Noisy Inventory Announcements and Energy Prices

Abstract

This study examines the effect of oil and

1. Introduction

Commodity prices are volatile. There is much de cross-sectional data on analyst forecasts of inventory, both Gay et al. (2009) and Chang et al. (2009) provide evidence that prices react more strongly to forecasts of analysts with better prior forecast accuracy. Halova (2012) finds that unexpected changes in natural gas inventory have a statistically significant effect on prices of crude oil futures. Similarly, unexpected changes in crude oil inventory move natural gas futures prices.

Despite using intraday futures returns, Gay et al. (2009) report an R^2 of only about 23% for an event study regression that allows for time variation in the response of natural gas futures to the Natural Gas Storage Report announcements. Chang et al. (2009) obtain an R^2 of about 35% in the regression of intraday crude oil futures returns on the aggregate forecast error for crude oil, gasoline and distillate fuel oil. It is surprising that much of the price variation remains unexplained by fundamental news even in a narrow intraday window around the most important and widely anticipated information release of the week. Limited explanatory power of event study regressions is consistent with substantial amount of noise in the measured inventory surprises. Due to the presence of noise in measures of inventory surprises, previous estimates of the response of energy prices to such news have been biased towards zero. We contribute to this literature by adjusting for the measurement error bias using the identification-through-censoring technique proposed by Rigobon and Sack (2008).

We examine own- and cross-commodity responses of four energy commodities to inventory news. The results show that the attenuation bias in event study estimates of price responsiveness to inventory surprises is quite large. For example, based on event study estimates, an unexpected 1% increase in natural gas inventory seems to result in a 2.4% decline in natural gas futures prices. In contrast, our estimates adjusted for the measurement error bias show that natural gas prices fall by almost 10% on average in response to a 1% inventory shock. In other

2. Identification-Through-Censoring

In a typical event study, asset returns are regressed on the unexpected component of the data release. In the context of inventory announcements with one inventory surprise and one commodity return, this approach implies the following specification:

$$R_t \quad Z_t \quad H_t$$

data. Second, the announced value of the inventory change is a noisy estimate of the true change in inventory, for example, because the EIA's da

Sack (2008) propose a methodology called identification-through-censoring (ITC). Scheduled data releases occur at pre-specified times. On non-event days both the true surprise z_t^* and the measurement error η_t are zero. In effect, the measurement error is "censored" on non-event days. Returns on non-event days provide additional information needed for identification. This approach can be represented as follows:

$$R_t = \begin{cases} \gamma z_t^* + \varepsilon_t & t \in D \\ \varepsilon_t & t+1 \in D \end{cases} \qquad (5)$$

$$z_t = z_t^* + \eta_t,$$

where D is the set of announcement days. Assuming that σ_ε^2 does not change on announcement days, we can estimate this variance using returns before the announcement.[4] This model leads to the following set of moment conditions:

$$\begin{aligned} \operatorname{var}(R_{t-1}) &= \sigma_\varepsilon^2, \\ \operatorname{var}(R_t) &= \gamma^2 \sigma_{z^*}^2 + \sigma_\varepsilon^2, \\ \operatorname{var}(z_t) &= \sigma_{z^*}^2 + \sigma_\eta^2, \\ \operatorname{cov}(R_t, z_t) &= \gamma \sigma_{z^*}^2. \end{aligned} \qquad (6)$$

Solving these equations for the main parameter of interest, we get:

$$\gamma = \frac{\operatorname{var}(R_t) - \operatorname{var}(R_{t-1})}{\operatorname{cov}(R_t, z_t)}. \qquad (7)$$

Volatility varies over the trading day in a predictable manner. Therefore, we use pre-event-day returns in the same intraday interval as the interval used to compute event-day returns.

[4] Returns do not have to be conditionally homoscedastic to satisfy this identifying assumption. Return volatility varies over time. Yet, unless the varian

For example, when the Petroleum Status Report is released on the regular schedule (Wednesday at 10:30 a.m.), the event-window returns are computed in the interval from 10:25 a.m. to 10:40 a.m. on the day of the announcement. Non-announcement returns are computed in the interval from 10:25 a.m. to 10:40 a.m. on the day before.

The Petroleum Status Report announcements include inventory estimates for three petroleum commodities: crude oil, gasoline, and distillate. Chang et al. (2009) show that gasoline and distillate inventory surprises move crude oil futures prices. Therefore, in addition to the inventory surprise for crude oil, they also use the agga.m87petrol eum inventory surprise. However, inventory surprises for crude oil, gasoline and distillate are likely to have a larger effect on prices of crude oil, gasoline, and heating oil, respectively. The ITC estimation can easily accommodate multiple markets and multiple data surprises. In the case of three data surprises and three markets, the model becomes:

$$
\begin{aligned}
&R_{1,t} \quad J_{1,1} z^*_{1,t} \quad J_{2,1} z^*_{2,t} \quad J_{3,1} z^*_{3,t} \quad H_{1,t}, \\
&R_{2,t} \quad J_{2,1} z^*_{1,t} \quad J_{2,2} z^*_{2,t} \quad J_{3,2} z^*_{3,t} \quad H_{2,t}, \\
&R_{3,t} \quad J_{3,1} z^*_{1,t} \quad J_{3,1} z^*_{2,t} \quad J_{3,3} z^*_{3,t} \quad H_{3,t}, \\
&z_{1,t} \quad z^*_{1,t} \quad K_{1,t}, \\
&z_{2,t} \quad z^*_{2,t} \quad K_{2,t}, \\
&z_{3,t} \quad z^*_{3,t} \quad K_{3,t}.
\end{aligned}
\tag{8}
$$

