CRUDE OIL PRICE PREDICTION

LITERATURE SURVEY:

The goal of this article is to review the existing literature on crude oil price forecasting. We categorized the existing forecasting techniques into the two main groups of quantitative and qualitative methods; and then we performed an almost comprehensive survey on the available literature with respect to these two main forecasting techniques.

J Cai "A Markov model of switching-regime ARCH Journal of Business & Economic Statistics, volume 12"

In this article I present a new approach to model more realistically the variability of financial time series. I develop a Markov-ARCH model that incorporates the features of both Hamilton's switching-regime model and Engle's autoregressive conditional heteroscedasticity (ARCH) model to examine the issue of volatility persistence in the monthly excess returns of the three-month treasury bill. The issue can be resolved by taking into account occasional shifts in the asymptotic variance of the Markov-ARCH process that cause the spurious persistence of the volatility process. I identify two periods during which there is a regime shift, the 1974:2-1974:8 period associated with the oil shock and the 1979:9-1982:8 period associated with the Federal Reserve's policy change. The variance approached asymptotically in these two episodes is more than 10 times as high as the asymptotic variance for the remainder of the sample. I conclude that regime shifts have a greater impact on the properties of the data, and I cannot reject the null hypothesis of no ARCH effects within the regimes. As a consequence of the striking findings in this article, previous empirical results that adopt an ARCH approach in modeling monthly or lower frequency interest-rate dynamics are rendered questionable.

C W Cheong "Modeling and forecasting crude oil markets using ARCH-type models Energy Policy, volume 37".

This study investigates the time-varying volatility of two major crude oil markets, the West Texas Intermediate (WTI) and Europe Brent. A flexible autoregressive conditional heteroskedasticity (ARCH) model is used to take into account the stylized volatility facts such as clustering volatility, asymmetric news impact and long memory volatility among others. The empirical results indicate that the intensity of long-persistence volatility in the WTI is greater than in the Brent. It is also found that for the WTI, the appreciation and depreciation shocks of the WTI have similar impact on the resulting volatility. However, a leverage effect is found in Brent. Although both the estimation and diagnostic evaluations are in favor of an asymmetric long memory ARCH model, only the WTI models provide superior in the out-of-sample forecasts. On the other hand, from the empirical out-of-sample forecasts, it appears that the simplest parsimonious generalized ARCH provides the best forecasted evaluations for the Brent crude oil data.

G Chevillon , C Rifflart “Physical market determinants of the price of crude oil and the market premium Energy Economics, volume 31”.

We analyze the determinants of the real price of crude oil by means of an equilibrium correction model over the last two decades where we focus on the aspects of the physical market that impact on the clearing price. We find that two cointegrating relations affect the changes in prices: one refers to OPEC's behavior, attempting to control prices using its market power and quotas; the other to the coverage rate of OECD expected future demand using inventory behaviors. We derive a forecasting equation for the change in oil prices which we use to assess the speculative elements of the price increases of the period 2000–05. We show that worries alien to the physical markets were the causes of the increase in oil prices and we quantify their overall impact.

A Coppola.”Forecasting oil price movements: exploiting the information in the futures market Journal of Futures Market, volume 28”.

Relying on the cost of carry model, the long-run relationship between spot and futures prices is investigated and the information implied in these cointegrating relationships is used to forecast out of sample oil spot and futures price movements. To forecast oil price movements, a vector error correction model (VECM) is employed, where the deviations from the long-run relationships between spot and futures prices constitute the equilibrium error. To evaluate forecasting performance, the random walk model (RWM) is used as a benchmark. It was found that (a) in-sample, the information in the futures market can explain a sizable portion of oil price movements; and (b) out-of-sample, the VECM outperforms the RWM in forecasting price movements of 1-month futures contracts. © 2008 Wiley Periodicals, Inc. Jrl Fut Mark 28:34–56, 2008.

G Cortazar, E S Schwartz.”Implementing a Stochastic Model for Oil Futures Prices Energy Economics, volume 25”.

This paper develops a parsimonious three-factor model of the term structure of oil futures prices that can be easily estimated from available futures price data. In addition, it proposes a new simple spreadsheet implementation procedure. The procedure is flexible, may be used with market prices of any oil contingent claim with closed form pricing solution, and easily deals with missing data problems. The approach is implemented using daily prices of all futures contracts traded at the New York Mercantile Exchange between 1991 and 2001. In-sample and out-of-sample tests indicate that the model fits the data extremely well. Though the

paper concentrates on oil, the approach can be used for any other commodity with well-developed futures markets.

