EFFECTS OF WEEKLY INVENTORY DATA RELEASES ON CRUDE OIL SPOT PRICES

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Abstract

A weekly event which is frequently blamed for oil price movements is the moment when the US Energy Information Administration publishes its report on ending stocks of crude oil and petroleum products for the previous week. The data, usually released on Wednesdays, are awaited by market analysts as well as by investors, who compare them to some consensus forecast and draw conclusions on current supply and demand fundamentals.

The purpose of our study is to investigate the role of weekly inventory data releases as determinants of expectation and volatility of daily crude price changes.

While an ARIMA model provides us with a forcast of inventories levels, the residuals of this model render the markets' perception of deviation, which can be classified according to magnitude and sign. We study the residuals' impact on expectation and volatility of oil price changes on the basis of a combination of regression and GARCH models.

Among our findings is that an unexpected rise in US crude oil stocks boosts volatility much more pronouncedly than does an unexpected fall.

Key words: Crude oil prices; inventory data releases; ARIMA forecast; regression; GARCH with covariates; WTI crude oil

1 Introduction

On the days when weekly US ending stocks of crude and petroleum products are released, headlines like "Sharp rise in US inventories weighs on oil"[1] or vice versa "Oil prices increase after US inventories decline"[2] of economic news use to catch the reader's eye. The weekly oil report by the US Energy Information Administration, usually released on Wednesdays, is awaited by market analysts as well as by investors, who draw conclusions from changes in inventory on the current oil market supply and demand fundamentals.

The "swings" in crude oil prices appear to be "coupled with counter-swings" in inventories. — This frequent phenomenon is adopted by some short-run forecasting models of monthly crude

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[1] FT, 2010-01-15
[2] FT, 2006-12-14

oil prices by Ye, Zyren & Shore ([4], [6]). They focus on concepts of "normal" and "relative" levels, in the sense of deviation from the "normal", of market indicators such as demand, field production, net imports, and inventory. Empirically, Ye, Zyren & Shore ([5]) found that the demand elasticity with respect to short-run market price fluctuations is much less than the short-run inventory elasticity in the US, while the supply elasticity due to long production chains is virtually zero. Their conclusion is, that trends of inventory together with seasonal patterns reflect the supply/demand balance and matter crude prices in the long-run, while deviations from the "normal level" affect the price behaviour in the short run.

In our study we expand these ideas to ask:

- In which way do inventory data on the very day of their release bear on oil prices?
- In particular: Do prices respond to the markets' perception of deviation from some consensus forecast?

An ARIMA model provides us with a forcast of inventories levels, the residuals of this model render the markets' perception of deviation, which can be classified according to magnitude and sign. We study the residuals' impact on expectation and volatility of oil price changes on the basis of a combination of regression and GARCH models.

We restrict this paper to the investigation of US crude inventory releases and their impact on the behaviour of WTI price changes. Our empirical basis consists of data from January 2000 through December 2009, which is split into two five-year periods in order to account for the remarkable rise of prices during the recent five years in comparison to the early years in this decade.

All computations were carried out in R ([3]).

2 Data

The time series of daily WTI spot prices (in USD/barrel) and price changes in percent are shown in Figure 1. Prices are available from the website of the US Energy Information Administration.[3] Weekly US ending stocks of crude oil, petroleum products, and of the strategic petroleum reserve are posted to the web site after 10:30 a.m. Eastern Time on Wednesdays. For some weeks starting with public holidays, the release is delayed by one day. Figure 2 displays three sequences of weekly ending stocks (in thousand barrels) on the day of release.

3 Modeling the Effect of Inventories' Release Data

The idea of this investigation is that the market perception of deviations of released inventories data from forecast values can have an effect on the expectation of the return on crude oil prices, as well as on its volatility.

Our analysis proceeds in three steps: In the first step, we provide weekly forecasts of crude oil inventory levels and compare them to the data as released. Our forecasting model is an ARIMA(p,d,q)

$$\left(1-\sum_{i=1}^{p}\phi_i L^i\right)(1-L)^d\, x_t = \left(1+\sum_{i=1}^{q}\theta_i L^i\right)\epsilon_t' \tag{1}$$

where (x_t) is the series of weekly inventory levels as reported. L designates the lag operator and the integers p, d, and q refer to the order of the autoregressive, integrated, and moving average parts of the model, respectively.

