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On the predictive accuracy of crude oil futures prices

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Abstract

This paper evaluates the predictive accuracy of 1-, 3-, 6-, 9-, and 12-month ahead crude oil futures prices for 1991.01–2001.12. In addition to testing for unbiasedness, a naive forecasting model is constructed to generate comparable forecasts, as benchmarks. Our empirical findings reveal that futures prices and naive forecasts are unbiased at all forecast horizons. However, the 1-, and 12-month ahead futures prices are the only forecasts outperforming the naive, suggesting their potential usefulness in policy making. Continuing political instability of the Middle East and the inability of OPEC to offset market sentiment, among other factors, may in the future adversely affect the predictive accuracy of the 1- and 12-month ahead futures prices. Accordingly, caution must be exercised when utilizing such prices as a forecasting tool.

Keywords: Crude oil futures price; Futures market efficiency; Predictive information content

1. Introduction

The role of commodity and financial futures markets in providing an accurate picture of future movements in spot prices has been an area of extensive empirical investigation. This is particularly true for the crude oil futures markets, as crude oil price changes may potentially have significant effects on the economic performance of both oil importing and oil exporting countries. Sharp increases in crude oil prices adversely affect the economic growth and inflation of oil importing economies. On the other hand, crude oil price deteriorations, like the one in 1998, create serious budgetary problems for oil exporting countries. An effective policy response to such changes requires reliable and accurate short-term and long-term crude oil price forecasts. Whether or not crude oil futures prices provide such forecasts is the question investigated in this paper.

Recent studies testing market efficiency in this area offer mixed conclusions. For example, while Quan (1992) and Moosa and Al-Loughani (1994) argue against futures market efficiency in crude oil, Gulen (1998) and Peroni and McNown (1998) present evidence in support of it. Studies by Bopp and Sitzer (1987) and Bopp and Lady (1991) are in favor of market efficiency for the short-term or 1-month ahead futures price, but reject the notion of efficiency for longer-term futures prices.

Utilizing the test procedures suggested by Fair and Shiller (1989, 1990), this study adds to the literature by evaluating the forecasting performance of the 1- 3-, 6-, 9-, and 12-month ahead futures prices of crude oil for 1991.01–2001.12. In addition to testing for unbiasedness, we shall construct a naive forecasting model to generate comparable forecasts, as benchmarks, to investigate the predictive information content of futures prices. Our empirical findings reveal that futures prices and naive forecasts are unbiased at all forecast horizons. Unlike the 1- and 12-month ahead futures prices, which outperform the naive forecasts, the 3-, 6-, and 9-month ahead futures prices fail to outperform the naive forecasts.

This study is organized as follows. Section 2 describes the data and presents the test procedures. Section 3 discusses the empirical results. Section 4 concludes this paper.

2. Data and the test procedures

This study utilizes monthly spot and futures prices of West Texas Intermediate (WTI) crude oil. The monthly

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spot price is the closing spot price for the last trading day of the month. The monthly futures prices for 1-, 3-, 6-, 9-, and 12-month ahead contracts are the closing futures prices for the last trading day of the month. The data on the spot price of WTI are from the Energy Information Administration. The futures price data on the 1-, 3-, 6-, 9-, and 12-month ahead contracts are obtained from the New York Mercantile Exchange (NYME).

The logarithm of the spot price for month t is denoted by S_t. The logarithms of the 1-, 3-, 6-, 9-, and 12-month ahead futures prices made in month t are denoted, respectively, by PF_{t+1}, PF_{t+3}, PF_{t+6}, PF_{t+9}, and PF_{t+12}. The logarithms of comparable naive forecasts made in month t are denoted, respectively, by PN_{t+1}, PN_{t+3}, PN_{t+6}, PN_{t+9}, and PN_{t+12}. These forecasts are generated, based on the following naive model,

$$PN_{t+f} = S'_t \quad f = 1, 3, 6, 9, 12,$$

where S'_t is the logarithm of the closing spot price in the trading day before the last trading day of the month t. This is the most recently known spot price available on the last trading day of the month when the futures market forecasts, utilized here, are made.

The naive is the simplest form of forecast available and, therefore, may not be a good measure of forecast efficiency. This is because the naive forecast may not efficiently utilize the information available in the past history of the spot price. Futures market efficiency is rejected, if the naive forecast outperforms the futures price. However, the potential for accepting the futures market efficiency exists, if the futures price is unbiased and outperforms the naive forecast.