A Costello, E Asem, E Gardner."Comparison of historically simulated VaR: evidence from oil prices.Energy Economics, volume 30".

Cabedo and Moya [Cabedo, J.D., Moya, I., 2003. Estimating oil price 'Value at Risk' using the historical simulation approach. Energy Economics 25, 239–253] find that ARMA with historical simulation delivers VaR forecasts that are superior to those from GARCH. We compare the ARMA with historical simulation to the semi-parametric GARCH model proposed by Barone-Adesi et al. [Barone-Adesi, G., Giannopoulos, K., Vosper, L., 1999. VaR without correlations for portfolios of derivative securities. Journal of Futures Markets 19 (5), 583–602]. The results suggest that the semi-parametric GARCH model generates VaR forecasts that are superior to the VaR forecasts from the ARMA with historical simulation. This is due to the fact that GARCH captures volatility clustering. Our findings suggest that Cabedo and Moya's conclusion is mainly driven by the normal distributional assumption imposed on the future risk structure in the GARCH model.

J Davidson."Moment and memory properties of linear conditional heteroscedasticity models, and a new model Journal of Business & Economic Statistics, volume 22" .

This article analyses the statistical properties of that general class of conditional heteroscedasticity models in which the conditional variance is a linear function of squared lags of the process. GARCH, IGARCH, FIGARCH, and a newly proposed generalization, the HYGARCH model, belong to this class. Conditions are derived for the existence of second and fourth moments, and for the limited memory condition of near-epoch dependence. The HYGARCH model is applied to 10 daily dollar exchange rates, and also to data for Asian exchange rates over the 1997 crisis period. In the latter case, the model exhibits notable stability across the pre-crisis and post-crisis periods.

F X Diebold, R S Mariano."Comparing predictive accuracy Journal of Business & Economic Statistics, volume 13".

We propose and evaluate explicit tests of the null hypothesis of no difference in the accuracy of two competing forecasts. In contrast to previously developed tests, a wide variety of accuracy measures can be used (in particular, the loss function need not be quadratic and need not even be symmetric), and forecast errors can be non-Gaussian, nonzero mean, serially correlated, and

contemporaneously correlated. Asymptotic and exact finite-sample tests are proposed, evaluated, and illustrated.

Z Ding, C W J Granger, R F Engle.”A long memory property of stock market returns and a new model Journal of Empirical Finance, volume 1”.

A ‘long memory’ property of stock market returns is investigated in this paper. It is found that not only there is substantially more correlation between absolute returns than returns themselves, but the power transformation of the absolute return $|r_t|^d$ also has quite high autocorrelation for long lags. It is possible to characterize $|r_t|^d$ to be ‘long memory’ and this property is strongest when d is around 1. This result appears to argue against ARCH type specifications based upon squared returns. But our Monte-Carlo study shows that both ARCH type models based on squared returns and those based on absolute return can produce this property. A new general class of models is proposed which allows the power δ of the heteroskedasticity equation to be estimated from the data.

B Dong, C Cao, S E Lee.”Applying support vector machines to predict building energy consumption in tropical region Energy and Buildings, volume 37”.

The methodology to predict building energy consumption is increasingly important for building energy baseline model development and measurement and verification protocol (MVP). This paper presents support vector machines (SVM), a new neural network algorithm, to forecast building energy consumption in the tropical region. The objective of this paper is to examine the feasibility and applicability of SVM in building load forecasting area. Four commercial buildings in Singapore are selected randomly as case studies. Weather data including monthly mean outdoor dry-bulb temperature (T_0), relative humidity (RH) and global solar radiation (GSR) are taken as three input features. Mean monthly landlord utility bills are collected for developing and testing models. In addition, the performance of SVM with respect to two parameters, C and ε, was explored using stepwise searching method based on radial-basis function (RBF) kernel. Finally, all prediction results are found to have coefficients of variance (CV) less than 3% and percentage error (%error) within 4%.

Y Fan, Y-J Zhang, Y J Tsai, H T Wei, Y M.”Estimating value at risk of crude oil price and its spillover effect using the GED-GARCH approach Energy Economics, volume 30”.

