

Information, Price Levels and Price Volatility of Petroleum Product Futures Price

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Unexpected Information and Price Changes

- Markets form **expectations** about economic variables (changes in inventories, macro news, etc.) based upon existing information
- The arrival of **unexpected** information (**surprises**) alters the current information set
- If the unexpected information is **relevant** for pricing
 - Prices respond

The Response of Energy Futures Prices to Unexpected Information

- Empirical examinations of oil, natural gas and product futures price responses to unexpected information (surprises) have focused on:
 1. Changes in energy commodity inventories
 2. Reports about macroeconomic variables
 3. Monetary policy news: Press releases following U.S. Federal Open Market Committee meetings
 4. U.S. Strategic Petroleum Reserve News
- We briefly summarize the extant literature and present supporting empirical analyses
 - Announcements by OPEC will be the subject of a future investigation

1. Changes in energy commodity inventories

- Information about unexpected changes in inventories reveals shifts in supply and demand and expectations about future supply and demand
- Release of Weekly Petroleum Status Report (typically Wed., 10:30 AM ET)
 - Oil, gasoline, distillate
- Release of Weekly Natural Gas Storage Report (typically Thurs., 10:30 AM ET)
- Unexpected change in inventory
 - Actual change – Expected change (typically from Bloomberg survey)
 - Often standardized

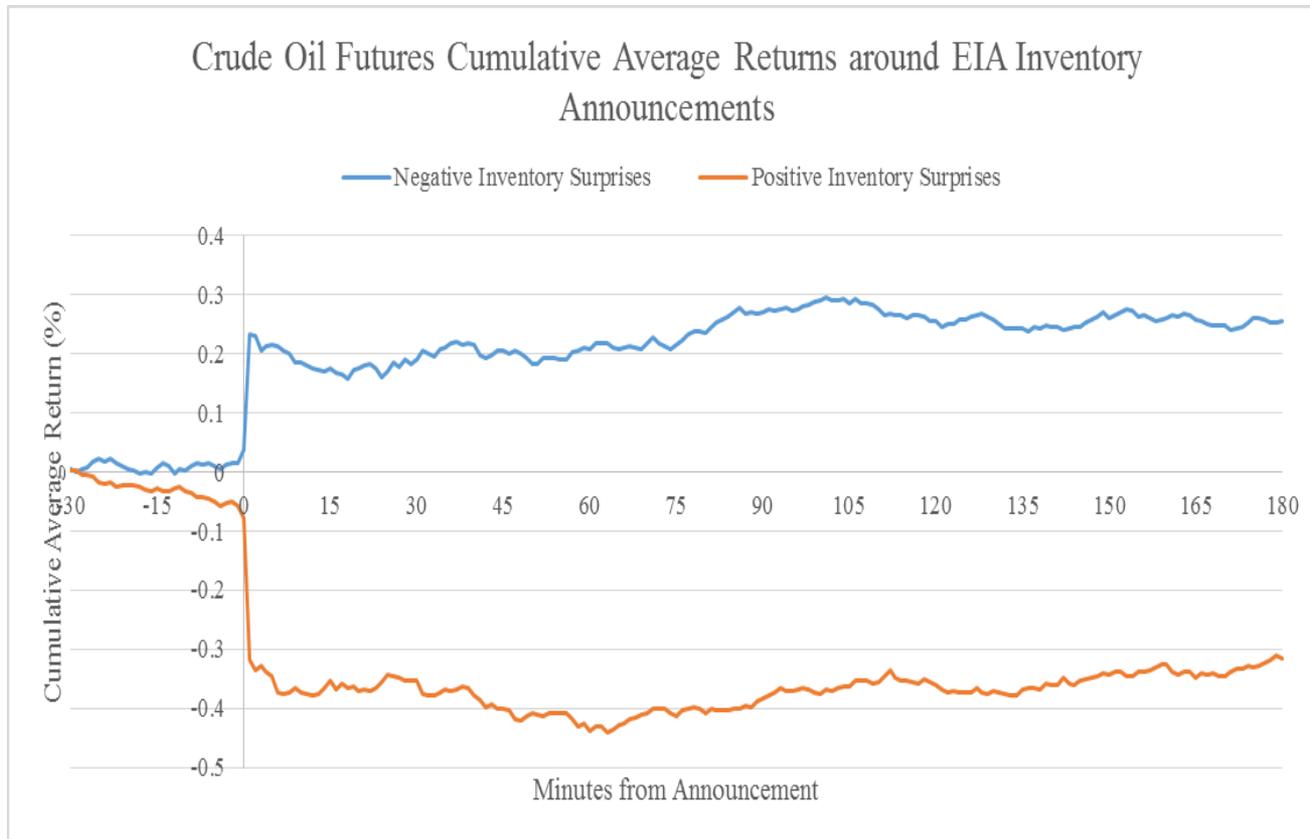
Empirical Evidence on Price Responses to Unexpected Changes in Inventory

