considered of the return distribution. In this paper the 1%, 5%, 10%, 90%, 95% and 99% quantiles are considered. Values of theta greater than 50% have been assumed to correspond to short trading position, while values below 50% correspond to long trading position. This is because VaR and ES are risk measures that consider extreme losses. For short trading positions these are found in the right tail of the returns distribution, since a loss occur when the price change is positive, while for long trading positions these are in the left tail, since losses occur for negative price changes. The 1%, 5%, 10%, 90%, 95% and 99% quantiles in the return distribution therefore correspond to the 90%, 95% and 99% quantiles in the loss distribution for long and short trading positions, respectively.

In some of the programs random functions ("rand" and "randi") have been used. To ensure reproducibility of our results, we have let the seed to the random functions be constant. In this paper the number 50 is used.

### F.2 How to Run the Programs

Each of the programs calculates VaR and ES for one return series at the time. This is to provide the user the flexibility to easily apply the models to other time series by changing input, and to allow the results to be stored in separate files if desired. When working in

MATLAB it is important to add all the relevant folders and subfolders to the path in order to make all functions available. In addition to the programs provided in the attached zip-file, the Statistics Toolbox for MATLAB needs to be added to use the GARCH program, since it calls some probability distribution functions from the toolbox. For the CAViaR program, some functions are written in C, to make the programs up to a hundred times quicker. In order to call them from MATLAB, they must be converted to MEX files with a C compiler. Our MEX files are found in the attached zip file.

### F.2.1 EWQR

First, a work file containing the relevant return series needs to be open in EViews. This series needs to be named "r" for the program to run. Open the file "ewqr. prg" and click run. Among the variables created in the work file are then "var" and "es", which are matrices containing the VaR and ES forecasts respectively. The vector "theta" contains the considered quantiles, and the columns of "var" and "es" correspond to the elements for "theta".

Regarding the VaR tests, the program "coverage tests" needs to be run before the "dqtest". The p-values from the tests are displayed in pop-up windows, but can also be found in the work file as "ucpvalue" (p-value for the unconditional coverage test), "ccpvalue" (p-value for the conditional coverage test) and "dqpvalue" (p-value for the dynamic quantile test). Each row correspond to the test result for a quantile in "theta".

The ES tests are written in MATLAB. Thus, to perform them some variables need to be exported from EViews and imported to MATLAB. Export the return series "r" and the VaR and ES forecasts "var" and "es". Import them to MATLAB and run "estest". This test considers only one quantile at the time, and is done by writing the following command in MATLAB, where r is the out-of-sample period of the returns, THETA is the quantile to consider, VaR and ES are the column of "var" and "es", respectively, that correspond to THETA, and nb is the number of bootstraped samples to consider (e.g. 10000).

```
[DV1 DV2 IV1 IV2] = estest(r,THETA,VaR,ES,nb)
```

The test results are then put in the variables: "DV1" (one-sided DV test), "DV2" (two-sided DV test), "IV1" (one-sided IV test) and "IV2" (two-sided DV test).

### F.2.2 GARCH

To run the GARCH program in MATLAB, simply type one of the following two commands, where r is replaced by the name of a return series that is imported as a variable in MATLAB.

```
rungarch(r,1)
```

rungarch(r,2)

Use the first line to use GARCH(1,1) to estimate VaR and ES, and the second line to use GJR-GARCH(1,1,1). Both of them automatically estimate VaR and ES for all of the six quantiles (1%, 5%, 10%, 90%, 95% and 99%) and the four distributions (normal, student t, GED and skewed student t) and perform the VaR and ES tests. The test results for VaR are saved in the variables "UCpvalue" (unconditional coverage test), "CCpvalue" (conditional coverage test), "DQpvalue" (dynamic quantile test), while the ES test results are names as for EWQR.

### F.2.3 CAViaR

A difference between the CAViaR program and the others is that the return series is not imported to MATLAB before running the program. Instead, the program imports it from a .txt file. In order to do so, it is important to change the saving path in line 39 of "CAViaR.m" and the loading path with corresponding variable in lines 34 and 35 of "CAViaROptimisation.m". When this is done, run the program by typing:

### CAViaR

The program automatically estimates VaR for each quantile for each of the following five CAViaR specifications:

1: Symmetric Absolute Value

- 2: Asymmetric Slope
- 3: Indirect GARCH
- 4: Adaptive
- 5: Indirect AR-GARCH

The name of the test result variables are the same as for GARCH. In addition more information about each model and quantile is saved in structures such as "output(x)\_(y)", where x refers to the CAViaR specification and y to the quantile. For example does the structure "output1\_5" contain among other things VaR forecasts, the hit percentage, volatility forecasts and parameters for the first CAViaR model at the 5% quantile.