Estimating this model involves 27 unknown parameters (nine response coefficients, three variances of the structural shocks $H_{i,t}$, three variances of the true surprises $z^*_{i,t}$, three variances of the noise terms $K_{i,t}$, three covariances of the structural shocks, three covariances of the surprises, and three covariances of the noise terms). Futures returns and the observed data surprises provide 27 moment equations. This number includes six moment equations provided by the variance-covariance matrix of non-announcement returns and 21 moment equations provided by the variance-covariance matrix of announcement window returns and inventory surprises. The model parameters can be estimated using the generalized method of moments (GMM).[5]

It is also interesting to examine the effect of the Petroleum Status Report announcements

3. Data and Sample Selection

3.1. Energy Inventory Reports

Our data for the U.S. inventory of crude oil and other petroleum products are obtained from the Weekly Petroleum Status Report compiled by the EIA. The data include weekly ending commercial stocks of crude oil, gasoline, and distillate fuel oil. The data included in the Petroleum Status Report are collected by the EIA on weekly surveys from a sample of operators at several key points along the petroleum production and supply chain.[7] The key data in the Petroleum Status Report are released at 10:30 a.m. (Eastern Time) every Wednesday for the week ending the previous Friday. For some weeks which include holidays, releases are delayed by one day.

The inventory data for natural gas represent weekly estimates of natural gas in underground storage in the Lower 48 States. These estimates are reported in the EIA's Weekly Natural Gas Storage Report.[8] The data in this report are obtained from a survey of a sample of natural gas storage operators. The report is released at 10:30 a.m. (Eastern Time) every Thursday, except for certain weeks that include Federal holidays. Historical dates and times of release for both inventory reports are obtained from Bloomberg.

Figure 1 shows historical values of inventory for crude oil, distillate, gasoline, and natural gas over our sample period.[9] The natural gas inventory exhibits strong seasonality. On average, natural gas inventory increases from April to November and falls during the heating season in winter and early spring.

[Insert Figure 1 about here]

[7] The survey and estimation methodology used in the Weekly Petroleum Status Report are described at http://www.eia.gov/pub/oil_gas/petroleum/data_publications/weekly_petroleum_status_report/current/pdf/appendixb.pdf
[8] The methodology used in the Natural Gas Storage Report is described at http://ir.eia.gov/ngs/methodology.html.
[9] These data are available on the EIA's website at http://www.eia.gov/.

3.2. Sample Selection

Our sample period extends from July 16, 2003 through June 27, 2012.[10] This period contains 468 releases of the Petroleum Status Report and 467 releases of the Natural Gas Storage Report. During this period, there were 30 occasions when the two reports were released simultaneously, at 10:30 a.m. on Thursdays. We exclude such simultaneous announcements from the sample. A few observations are removed due to missing futures returns data. The final sample contains 435 observations for each of the two inventory reports.

3.3. Inventory Surprises

To compute the unexpected changes in inventory, or inventory surprises, we need a proxy for the market expectations at the time of the inventory announcement. Following the previous literature, we use the Bloomberg consensus forecasts to measure expected changes in inventory. The consensus forecast is computed as the median of individual analyst forecasts. We compute inventory surprises as the difference between the actual and expected change in inventory, divided by the inventory level.

Summary statistics for inventory surprises are shown in Panel A of Table I. The standard deviation of inventory surprises for natural gas is lower than those for crude oil and other petroleum products. This indicates that natural gas inventory changes are more predictable than petroleum inventory changes. This higher predictability is likely to be related to the seasonal pattern in the natural gas inventory.

[Insert Table I about here]

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[10] Our sample period begins in July 2003 because the first Weekly Petroleum Status Report announcement date for which Bloomberg forecast data is available for all three petroleum commodities is July 16, 2003.

3.4. Energy Futures Returns

To examine the response of energy prices to inventory news, we use intraday futures prices for WTI crude oil, gasoline, heating oil, and natural gas.[11] These futures contracts are traded on the New York Mercantile Exchange (NYMEX). Energy futures markets are very liquid, with the combined average daily trading volume in the four futures contracts that we examine exceeding 1.2 million contracts in the first six months of 2012. Futures markets have been shown to dominate price discovery in energy commodities (e.g., Schwarz and Szakmary, 1994).