- Generally focus on log price changes ('returns') for front month futures contracts: Oil, Gasoline, Distillate, Natural Gas
- Immediate response that does not revert (Halova et al. ,2014; this study)
- Response inversely related to unexpected change in own inventory and to inventory of companion products (Oil and Pet. Products: Chang et al.,2009; Rosa, 2014; Halova et al., 2014; Bu, 2014; Bjursell et al., 2015; Ye and Karali, 2016; Miao et al., 2017, this study; Natural Gas: Gay et al., 2008; Chiou-Wei et al., 2013, Halova et al., 2014, this study)
- Jumps in prices tied to inventory announcements (Oil: Elder et al., 2013; Bjursell et al., 2015; Natural Gas: Bjursell et al., 2015)
- Response coefficient smaller after advent of effective 24-hour trading (electronic) (this study)
- No asymmetric response to positive versus negative surprises (Elder et al., 2013; Miao et al. 2017, this study)
- Spikes in volatility tied to inventory announcements (Linn and Zhu, 2004; Bjursell et al., 2015; this study)

Empirical Analysis

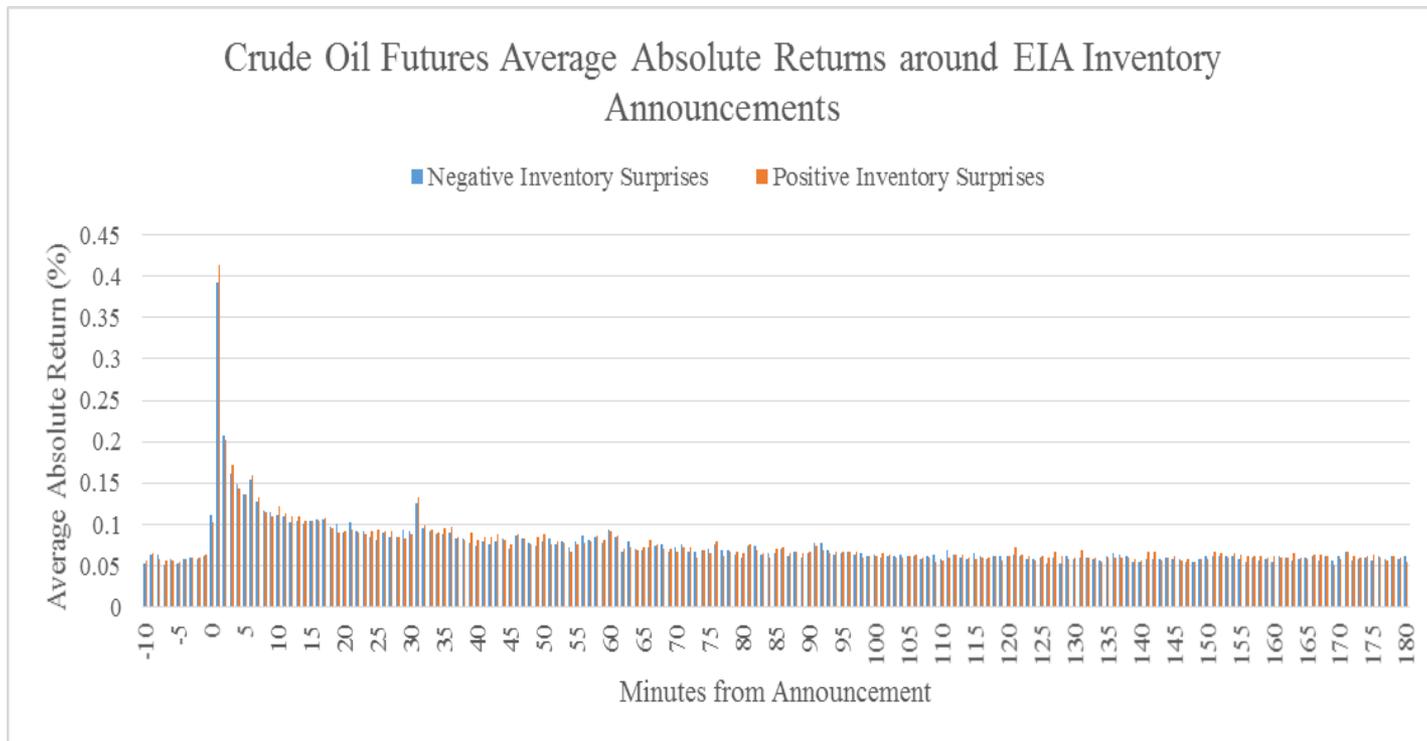
- Transaction price data, front month contract
 - Log futures price changes
 - Intraday (5 mins before announcement through 10 mins after); daily
- Unexpected changes in inventory
 - EIA and Bloomberg
 - Surprise = $(\text{Actual change} - \text{Expected change}) / \text{Std.Dev. [Bloomberg median forecast]}$
 - Response coefficient: Log price change response to 1 standard deviation shock to Raw Surprise
- Sample period: 7/16/2003 – 6/30/2017 (observations vary depending on data availability)