Estimation has been carried out using GARCH-type models, based on the Generalized Error Distribution (GED), for both the extreme downside and upside Value-at-

Risks (VaR) of returns in the WTI and Brent crude oil spot markets. Furthermore, according to a new concept of Granger causality in risk, a kernel-based test is proposed to detect extreme risk spillover effect between the two oil markets. Results of an empirical study indicate that the GED-GARCH-based VaR approach appears more effective than the well-recognized HSAF (i.e. historical simulation with ARMA forecasts). Moreover, this approach is also more realistic and comprehensive than the standard normal distribution-based VaR model that is commonly used. Results reveal that there is significant two-way risk spillover effect between WTI and Brent markets. Supplementary study indicates that at the 99% confidence level, when negative market news arises that brings about a slump in oil price return, historical information on risk in the WTI market helps to forecast the Brent market. Conversely, it is not the case when positive news occurs and returns rise. Historical information on risk in the two markets can facilitate forecasts of future extreme market risks for each other. These results are valuable for anyone who needs evaluation and forecasts of the risk situation in international crude oil markets.

W M Fong, K H See.”A Markov switching model of the conditional volatility of crude oil prices Energy Economics, volume 24”.

This paper examines the temporal behaviour of volatility of daily returns on crude oil futures using a generalised regime switching model that allows for abrupt changes in mean and variance, GARCH dynamics, basis-driven time-varying transition probabilities and conditional leptokurtosis. This flexible model enables us to capture many complex features of conditional volatility within a relatively parsimonious set-up. We show that regime shifts are clearly present in the data and dominate GARCH effects. Within the high volatility state, a negative basis is more likely to increase regime persistence than a positive basis, a finding which is consistent with previous empirical research on the theory of storage, e.g. Fama and French, 1988a, Fama and French, 1988b and Ng and Pirrong (1994). The volatility regimes identified by our model correlate well with major events affecting supply and demand for oil. Out-of-sample tests indicate that the regime switching model performs noticeably better than non-switching models regardless of evaluation criteria. We conclude that regime switching models provide a useful framework for the financial historian interested in studying factors behind the evolution of volatility and to oil futures traders interested short-term volatility forecasts.

A Gaffari, S Zare.”A novel algorithm for prediction of crude oil price variation based on soft computing Energy Economics, volume 31”.

In this paper a method based on soft computing approaches is developed to predict the daily variation of the crude oil price of the West Texas Intermediate (WTI). The predicted daily oil price variation is compared with the actual daily variation of the oil price and the difference is implemented to activate the learning algorithms. In order to reduce the effect of

unpredictable short term disturbances, a data filtering algorithm is used. In this paper, the prediction is called “true” if the predicted variation of the oil price has the same sign as the actual variation, otherwise the prediction is “false”. It is shown that for several randomly selected durations, the true prediction is considerably higher than the result of most recent published prediction algorithms. To ensure the accuracy and reliability of the algorithm, several on line predictions are executed during one complete month. The on line results indicate that the true predictions are consistently the same percentage for periods of one month.

P Giot, S Laurent.”Market risk in commodity markets: a VaR approach Energy Economics, volume 25”.

We put forward Value-at-Risk models relevant for commodity traders who have long and short trading positions in commodity markets. In a 5-year out-of-sample study on aluminium, copper, nickel, Brent crude oil and WTI crude oil daily cash prices and cocoa nearby futures contracts, we assess the performance of the RiskMetrics, skewed Student APARCH and skewed student ARCH models. While the skewed Student APARCH model performs best in all cases, the skewed Student ARCH model delivers good results and its estimation does not require non-linear optimization procedures. As such this new model could be relatively easily integrated in a spreadsheet-like environment and used by market practitioners.

S L Green, K M Mork.”Towards Efficiency in the rude Oil Market Journal of Applied Econometrics”.

The ‘official’ (OPEC) prices of crude oil before the collapse in the oil market in the mid-1980s can be interpreted as contract prices and analysed on the basis of the theory of futures (or forward) markets. This paper uses the generalized method of moments estimation technique to test for efficiency in the relationship between the official prices and the ex-post spot prices at the time of delivery. Efficiency is rejected for the sample period 1978–1985 as a whole, but evidence is found of improvements over time. Further, the GMM Wald and Hansen tests, although asymptotically equivalent, are shown to differ greatly when applied to a small sample of monthly oil price data.

S G Gulen.”Efficiency in the Crude Oil Futures Markets Journal of Energy Finance and Development”.