We compute continuously compounded returns in an intraday event window surrounding the inventory announcement surprises using prices of the nearby futures contract. The nearby contract becomes relatively illiquid in its last few days of trading. Therefore, in the last three days of trading of the nearby contract we substitute prices of the next closest contract. The event window is from five minutes before to ten minutes after the announcement time.[12] The 15-minute event window allows for a comparison of our results with results of existing studies looking at the market response to energy inventory announcements. For example, Gay, Simkins, and Turac (2009) also use 15-minute intervals containing the announcement.

Summary statistics for futures returns are shown in Panel B of Table I. The table also provides non-announcement day returns, which are used in the ITC estimation. We use equally matched numbers of event and non-event days. The non-announcement day returns are computed in the same 15-minute intraday intervals as the announcement day returns. For the Petroleum Status Report, the non-announcement day returns are computed using futures prices from the day before the announcement. Because the Petroleum Status Report is normally released exactly one

[11] The futures market data are obtained from Genesis Financial Technologies.
[12] The results with longer event windows are similar.

day before the Natural Gas Storage Report, the non-announcement day returns for the Natural Gas Storage Report are computed using futures prices from two days before the announcement.

The table shows that volatility of petroleum futures returns approximately doubles when the Petroleum Status Report is released. The increase in volatility of the natural gas futures around releases of the Natural Gas Storage Report is even larger. Volatility of natural gas futures returns also increases somewhat after the release of the Petroleum Status Report. In contrast, volatility of petroleum futures seems to be unchanged after the release of the Natural Gas Storage Report.

Figure 2 shows cumulative average returns (CARs) for crude oil and natural gas futures around the inventory announcements. The CARs are presented separately for positive and negative inventory surprises. Futures prices tend to increase when the inventory is lower than expected and decline when the inventory is larger than expected. The negative relation between excess supply shocks and futures return movements is consistent with basic economic theory (prices fall when supply increases). The natural gas futures returns after the release of the Natural Gas Storage Report tend to be larger in absolute value than returns in the crude oil futures market following the release of the Petroleum Status Report. There also seems to be some asymmetry between the effects of positive and negative inventory surprises. Specifically, positive inventory surprises tend to be followed by bigger price moves, particularly in the natural gas futures market. Overall, the figure shows that the price impact of the news is immediate and appears to be permanent.

[Insert Figure 2 about here]

4. Empirical Results

4.1. Full Sample Results

Estimation results for the effect of petroleum inventory surprises on energy prices are presented in Table II.[13] According to the OLS estimates, a 1% unexpected increase in crude oil inventory leads to an approximately 0.5% drop in the crude oil futures price. The corresponding ITC estimate is more than twice as large. As expected, the response coefficients differ across the three inventory surprises. For example, the ITC estimate of the crude oil response coefficient for crude oil inventory surprises is about –1.06, whereas the crude oil response coefficient for gasoline inventory surprises is only about –0.55. The corresponding estimates for gasoline futures are about –0.52 and –1.25, respectively. All three petroleum inventory surprises have similar (and relatively small) impacts on the natural gas futures prices. The average ratio of ITC to OLS estimates ranges from about 1.7 for natural gas to about 1.9 for crude oil, showing that traditional event study regressions underestimate the energy market responses to news about petroleum inventory by approximately a factor of two. The estimated proportion of the variance of the measured inventory surprise due to noise (V_K^2 / V_z^2) ranges from about 49% for gasoline to about 59% for crude oil, showing that the measured inventory surprises are quite noisy. For comparison, the corresponding statistic for several major macroeconomic announcements reported in Rigobon and Sack (2008) exceeded 90%.

[Insert Table II about here]

To examine the effects of the natural gas inventory announcements on the four energy commodity markets, we estimate an ITC model with four markets and one inventory surprise. The model has 16 unknown parameters, and the variance-covariance matrix of futures returns

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[13] Inventory surprises and futures returns are demeaned prior to estimation.

but also the storage amounts for the East, West, and Producing regions. Even if the overall amount of gas in storage is equal to the market's expectations, there may be unexpected changes in regional gas inventories that may move energy futures prices. Therefore, ITC estimates may have some upward bias.

4.2. Injection and Withdrawal Seasons for Natural Gas

Natural gas storage involves two calendar periods: the "injection season" (April through October) and the "withdrawal season" (November through March). During injection, inventory surprises are determined to a large extent by supply shocks related to the technology of gas storage. During withdrawal, unexpected changes in natural gas inventory are driven primarily by demand shocks due to weather. Gay et al. (2009) argue that, since the demand curve for natural gas is less elastic than the supply curve, prices should respond more strongly to storage surprises during the injection season than during the withdrawal season. They find empirical support for this hypothesis. Gay et al. (2009) also provide evidence that inventory changes are less predictable during the withdrawal season.