Immediate Response: Oil



5 to 7 minute response relative to level at 100 minutes
 Similar for Gasoline, Distillate and Natural Gas

Immediate Response of Volatility: Oil (Average Absolute Returns)



The Relation Between Intraday Futures Price Response and Unexpected Change in Inventory?

Price Change	Oil Surprise	Gas Surprise	Dist. Surprise	NG Surprise
Oil	-0.392***	Negative***	Negative***	-0.066***
Gasoline	Negative***	-0.484***	Negative***	-0.037 (n.s.)
Distillate	Negative***	Negative***	-0.333***	-0.066***
Natural Gas	-0.112***	-0.105***	-0.107***	-1.005***

Log price change. Intraday interval 5 minutes prior to report release through 10 minutes after.

Basic model: $r_{i,t} = \alpha_i + \beta_i S_{i,t} + \varepsilon_{i,t}$ *** Statistically significantly different from zero at 1% level.

Red, response to own unexpected change in inventory on day of release.

Black, response of Oil, Gasoline, Distillate to companion product unexpected inv. changes.

Green: response of Natural Gas to oil, gasoline, distillate surprises on Wed.

Gold: response of Oil, Gasoline, Distillate to natural gas surprise on Thurs.

Model: $r_{i,t} = \beta_{i,O} + \beta_{i,E}E_t + \beta_{i,S}S_{i,t} + \beta_{i,SE} (S_{i,t} \bullet E_t) + \varepsilon_{i,t}$

$E_t = 1$ if $t = \text{June 6, 2006}$ and after, else 0

(estimates of $(\beta_{i,S}; \beta_{i,S} + \beta_{i,SE})$)

Price Change	Oil Surprise	Gas Surprise	Dist. Surprise	NG Surprise
Oil	-.429; -.271***			
Gasoline		-.746; -.470**		
Distillate			-.664; -.301***	
Natural Gas				-.708; -1.163***

Our results show that the response became more muted for Oil, Gasoline and Distillate but was intensified for Natural Gas.

*** Statistically significantly different from zero at 1%, ** at 5%

- Price Changes
 - Response not influenced by whether surprise was positive or negative
 - No relation between surprises and prices changes on the two days following the release
- Volatility
 - Average absolute return positively related to absolute value of surprise for Oil, Gasoline, Distillate (at Wed. release) and Natural Gas (at Thurs. release)
 - But not to $\text{abs}(\text{surprise})$ for other commodities (on Wed.), but all positively related to $\text{abs}(\text{natural gas surprise})$ on Thur.
 - Electronic trading had no differential effect on volatility
 - Response to negative surprises always smaller, but only statistically significant for Gasoline and Natural Gas

2. Reports About Macroeconomic Variables

- A variety of reports are issued on a regular basis by departments of the U.S. government as well as private organizations (example)
 - U.S. Employees on Nonfarm Payrolls Month-to-Month Change (U.S. Bureau of Labor Statistics, release time 8:30 AM ET, monthly)
- Expectations data are widely circulated, records generally obtained from surveys of professional economists (frequent source, Haver Analytics)
- Surprise = (Actual – Expected), often scaled by the standard deviation
- Price impacts have been studied using intraday price changes as well as changes at the daily frequency (generally futures prices)