This paper addresses the issue of “simple efficiency,” which states that the futures price is an unbiased predictor of the spot price, in the case of trading in crude oil futures at NYMEX. This issue received considerable attention in the literature using cointegration analysis. This paper, however, explicitly deals with the crash in 1986, which is built into the analysis as a structural break following Perron (1989), and, more importantly, analyzes the trivariate system of spot-futures-posted prices in addition to bivariate spot-futures and spot-posted systems. The results indicate that the futures price of light sweet crude oil traded at

NYMEX plays a significant role in price discovery. This observation is also supported by the widespread use of the futures price as a benchmark all over the world as well as by the decision of the U.S. Minerals Management Service to switch to the futures price from the posted price as the standard for calculating royalties.

M Haas, S Mittnik, M S Paollela.”Mixed normal conditional heteroscedasticity Journal of Financial Econometrics”.

Both unconditional mixed normal distributions and GARCH models with fat-tailed conditional distributions have been employed in the literature for modeling financial data. We consider a mixed normal distribution coupled with a GARCH-type structure (termed MN-GARCH) which allows for conditional variance in each of the components as well as dynamic feedback between the components. Special cases and relationships with previously proposed specifications are discussed and stationarity conditions are derived. For the empirically most relevant GARCH(1,1) case, the conditions for existence of arbitrary integer moments are given and analytic expressions of the unconditional skewness, kurtosis, and autocorrelations of the squared process are derived. Finally, employing daily return data on the NASDAQ index, we provide a detailed empirical analysis and compare both the in-sample fit and out-of-sample forecasting performance of the MN-GARCH as well as recently proposed Markov-switching models. We show that the MN-GARCH approach can generate a plausible disaggregation of the conditional variance process in which the components' volatility dynamics have a clearly distinct behavior, which is, for example, compatible with the well-known leverage effect.

M Haas, S Mittnik, M S Paollela.”A new approach to Markov-switching GARCH models Journal of Financial Econometrics”.

The use of Markov-switching models to capture the volatility dynamics of financial time series has grown considerably during past years, in part because they give rise to a plausible interpretation of nonlinearities. Nevertheless, GARCH-type models remain ubiquitous in order to allow for nonlinearities associated with time-varying volatility. Existing methods of combining the two approaches are unsatisfactory, as they either suffer from severe estimation difficulties or else their dynamic properties are not well understood. In this article we present a new Markov-switching GARCH model that overcomes both of these problems. Dynamic properties are derived and their implications for the volatility process discussed. We argue that the disaggregation of the variance process offered by the new model is more

plausible than in the existing variants. The approach is illustrated with several exchange rate return series. The results suggest that a promising volatility model is an independent switching GARCH process with a possibly skewed conditional mixture density.

J D Hamilton, R Susmel.”Autoregressive conditional heteroskedasticity and changes in regime.Journal of Econometrics”.

ARCH models often impute a lot of persistence to stock volatility and yet give relatively poor forecasts. One explanation is that extremely large shocks, such as the October 1987 crash, arise from quite different causes and have different consequences for subsequent volatility than do small shocks. We explore this possibility with U.S. weekly stock returns, allowing the parameters of an ARCH process to come from one of several different regimes, with transitions between regimes governed by an unobserved Markov chain. We estimate models with two to four regimes in which the latent innovations come from Gaussian and Student *t* distributions.

S Hammoudeh, V Madan.”Expectations, target zones and oil price dynamics Journal of Policy Modeling”.

This paper incorporates inventory shocks and market expectations in OPEC's oil pricing mechanism and applies the target zone and speculative attack literatures to oil price dynamics. The paper examines the oil price behavior in the two-sided target zone model and the asymmetric tolerance zone model. It focuses on the characteristics of the smooth-pasting and speculative-attack solutions that are associated with credible and noncredible intervention policies. The analysis shows that credibility of OPEC's intervention policy declines as its output ceiling is reduced to a low level, which makes the price vulnerable to speculative attacks, and increases as the ceiling rises. The credibility is directly related to sensitivity of the market price to changes in the output and the sensitivity of this price to changes in the price expectations, and is inversely related to the positive intertemporal bias in the size of the random shocks in the quantity.

P R Hansen.”A test for superior predictive ability .Journal of Business & Economic Statistics”.