[3] http://eia.doe.gov

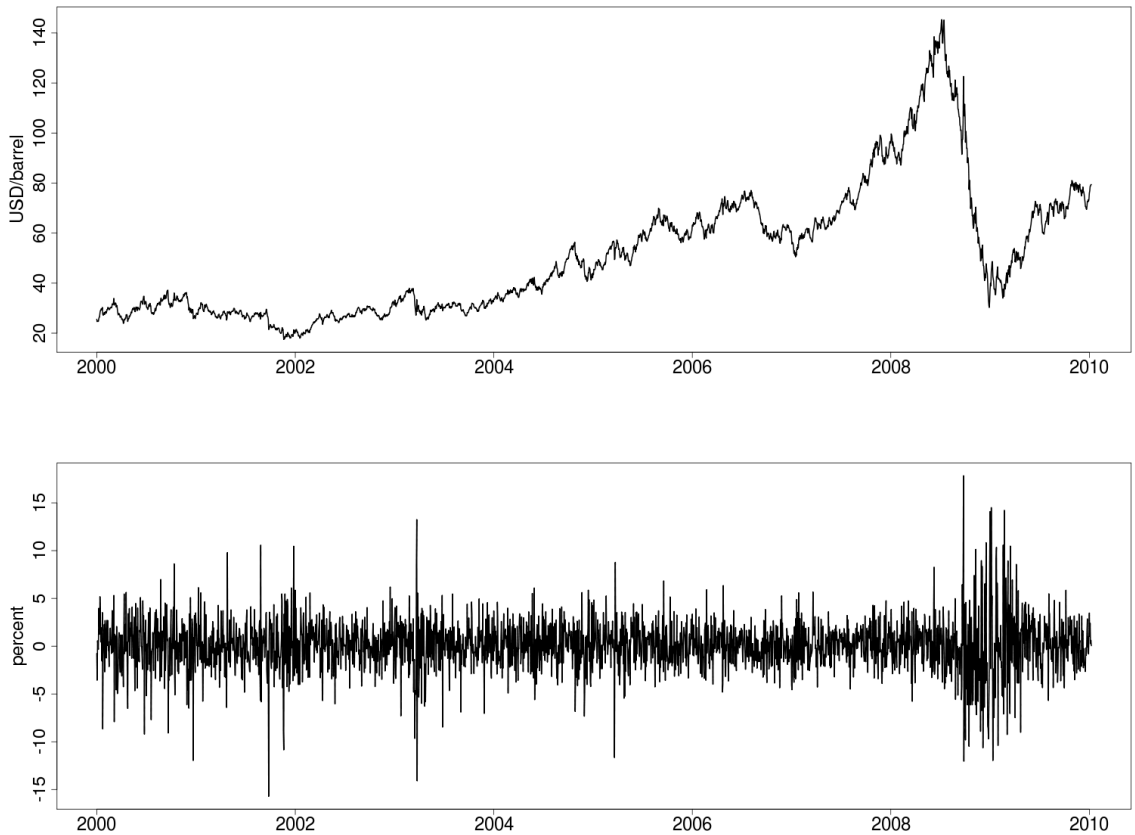

Figure 1: Daily WTI spot prices / price changes

The series of residuals ϵ'_t obtained from this forecasting model is standardized and transformed into variables d_t on a daily basis, with zeros inserted on days t without release of inventories data. The variables d_t, whose values can be classified according to magnitude and sign, serve as covariates to the following model:

$$r_t = c + \sum_i b_i d_{it} + \epsilon_t, \tag{2}$$

$$\epsilon_t = \nu_t \cdot \sqrt{h_t}, \tag{3}$$

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta h_{t-1} + \sum_i \gamma_i d_{it}, \tag{4}$$

where (r_t) is the series of daily returns in percent on the WTI crude spot price, and (d_{it}) is the series of covariates referring to an inventory deviation of type i from the forecast.

Equation (2) specifies the conditional expectation of r_t, with the standardized residuals from the inventory forecasting model as regressors. In the second step of our investigation, we fit the series of returns to this regression model and obtain regression residuals for modeling the volatility of returns in the third step.