General Findings, Basic Model

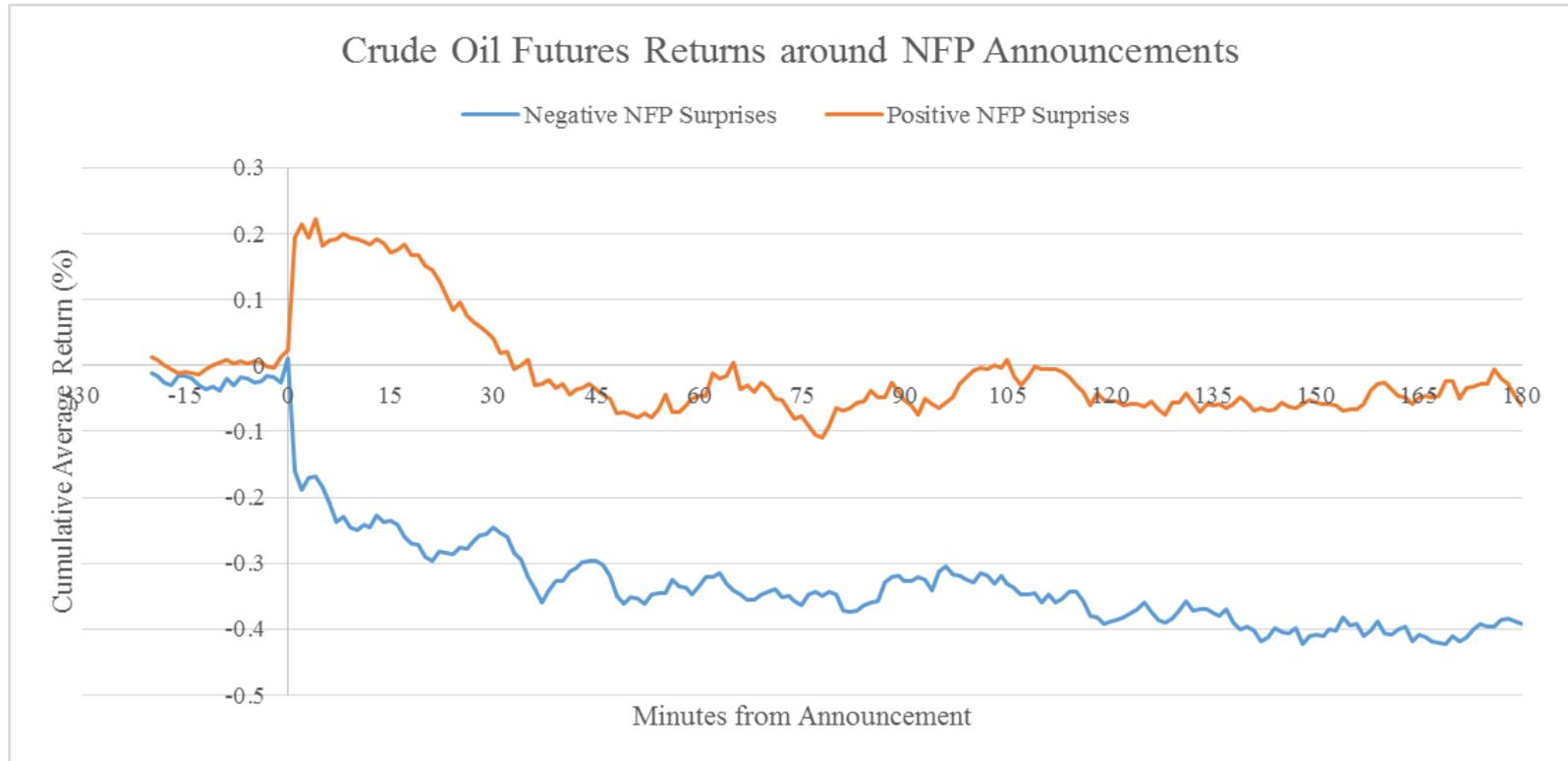
$$r_{i,t} = \alpha_i + \beta_i S_{i,t} + \varepsilon_{i,t}$$

Price Change Frequency	Price Change Response	Studies
Intraday	Yes (but limited to only a few variables, key amongst which is the non-farm payroll report)	Chatrath et al. (2012), Elder et al. (2013), Rosa (2013), Kurov and Stan (2016)
Daily	No	Kilian and Vega (2011), Roache and Rossi (2010), Chatrath et al. (2012), Rosa (2013), Chan and Gray (2017)