We propose a new test for superior predictive ability. The new test compares favorably to the reality check (RC) for data snooping, because it is more powerful and less sensitive to poor and irrelevant alternatives. The improvements are achieved by two modifications of the RC. We use a studentized test statistic that reduces the influence of erratic forecasts and invoke a sample-dependent null distribution. The advantages of the new test are confirmed by Monte Carlo experiments and an empirical exercise in which we compare a large number of regression-based forecasts of annual U.S. inflation to a simple random-walk forecast. The random-walk forecast is found to be inferior to regression-based forecasts and, interestingly, the best sample performance is achieved by models that have a Phillips curve structure.

J C Hung, M C Lee, H C Liu.”Estimation of value-at-risk for energy commodities via fat-tailed GARCH models Energy Economics”.

The choice of an appropriate distribution for return innovations is important in VaR applications owing to its ability to directly affect the estimation quality of the required quantiles. This study investigates the influence of fat-tailed innovation process on the performance of one-day-ahead VaR estimates using three GARCH models (GARCH-*N*, GARCH-*t* and GARCH-HT). Daily spot prices of five energy commodities (WTI crude oil, Brent crude oil, heating oil #2, propane and New York Harbor Conventional Gasoline Regular) are used to compare the accuracy and efficiency of the VaR models.

Empirical results suggest that for asset returns that exhibit leptokurtic and fat-tailed features, the VaR estimates generated by the GARCH-HT models have good accuracy at both low and high confidence levels. Additionally, MRSB indicates that the GARCH-HT model is more efficient than alternatives for most cases at high confidence levels. These findings suggest that the heavy-tailed distribution is more suitable for energy commodities, particularly VaR calculation.

S H Kang, S M Kang, S M Yoon.”Forecasting volatility of crude oil markets Energy Economics”.

This article investigates the efficacy of a volatility model for three crude oil markets — Brent, Dubai, and West Texas Intermediate (WTI) — with regard to its ability to forecast and identify volatility stylized facts, in particular volatility persistence or long memory. In this context, we assess persistence in the volatility of the three crude oil prices using conditional volatility models. The CGARCH and FIGARCH models are better equipped to capture persistence than are the GARCH and IGARCH models. The CGARCH and FIGARCH models also provide superior performance in out-of-sample volatility forecasts. We conclude that the CGARCH and FIGARCH models are useful for modeling and forecasting persistence in the volatility of crude oil prices.

R K Kaufmann.”A Model of the World Oil Market for Project LINK: Integrating Economics Geology, and Politics. Economic Modelling”.

This paper describes a new model of the world oil market for Project LINK that integrates the effect of changes in the economic, geological and political environment. The model forecasts non-OPEC oil production using a new technique that quantifies the effect of geological, economic and political variables. The model forecasts real oil prices based on changes in market conditions and OPEC behaviour. Scenarios indicate that OPEC can influence the price for oil over the medium and long term by adjusting the rate at which it adds capacity. On the other hand, OPEC will find it difficult to influence oil prices by shutting in operable capacity.

R K Kaufmann, S Dees, A Gasteuil, M Mann.”Oil prices: the role of refinery utilization, futures markets and non-linearities Energy Economics”.

We test the hypothesis that real oil prices are determined in part by refinery capacity, non-linearities in supply conditions, and/or expectations and that observed changes in these variables can account for the rise in prices between 2004 and 2006. Results indicate that the refining sector plays an important role in the recent price increase, but not in the way described by many analysts. The relationship is negative such that higher refinery utilization rates reduce crude oil prices. This effect is associated with shifts in the production of heavy and light grades of crude oil and price spreads between them. Non-linear relationships between OPEC capacity and oil prices as well as conditions on the futures markets also account for changes in real oil prices. Together, these factors allow the model to generate a one-step ahead out-of-sample forecast that performs as well as forecasts implied by far-month contracts on the New York Mercantile Exchange and is able to account for much of the $27 rise in crude oil prices between 2004 and 2006.

C G Lamoureux, W D Lastrapes.”Persistence in variance, structural change, and the GARCH model Journal of Business & Economic Statistics”.

This article examines the persistence of the variance, as measured by the generalized autoregressive conditional heteroskedasticity (GARCH) model, in stock-return data. In particular, we investigate the extent to which persistence in variance may be overstated because of the existence of, and failure to take account of, deterministic structural shifts in the model. Both an analysis of daily stock-return data and a Monte Carlo simulation experiment confirm the hypothesis that GARCH measures of persistence in variance are sensitive to this type of model misspecification.