An alternative explanation for the seasonal variation in the price response to inventory news is that, due to a larger proportion of noise in the variance of the measured inventory news, the OLS attenuation bias is larger during the withdrawal season. To examine this issue, we estimate the four-commodity model for the Natural Gas Storage Report announcements separately for injection and withdrawal seasons. The results are provided in Panels B and C of Table III. Consistent with Gay et al. (2009), the OLS estimate of the own-commodity response to natural gas storage surprises is about 55% larger in absolute value during the injection season than during withdrawal. The ITC estimate of the own-commodity response coefficient is still larger in absolute value during the injection season than during withdrawal, but only by about

33%. The OLS estimates of cross-commodity effects are not statistically significant during the withdrawal season. The corresponding ITC estimates for crude oil and heating oil are statistically significant. Consistent with our expectations, there is evidence that noise accounts for a larger proportion of the variance of the measured inventory surprises during the withdrawal season.

4.3. The Effect of Analyst Forecast Dispersion on Response Coefficients

Chiou-Wei et al. (2010) examine the effect of market uncertainty on the response of the natural gas futures prices to the storage surprises. They use the standard deviation of the individual analysts' forecasts of the change in inventory as a proxy for market uncertainty. They find that the market response to inventory surprises estimated with OLS is significantly weaker at times of greater dispersion in analyst forecasts. In a study of the response of stock returns to earnings surprises, Imhoff and Lobo (1992) also find that firms with high dispersion of analyst forecasts exhibit little or no price response to earnings surprises. They provide evidence that analyst forecast dispersion is more likely to proxy for noise in earnings surprises than for uncertainty about the firm's earnings prospects.

Abarbanell, Lanen and Verrecchia (1995) show theoretically that the price response coefficient is negatively related to forecast dispersion for two reasons. First, measurement error in earnings surprises increases in the dispersion of analyst forecasts and introduces a downward bias in the earnings response coefficients. Second, even when the earnings surprise is measured without error, the market response increases in forecast precision, which is negatively related to forecast dispersion. In the context of earnings forecasts, precision reflects the extent to which current earnings is informative about future earnings a(firm(osgoTningsr6gr(r)-1)]TJ-2ana3 -2.3 TD.0004 Tc-.00

Figure 3 shows the standard deviation of analyst forecasts of natural gas inventory changes divided by the reported level of inventory. Consistent with Gay et al. (2009), dispersion of analyst forecasts tends to be much larger during the withdrawal season. The figure also shows forecasts as a proxy for measurement error. Even after correcting for the bias induced by noise in inventory surprises, the market response to the news is somewhat stronger in the low dispersion subsample. This finding is consistent with the notion that the forecast dispersion conveys information about precision of analyst forecasts.[15]

The fact that forecast dispersion increases during the withdrawal season raises the question whether the difference in price response coefficients between the injection and withdrawal seasons is driven by variation in forecast dispersion. We estimated an OLS regression that included the inventory surprise and the inventory surprise interacted with a dummy variable for the withdrawal season. Consistent with the results in Panels B and C of Table III, the coefficient of the interaction term is positive and statistically significant. However, this coefficient becomes insignificant when an interaction of the inventory surprise with a dummy for high forecast disper

4.4. Decoupling of Natural Gas and Petroleum Markets

This subsection examines whether the cross-commodity effects of petroleum and natural gas inventory announcements have diminished in recent years. Figure 4 shows weekly spot prices of natural gas and energy equivalent prices of WTI crude oil.[17] After collapsing during the 2008 recession, oil prices resumed their climb. Natural gas prices, however, have drifted downwards, after briefly trading at energy parity with oil in December 2008. This divergence between natural gas and oil prices is consistent with Ramberg and Parsons (2012), who show that the cointegrating relationship between the two prices is not stable through time. By June 2012, the energy equivalent price of oil exceeded the price of natural gas by a factor of six. This apparent decoupling of oil and gas prices has coincided with the shale gas boom in the U.S.

[Insert Figure 4 about here]

We begin by computing the daily realized correlation between natural gas and crude oil futures returns as follows:[18]

$$RC_t = \frac{\sum_{i=1}^{m} R_{o,i} R_{g,i}}{\sqrt{\sum_{i=1}^{m} R_{o,i}^2 R_{g,i}^2}}, \qquad (9)$$

where $R_{o,i}$ and $R_{g,i}$ are continuously compounded returns of the most actively traded crude oil and natural gas futures contracts, respectively, in a 5-minute intraday interval i, and m is the number of such intervals in trading day t.

[17] Natural gas prices are normally quoted in dollars per million British thermal units (BTU). One barrel of WTI crude oil contains 5.825 million BTUs. Therefore, energy equivalent price of crude oil can be computed by dividing the WTI crude price per barrel by 5.825.
[18] This measure is proposed by Andersen, Bollerslev, Diebold, and Labys (2001) and used by Wang, Wu, and Yang (2008), among others.

Figure 5 shows a pronounced decline in the correlation between the two energy futures markets in late 2009. The Quandt-Andrews breakpoint test for one or more unknown structural breakpoints identifies a shift in the mean of the realized correlations on December 11, 2009. The mean of the realized correlation declined from about 0.45 before December 2009 to about 0.09 after this structural break. This decline is strongly statistically significant.