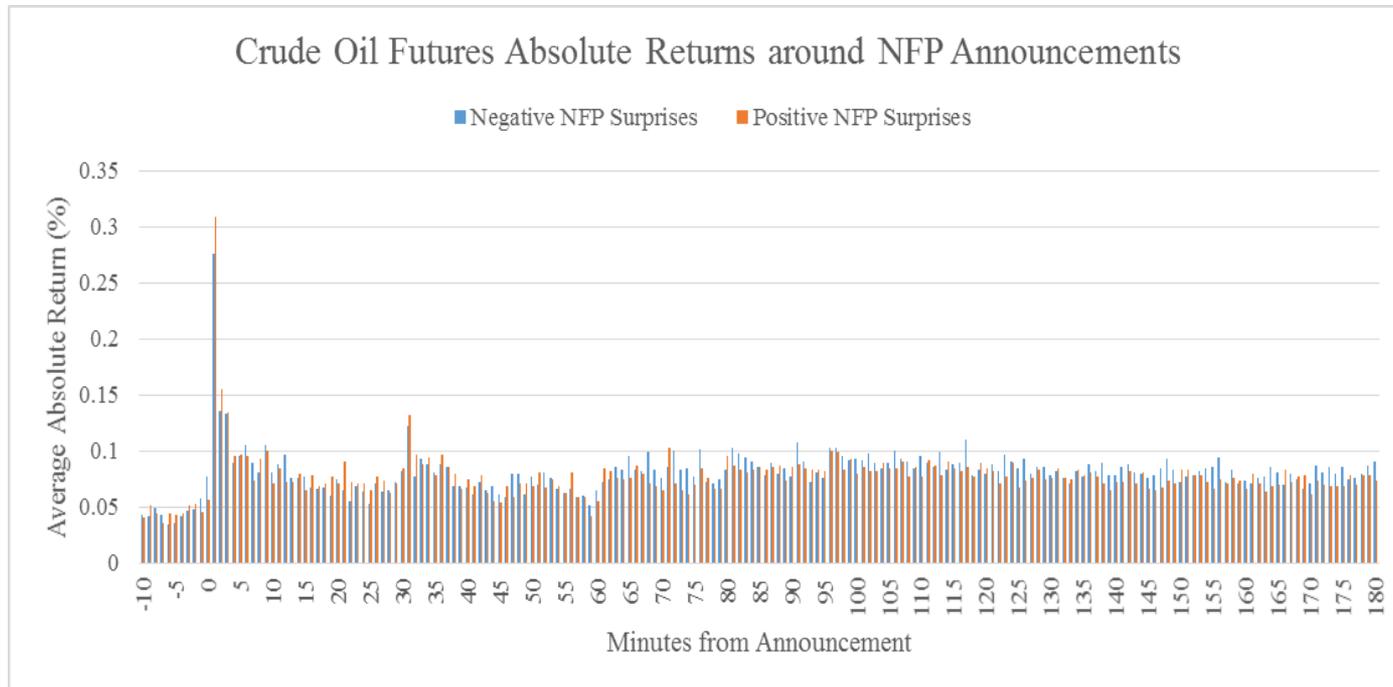
Empirical Analysis

- Focus on
 - U.S. Employees on Nonfarm Payrolls Month-to-Month Change (U.S. Bureau of Labor Statistics, release time 8:30 AM ET, monthly)
 - U.S. Retail Sales Month-to-Month % Change (U.S. Bureau of the Census, release time 8:30 AM ET, monthly)
 - U.S. Consumer Confidence Index (Conference Board, release time 10:00 AM ET, monthly)
 - U.S. ISM Manufacturing Composite Index (National Association of Purchasing Managers, release time 10:00 AM ET, monthly).
- Surprise = (Actual – Expected) scaled by standard deviation
- Sample period: Intraday price changes (July 16, 2003 to July 17, 2017; daily price changes (February 1993 through May 2017)
- Intraday price changes: 5 minutes prior to announcement through 10 minutes following

Immediate Response: Oil



Immediate Response of Volatility: Oil (Average Absolute Returns)



The Relation Between Intraday Price Responses and Macro News Surprises?

$$r_{i,t} = \alpha_i + \beta_i S_{i,t} + \varepsilon_{i,t}$$

Price Change	Non-farm Pay. Surprise	Retail Sales Surprise	ISM Prod Index Surprise	Con. Conf. Surprise
Oil	0.307***	0.111***	0.088***	0.044**
Gasoline	0.288***	0.074*	0.053**	0.026
Distillate	0.239***	0.057*	0.059**	0.033*
Natural Gas	0.124*	0.098***	0.038	0.014