Equations (3) and (4) specify the conditional variance of r_t, where (ν_t) is Gaussian white noise with $\mathrm{var}(\nu_t) = 1$. The conditional variance of r_t is also allowed to depend on the inventory variables d_{it}.[4]

Basically, two types of covariates are used in this model:

[4]Equation (4) is the conditional variance specification of a GARCH(1,1) process, see Engle [2], Bollerslev [1], with covariates added on.

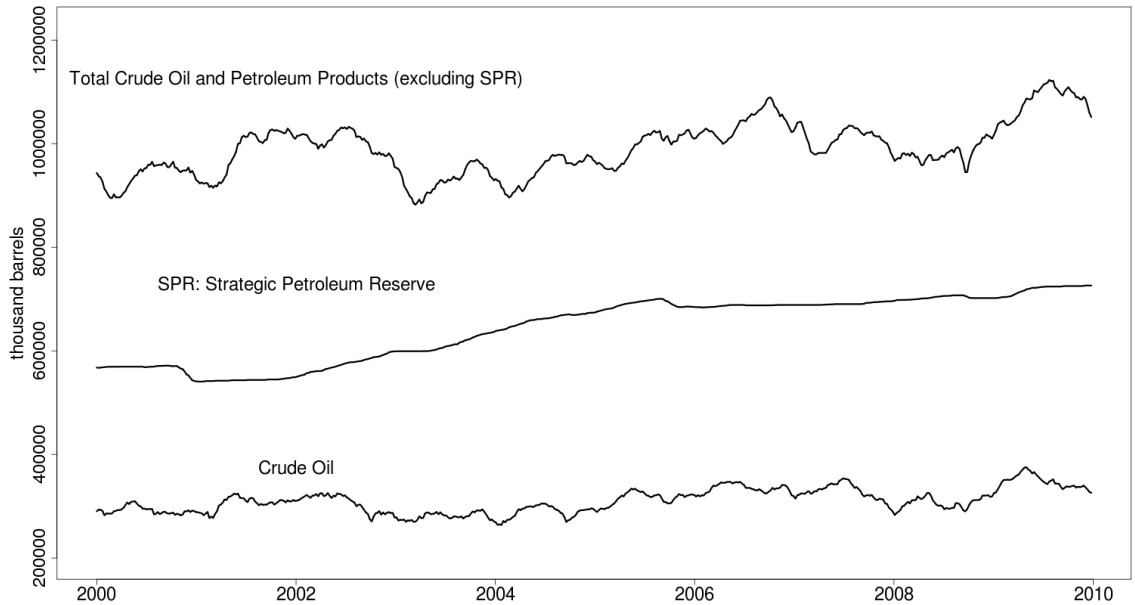

Figure 2: Weekly US ending stocks

$$
\begin{aligned}
d_{\text{pos},t} &= \begin{cases} d_t & \text{inventory data released on day } t \text{ show an increase as compared to the forecast,} \\ 0 & \text{no release on day } t, \end{cases} \\
d_{\text{neg},t} &= \begin{cases} |d_t| & \text{inventory data released on day } t \text{ show a decrease as compared to the forecast,} \\ 0 & \text{no release on day } t, \end{cases}
\end{aligned}
\tag{5}
$$

4 Empirical Results

Based on equations (1), (2), (3) and (4), a model for WTI price returns and volatility can now be constructed step by step. In the following, we display the estimation results concerning the time period from January 2005 until December 2009.

A. ARIMA model for crude inventories

An ARIMA(2,1,0) is used to fit the series of crude inventories data. Estimation results for this model are:[5]

$$
\begin{array}{cccc}
 & \text{estimate} & \text{std. error} & \\
\phi_1 & 0.2881 & 0.0612 & * \\
\phi_2 & 0.1587 & 0.0615 & *
\end{array}
\tag{6}
$$

The residual series from this model refers to deviations from the forecast values, and is shown in Figure 3.

B. Regression model for the expected return on WTI prices

In the next step, we fit a regression model to the sequence of crude returns w.r.t. the variables $d_{\text{pos},t}$ and $d_{\text{neg},t}$ in (5). Estimation results for this model are:

[5]The asterisk * indicates significance at the 5% level.