The unbiasedness of forecasts is examined by estimating

$$\begin{aligned} S_{t+f} - S_{t-1} &= a_0 + a_1(P_{t+f} - S_{t-1}) + v_{t+f} \\ f &= 1, 3, 6, 9, 12, \end{aligned} \tag{1}$$

where S_{t+f} is the logarithm of the crude oil spot price in month $t+f$ while P_{t+f} is the forecast of S_{t+f} made in month t with f defined as the forecast horizon. Following Fair and Shiller (1989, 1990), S_{t-1} is subtracted from both S_{t+f} and P_{t+f} to avoid problems due to the non-stationarity of the time series. The forecast fails to be unbiased if the null hypotheses $a_0 = 0$ and $a_1 = 1$ are individually and/or jointly rejected.

The predictive information content of the futures price, PF_{t+f}, is investigated by estimating

$$\begin{aligned} S_{t+f} - S_{t-1} = b_0 &+ b_1(PF_{t+f} - S_{t-1}) \\ &+ b_2(PN_{t+f} - S_{t-1}) \\ &+ v_{t+f}, \quad f = 1, 3, 6, 9, 12. \end{aligned} \tag{2}$$

The futures price outperforms the naive forecast, PN_{t+f}, when $\hat{b}_1$ is significant and $\hat{b}_2$ is insignificant. More specifically, significant $\hat{b}_1$ with insignificant $\hat{b}_2$ implies that the futures price includes more predictive information than that contained in the naive forecast. The converse is also true. Each forecast includes distinct information if $\hat{b}_1$ and $\hat{b}_2$ are both significant. Insignificant $\hat{b}_1$ and $\hat{b}_2$, furthermore, implies that each forecast contains similar information.

In estimating (1) and (2), the OLS parameter estimates are still consistent, but the OLS covariance matrix estimates prove to be inconsistent due to the serial correlation inherent in the forecast errors. For instance, when making the 1-month ahead forecast, the forecast error for the month in which the forecast is made is not yet known and thus is not part of the available information set. The possibility that v_{t+1} is correlated with the immediately preceding error, v_t, therefore, cannot be ruled out. This leads us to postulate a first-order moving average process for the 1-month ahead forecast error, under the null hypothesis of rationality. Similarly, a third-order moving average process is postulated for the 3-month ahead forecast error, v_{t+3}, a sixth-order moving average process for the 6-month ahead forecast error, v_{t+6}, and so on. That is,

$$v_{t+f} = \varepsilon_{t+f} + \sum_{j=1}^{f} \rho_j \varepsilon_{t+f-j}, \quad f = 1, 3, 6, 9, 12.$$

In addition, as also argued by Fair and Shiller (1990, p. 378), forecast errors, in general, are heteroskedastic. Allowing for the possibility of heteroskedasticity, the correct covariance matrix of Eqs. (1) and (2) is re-estimated, based on the procedure described below:

Consider the following general model

$$\mathbf{Y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{U},$$

where $\mathbf{Y}$ is the $(\mathbf{T} \times 1)$ vector of observations on the dependent variable, $\mathbf{X}$ is the $(\mathbf{T} \times \mathbf{k})$ matrix of observations on $\mathbf{k}$ explanatory variables, and $\mathbf{U}$ is the $(\mathbf{T} \times 1)$ vector of disturbances. Let $\hat{\beta}$ be the OLS estimator of $\boldsymbol{\beta}$; then the covariance matrix of, $\mathbf{V}(\hat{\beta})$, is estimated as

$$\mathbf{V}(\hat{\beta}) = (\mathbf{X}'\mathbf{X})^{-1}\mathbf{S}(\mathbf{X}'\mathbf{X})^{-1},$$

where

$$\mathbf{S} = \boldsymbol{\Omega}_0 + \sum_{j=1}^{f} (\boldsymbol{\Omega}_j + \boldsymbol{\Omega}_j')$$

In accounting for the heteroskedasticity, following White (1980),

$$\boldsymbol{\Omega}_0 = \sum_{t=1}^{T} \hat{\mathrm{u}}_{t+f}^2 \mathbf{x}'_{t+f} \mathbf{x}_{t+f}$$

and in accounting for the serial correlation,

$$\boldsymbol{\Omega}_j = \sum_{t=j+1}^{T} \hat{\mathrm{u}}_{t+f} \hat{\mathrm{u}}_{t+f-j} \mathbf{x}'_{t+f} \mathbf{x}_{t+f-j}, \quad j = 1, \ldots, f.$$

Note that $\hat{\mathrm{u}}_{t+f}$ is the OLS residual at row $t+f$ of matrix $\mathbf{U}$, and $\mathbf{x}_{t+f}$ is the row $t+f$ values of matrix $\mathbf{X}$. This procedure allows us to calculate the correct