Log Price Change. Intraday interval 5 minutes prior to report release through 10 minutes after
 *** Statistically significantly different from zero at 1%, ** 5%, * 10%

Price Response at Daily Frequency

- No relation was statistically significantly different from zero
 - Day of announcement
 - Announcement day + following day
 - Announcement day + 20 following days
- Referring back to the Figure we see that while the impact of a positive NFP surprise on oil reverts, the response following a negative surprise tends does not

3. Monetary Policy News

- Markets form expectations about U.S. Monetary Policy
- Surprises may occur when press releases following Federal Open Market Committee Meetings reveal changes that are of fundamental importance
- Surprises that reveal unexpected changes in policy may impact prices
 - Potential channels of influence include (Rosa, 2014; Anzuini et al, 2013; Barsky and Kilian, 2004): inventory carrying cost, supply (drilling and production), demand (economic growth), exchange rates

Issue – Measuring Surprises

- Policy Target: Federal funds rate
- Assumption: Markets form expectations about the Target rate based upon existing information and these expectations will be reflected in federal funds futures prices
- Press releases that change the information set and reveal new information about policy will be reflected in federal funds futures prices
- A measure reflecting the change in the implied federal funds rate using the change in the fed funds futures price, ***TS*** (Kuttner, 2001).
- Basic model: $r_{i,t} = \alpha_i + \beta_i TS_t + \varepsilon_{i,t}$

General Findings

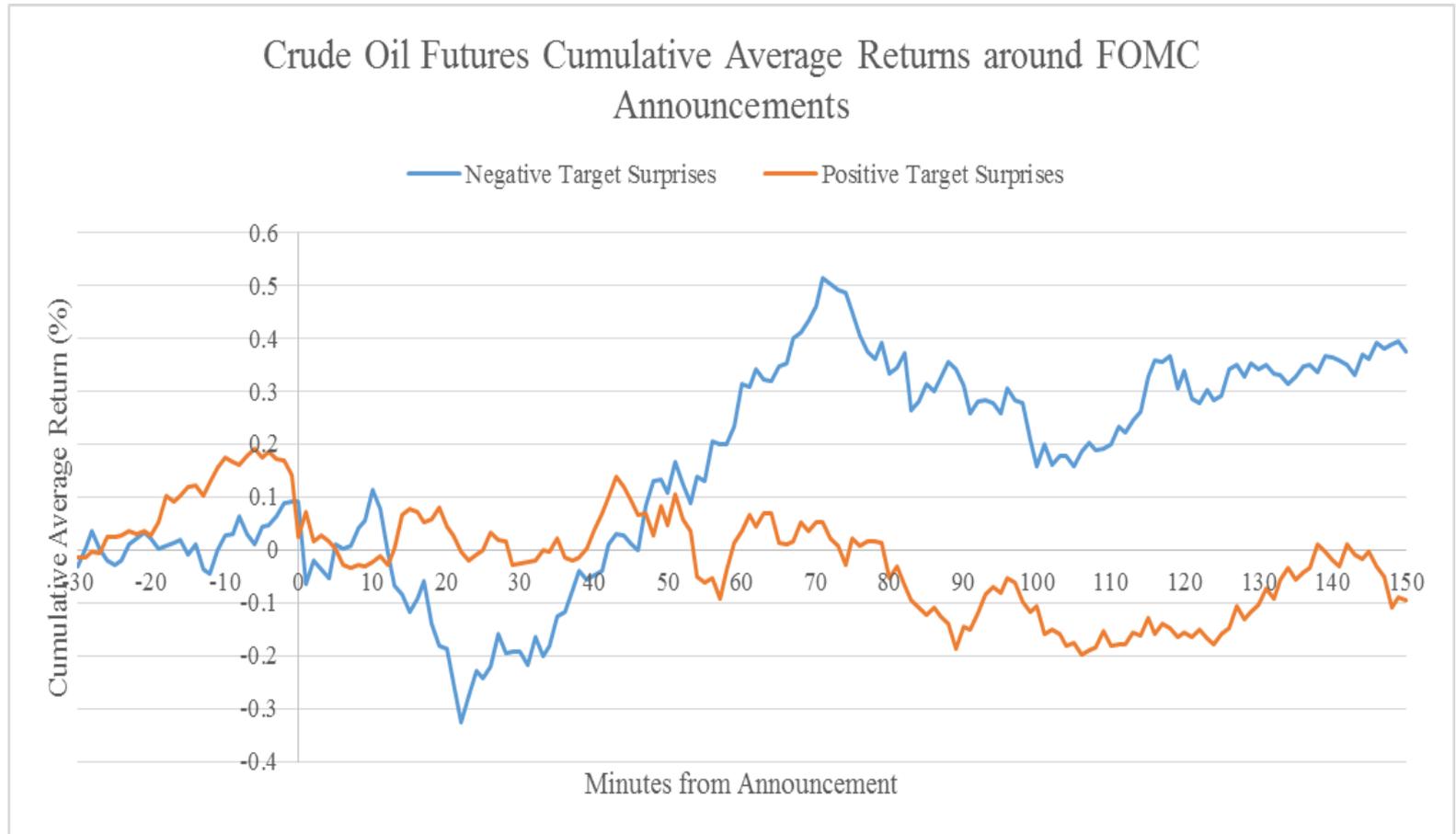
$$r_{i,t} = \alpha_i + \beta_i TS_t + \varepsilon_{i,t}$$