[Insert Figure 5 about here]

Table IV presents correlations of event-window returns in the four energy futures markets. The correlations between natural gas and petroleum futures returns after the release of the Natural Gas Storage Report are both economically meaningful and strongly statistically significant during the period before December 11, 2009. These correlations become small and statistically insignificant in the more recent period. A similar pattern is observed for return correlations around the Petroleum Status Report announcements, although two of the three correlation coefficients for natural gas remain statistically significant after December 2009.

[Insert Table IV about here]

Table V shows estimates of the effect of the natural gas inventory announcements on the four energy commodity futures markets before and after the decoupling of oil and natural gas markets. The OLS estimate of the response coefficient for natural gas is more than twice as high in the more recent period compared to the period before December 11, 2009. However, the ITC estimates of this coefficient show little change from one subperiod to the next. The larger attenuation bias in the OLS estimate in the first subperiod is due to a greater proportion of noise in the measured inventory surprises. The proportion of the variance of the measured inventory surprise due to noise declines from about 78% to about 53% in the more recent subperiod.

The Natural Gas Storage Report is the EIA's only report designated a Principal Federal Economic Indicator. The report received this designation in January 2008.[19] In mid-2008, the EIA modified its weekly underground natural gas storage sample and sample selection procedure to reflect changes in the industry and improve data quality.[20] According to the EIA, the new procedure improves the accuracy of storage estimates. The finding of less noise in the natural gas

Brown and Yücel, 2008) and is likely to contribute to the cross-commodity effects of oil and gas inventory announcements. The increased shale gas production in the U.S. in recent years has led to a glut of natural gas and sent gas prices to historical lows relative to oil prices. As a result, most facilities with fuel-switching capability have probably switched to natural gas. Only a large move of oil and gas prices towards energy parity would induce these facilities to consider switching to oil products. Price changes caused by inventory news are small compared to the recently observed deviation of oil and gas from energy parity. Under these conditions, inventory surprises should have little effect on the relative attractiveness of oil and gas as substitute fuels. This may contribute to our finding that the fundamental link between petroleum and natural gas markets has weakened in recent years.

5. Summary and Conclusion

This study examines the effect of unexpected changes in inventory on energy prices. Using intraday futures data and inventory surprises for petroleum products and natural gas, we estimate the price response coefficients using traditional event study regressions and Rigobon and Sack's ITC methodology. The results show that the noise in estimated inventory surprises and the resulting attenuation bias in OLS estimates are quite large. The ITC coefficient estimates are about twice as large as OLS estimates for petroleum commodities and about four times as large as OLS estimates for natural gas. Thus, energy prices are more strongly influenced by excess supply and demand shocks than shown in previous studies. Our results help to explain why we often observe large movements in energy prices in response to moderate demand and supply shocks. These findings are a step towards showing

Appendix. Moment Conditions Used in ITC Estimation of the Response of Crude Oil, Gasoline, Heating Oil, and Natural Gas Futures Prices to Petroleum Status Report Announcements

This estimation uses an ITC model with four markets and three inventory surprises. Estimating this model involves 34 unknown parameters. The variance-covariance matrix of returns and inventory surprises provides 38 moment conditions:

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Table I
Summary Statistics for Inventory Surprise and Futures Returns

Panel A. Inventory Surprises (%)

	Mean	Median	St. deviation	Minimum	Maximum
Petroleum Status Report					
Crude Oil	-0.03	0.01	0.94	-2.79	2.82
Gasoline	-0.02	-0.02	1.03	-3.04	3.33
Distillates	-0.01	0	1.19	-3.46	5.45
Natural Gas Storage Report	0.03	0	0.42	-1.86	1.36

Panel B. Futures Returns (%)

	Announcement Days			Non-announcement Days		
	Mean	Median	St. deviation	Mean	Median	St. deviation
Petroleum Status Report						
Crude Oil	-0.09	-0.08	0.94	-0.02	0	0.43
Gasoline	-0.13	-0.07	1.16	-0.03	-0.01	0.53
Heating Oil	-0.12	-0.12	0.93	-0.02	0	0.41
Natural Gas	-0.03	-0.02	0.70	-0.03	0	0.54
Natural Gas Storage Report						
Natural Gas	-0.26	-0.32	2.02	-0.03	0	0.55
Crude Oil	-0.03	-0.01	0.44	-0.04	0	0.44
Gasoline	-0.01	-0.02	0.47	-0.04	-0.01	0.55
Heating Oil	-0.01	-0.004	0.44	-0.03	0	0.41

The inventory surprises are computed as the difference between the actual and expected change in inventory, divided by the inventory level. The continuously compounded futures returns are computed in the intraday event window surrounding the inventory announcement. The event window is from 5 minutes before to 10 minutes after the announcement time. Non-announcement day returns are computed in the same time interval one day before the Petroleum Status Report announcements and two days before the Natural Gas Storage Report announcements. The sample period is from July 16, 2003 through June 27, 2012. The number of observations is 435.