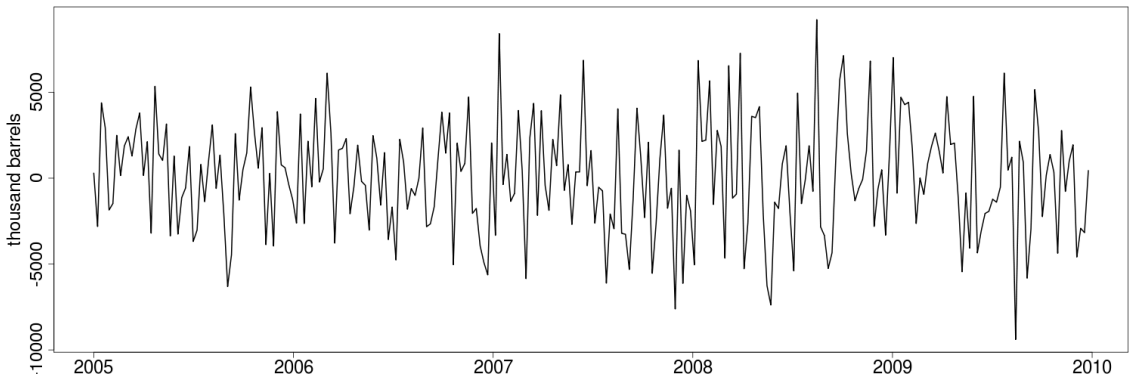

Figure 3: Inventories vs ARIMA forecast

	estimate	std. error	t value	$\Pr(>\|t\|)$	
c	0.09545	0.08411	1.135	0.25669	
b_{pos}	-0.77741	0.25137	-3.093	0.00203	*
b_{neg}	0.67520	0.25391	2.659	0.00793	*
AIC: 6138.049					

(7)

Deviations from the inventory forecasts impact on crude returns significantly and on the very day of the release of the data. If inventories fall below the forecast, returns on crude prices climb, while a surplus in inventories as compared to the forecast leads to a decline in returns.

C. Augmenting the regression model with a GARCH process

The residual series from the regression model in (**B**) is further analyzed on the basis of a GARCH process. Including the deviation variables $d_{\text{pos},t}$ and $d_{\text{neg},t}$ in (5) in the conditional variance specification amounts to a GARCH(1,1) process with covariates. Estimation results for this model are:

	estimate	std. error	t value	$\Pr(>\|t\|)$	
α_0	0.000000001	0.04907950	$2.037511e-08$	0.99999998	
α_1	0.068271661	0.01719143	$3.971260e+00$	0.00007149	*
β	0.909093765	0.02263250	$4.016763e+01$	0.00000000	*
γ_{pos}	1.009810182	0.39804800	$2.536906e+00$	0.01118371	*
γ_{neg}	0.607833322	0.28265797	$2.150420e+00$	0.03152202	*
AIC: 5706.739					

(8)

Again, deviations in either direction from the inventory forecasts show a significant impact. But volatility rises much more more pronouncedly if a surplus of inventories is witnessed.

Analogous investigations for the 5-year time period prior to the one we elucidated here, reveal significant effects of forecast deviations in neither direction on the volatility of price changes. However, an unexpected rise in inventories shows a significant impact on the conditional regression of returns.

5 Summary and Conclusions

The purpose of our study was to ascertain possible effects of the weekly release of US inventories data on the expectation and volatility behavior of WTI spot price changes in a daily time horizon. We apply a regression model with GARCH residuals, where covariates indicate the day of release as well as the amount of positive/negative deviation from the weekly forecast of crude inventories. The forecast is derived from an ARIMA specification for the series of inventory levels. The empirical basis of the investigation consisted of data from January 2000 through December 2009, which was split into two five-year periods for comparison reasons.

Our findings suggest that there is a pronounced impact of the market's perception of deviation on the behaviour of daily WTI price changes in the period from 2005 through 2009. There is an asymmetry w.r.t. the direction of deviation. An unexpected surplus of inventories implies a much higher volatility of price changes than if the forecast was undercut.

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