Price Change Frequency	Price Change Response	
Intraday	Negative [†]	Rosa (2014), Basistha and Kurov (2015)
Daily	No	Roache and Rossi (2010) ^{††} , Kilian and Vega (2011), Rosa (2014), Basistha and Kurov (2015)

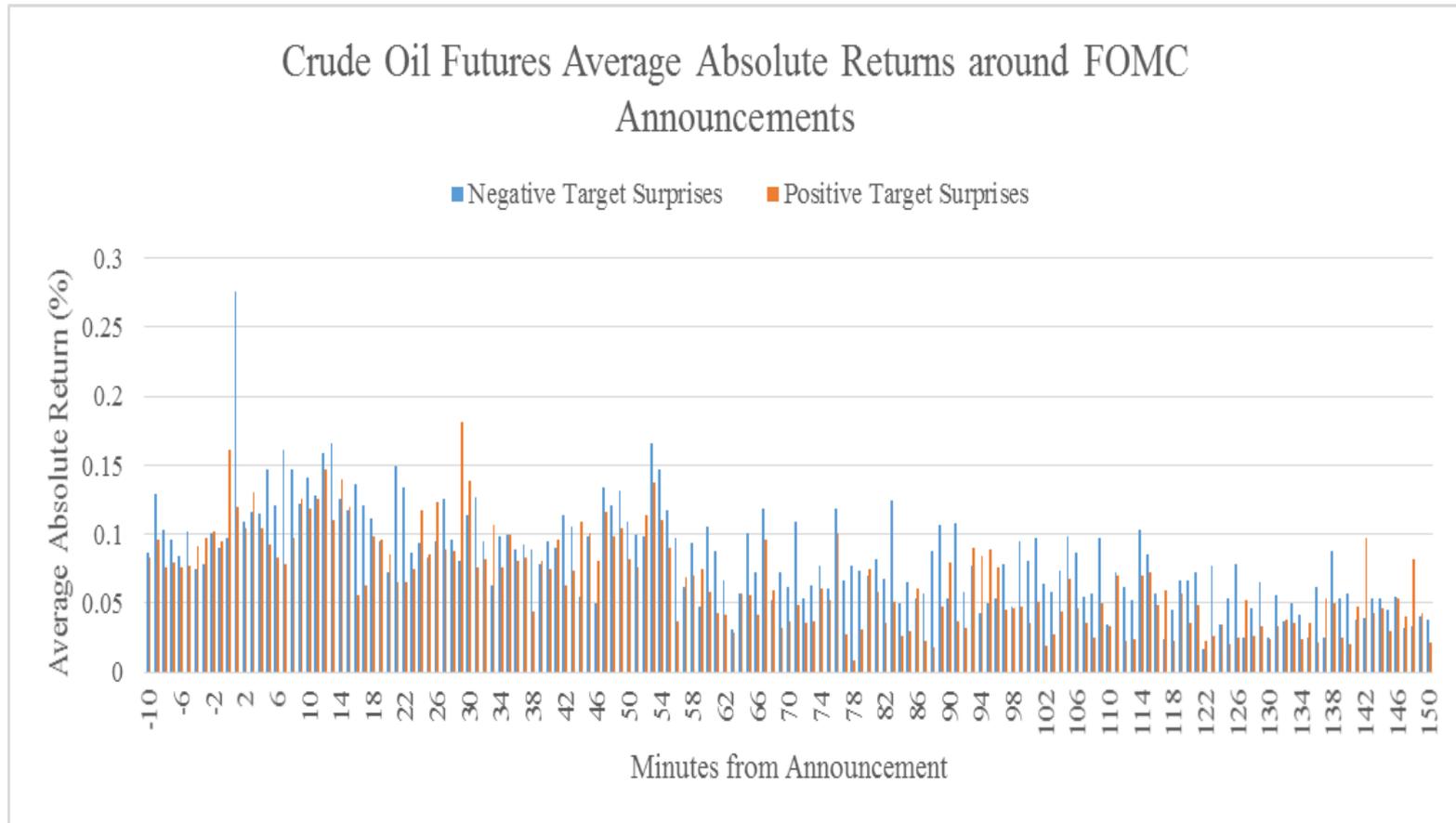
[†] Statistically different from zero at conventional levels