Table II

Response of Energy Futures Prices to Petroleum Status Report Announcements

Table III
Response of Energy Futures Prices to Natural Gas Storage Report Announcements

	OLS Estimates		ITC Estimates			
	Response Coefficient	R^2	Response Coefficient	Pseudo-R^2	Ratio ITC/OLS	Proportion of Measured Surprise Due to Noise V_K^2/V_z^2
Panel A. Full Sample (N=435)						
Natural Gas	-2.40 (0.25)***	0.244	-9.56 (0.94)***	0.929	3.98	73%
Crude Oil	-0.14 (0.08)*	0.017	-0.46 (0.12)***	0.203	3.28	
Gasoline	-0.13 (0.07)**	0.014	-0.33 (0.13)**	0.080	2.47	
Heating Oil	-0.15 (0.07)**	0.021	-0.48 (0.12)***	0.223	3.19	
Panel B. Injection Season (N=255)						
Natural Gas	-3.17 (0.43)***	0.266	-10.75 (0.99)***	0.918	3.38	69%
Crude Oil	-0.22 (0.08)***	0.021	-0.64 (0.14)***	0.062	2.99	
Gasoline	-0.24 (0.10)**	0.025	-0.54 (0.15)***	0.087	2.31	
Heating Oil	-0.24 (0.09)***	0.029	-0.64 (0.13)***	0.134	2.63	
Panel C. Withdrawal Season (N=180)						
Natural Gas	-2.05 (0.31)***	0.228	-8.07 (1.39)***	0.938	3.94	73%
Crude Oil	-0.11 (0.11)	0.012	-0.30 (0.15)**	0.348	2.83	
Gasoline	-0.08 (0.09)	0.008	-0.12 (0.17)	0.122	1.40	
Heating Oil	-0.11 (0.10)	0.011	-0.35 (0.15)**	0.358	3.36	
Panel D. Low Dispersion of Analyst Forecasts (N=218)						
Natural Gas	-4.99 (0.45)***	0.422	-10.80 (1.04)***	0.922	2.16	52%
Crude Oil	-0.20 (0.09)**	0.020	-0.50 (0.15)***	0.077	2.49	
Gasoline	-0.06 (0.10)	0.002	-0.32 (0.14)**	0.110	4.91	
Heating Oil	-0.21 (0.09)**	0.026	-0.48 (0.12)***	0.086	2.23	
Panel E. High Dispersion of Analyst Forecasts (N=217)						
Natural Gas	-1.76 (0.24)***	0.210	-7.77 (1.44)***	0.933	4.41	77%
Crude Oil	-0.12 (0.09)	0.017	-0.35 (0.15)**	0.244	2.83	
Gasoline	-0.15 (0.08)*	0.023	-0.27 (0.17)	0.027	1.81	
Heating Oil	-0.14 (0.09)	0.019	-0.46 (0.17)***	0.259	3.35	

The table shows the estimated responses of energy futures returns to unexpected changes in natural gas inventory. The sample period is from July 16, 2003 through June 27, 2012. The response coefficients are estimated using (1) equation-by-equation OLS with the White (1980) heteroskedasticity consistent covariance matrix and (2) identification-through-censoring (ITC) approach. All variables are demeaned prior to estimation. The null hypothesis of the Hansen (1982) test that the over-identifying restrictions of the ITC model are valid is not rejected at the 5% level. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table IV
Event-Window Correlations of Energy Futures Returns Before and After December 11, 2009

	Natural Gas Storage Report Announcements			Petroleum Status Report Announcements		
	Natural Gas	Crude Oil	Gasoline	Natural Gas	Crude Oil	Gasoline
Panel A. July 16, 2003 – December 11, 2009 (N=304)						
Crude Oil	0.48***			0.64***		
Gasoline	0.39***	0.84***		0.58***	0.84***	
Heating Oil	0.50***	0.87***	0.83***	0.65***	0.89***	0.79***
Panel B. December 12, 2009 – June 27, 2012 (N=131)						
Crude Oil	0.07			0.15*		
Gasoline	0.03	0.84***		0.19**	0.81***	
Heating Oil	0.03	0.88***	0.91***	0.14	0.88***	0.81***

The table shows Pearson correlations of energy futur

Table V
Response of Energy Futures Prices to Natural Gas Storage Report Announcements
Before and After December 11, 2009

	OLS Estimates		ITC Estimates			
	Response Coefficient	R^2	Response Coefficient	Pseudo-R^2	Ratio ITC/OLS	Proportion of Measured Surprise Due to Noise V_κ^2 / V_z^2
Panel A. July 16, 2003 – December 11, 2009 (N=304)						
Natural Gas	-2.03 (0.26)***	0.209	-9.54 (1.29)***	0.912	4.71	78%

Table VI
Response of Energy Futures Prices to Petroleum Status Report Announcements Before and After December 11, 2009