^{††} Except for the period 2002-2009 during which a negative relation for oil is found

Immediate Response:



Immediate Response of Volatility: Oil (Average Absolute Returns)



Intraday Price Response and the Target Surprise?

$$\text{Model 1 } r_{i,t} = \alpha_i + \beta_i TS_t + \varepsilon_{i,t}$$

$$\text{Model 2 } r_{i,t} = \alpha_i + \beta_{i,C} D_{C,t} + \beta_{i,TS} TS_t + \beta_{i,DTS} (D_{C,t} \bullet TS_t) + \varepsilon_{i,t}$$

	Model 1	Model 2		
	TS alone	TS	Conf. Call	Conf. Call x TS
Oil	-1.21	-1.214	-7.001***	-16.89***
Gasoline	4.47	-1.963	-49.31***	-110.2***
Distillate	1.12	-0.878	-14.35***	-31.89***
Natural Gas	-0.85	-6.127**	-11.24***	-19.86***

Intraday interval 10 minutes prior to report release through 50 minutes after.

Conf. Call = 1 if meeting involved a conference call and 0 otherwise

***Statistically significantly different from zero at 1%, ** at 5%

Response on Day of Press Release

- Oil and Gasoline: response coefficients negative but not significantly different from zero
- Distillate: coefficient is positive but not significant
- Including a measure of the path of monetary policy does not influence either the intraday or daily results

4. U.S. Strategic Petroleum Reserve News

- Increases and decreases in the amount of oil held in the U.S. Strategic Petroleum Reserve may potentially impact supply and demand conditions as well as expectations
- As such announcements of pending changes may reveal information to the market which alters the information set participants employ in the setting of prices

Existing Literature

- We identified only one study that examined the price impact of changes in the SPR within a reasonable recent period
- The authors find no impact when examining price impacts over a number of days following the announcement but do not study the date of the announcement (Demirer and Kutan, 2010).

Background

- We identified 26 instances of announcements of increases or decreases of oil held in the SPR over the time period February 11, 1999 through February 21, 2017.
 - Of these 16 involved announcements of increases and 10 involved decreases
- The press/announcement releases are dated but we are unable to identify a time of day, hence our analysis is restricted to daily price changes.

Price Response to Announcements of Increases and Decreases in the SPR. Model: $r_{i,t} = \alpha_i + \beta_{i,c} (D_{c,t}) + \varepsilon_{i,t}$
 $D_{c,t} = 1$ if increase and 0 otherwise (estimates: $\alpha_i, \beta_{i,c}$)

	Ann. Day	Ann. Day + Day Following
Oil	-1.474*, 2.486**	-1.933, 2.596
Gasoline	-1.438, 2.828*	-1.642, 2.87
Distillate	-1.294, 2.291*	-1.276, 1.76
Natural Gas	-0.0602, 1.178	-0.638, 1.607

**Statistically significantly different from zero at 5%, * at 10%

Conclusion

- Oil prices respond negatively to announcements of decreases in oil to be stored in the SPR and positively to announcements of increases
- Response occurs on the day of the announcement

Summary

- Futures prices of oil, gasoline, distillate and natural gas respond
 - Inversely to unexpected changes in inventories of these products (intraday response)
 - Positively to surprises for a few key macroeconomic measures of economic activity (intraday response)
 - But no relation at longer horizons
 - Inversely to target rate surprises inferred from U.S. Monetary Policy press releases (intraday response), but the effect appears to be driven by a subset following conference calls
 - No relation at longer horizons
 - Positively to announcements of planned increases in oil stored in the U.S. Strategic Petroleum Reserve and negatively to decreases (day of announcement)
- Volatility increases at the time of announcement for all four types of announcements and then dies out

Thank You