	OLS Estimates				ITC Estimates				
	Crude Oil Surprise	Gasoline Surprise	Distillate Surprise	R^2	Crude Oil Surprise	Gasoline Surprise	Distillate Surprise	Pseudo-R^2	Average Ratio ITC/OLS
Panel A. July 16, 2003 – December 11, 2009 (N=304)									
Crude Oil	-0.59***	-0.36***	-0.24***	0.477	-1.18***	-0.59***	-0.34***	0.824	1.67
	(0.05)	(0.05)	(0.04)		(0.16)	(0.10)	(0.11)		
Gasoline	-0.37***	-0.77***	-0.20***	0.498	-0.60***	-1.35***			
	(0.06)	(0.07)	(0.06)		(0.13)	(0..18 Tc3.9558 l-0.0(7T6Tc[(-0.34*)5(**)]TJ0 -1.1475 T4))7.2(			

Figure 1
Petroleum and Natural Gas Inventory

Panel A. Petroleum Inventory

Panel B. Natural Gas Inventory

Source: http://www.eia.gov/

Figure 2
Futures Returns around Inventory Announcements

Panel A. Crude Oil Futures Returns around Petroleum Status Report Announcements

Panel B. Natural Gas Futures Returns around Natural Gas Storage Report Announcements

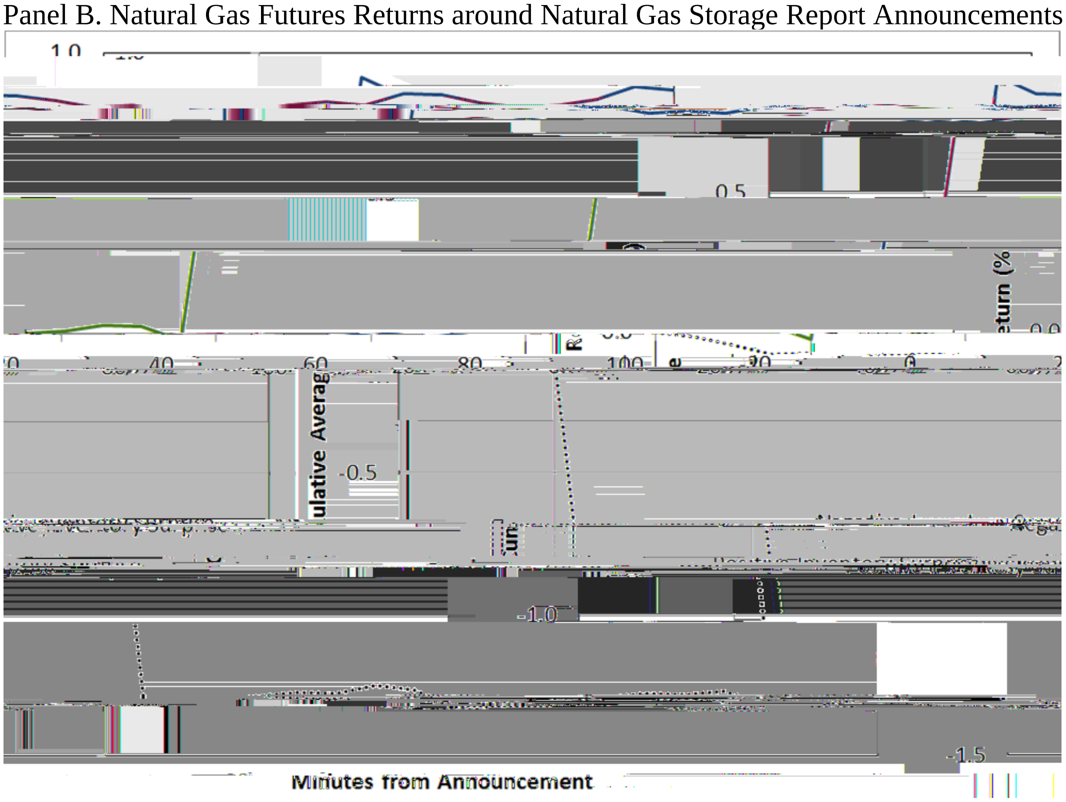
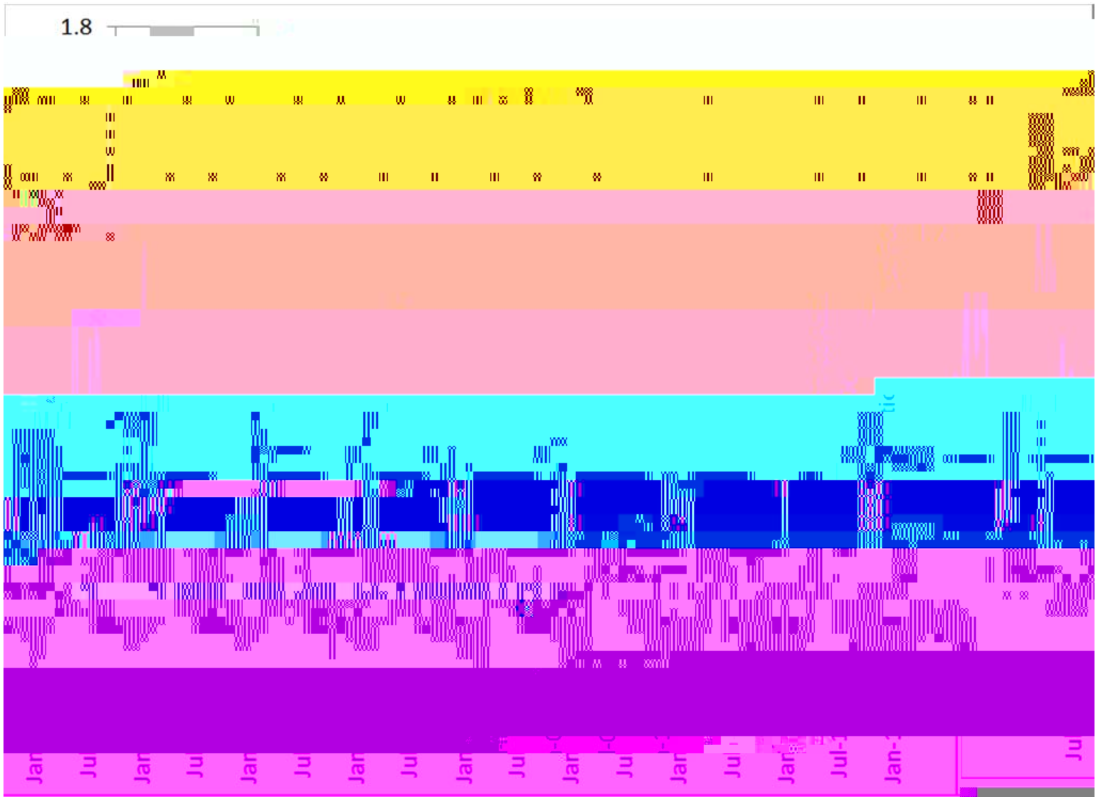
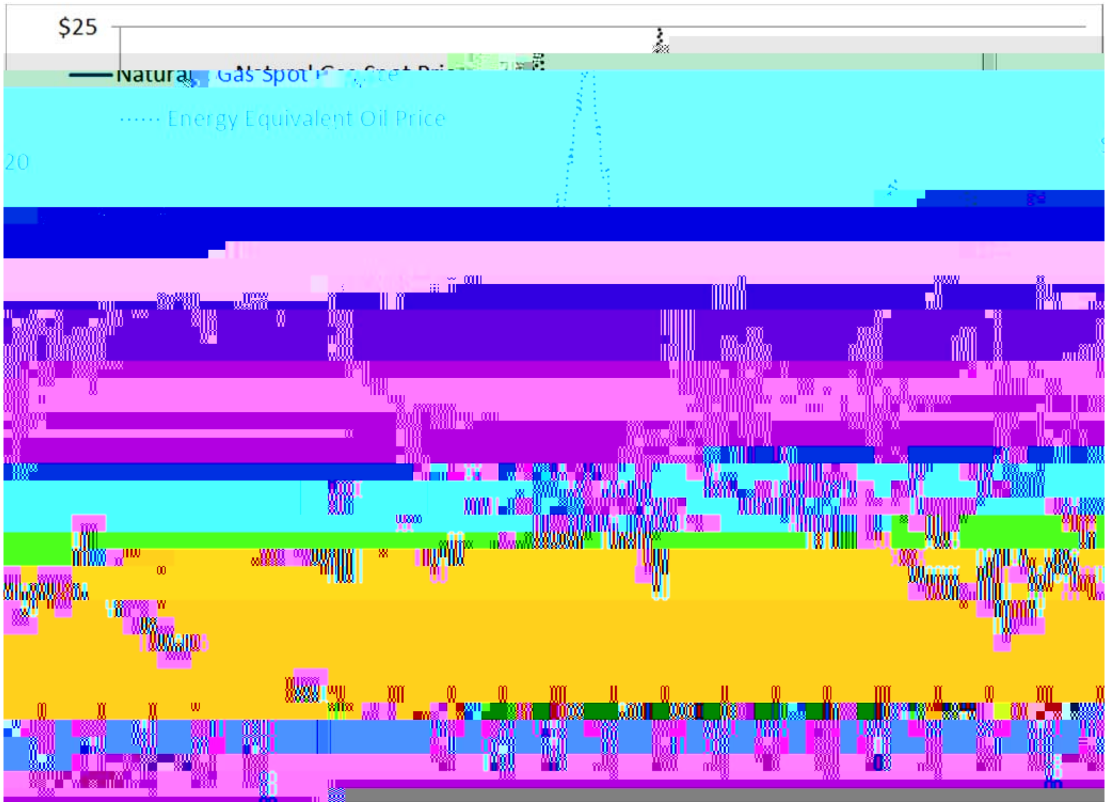


Figure 3
Standard Deviation of Analyst Forecasts for Natural Gas Inventory Changes



Shaded areas represent the withdrawal season (November through March).

Figure 4
Weekly Spot Natural Gas and Crude Oil Prices



Source: http://www.eia.gov/.

Energy equivalent price of crude oil is computed by dividing the WTI crude oil price per barrel by 5.825.

Figure 5

Realized Correlation Between Crude Oil and Natural Gas Futures Returns