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News and Social Media Emotions in the Commodity Market

Jiancheng Shen

Mohammad Najand
Old Dominion University

Feng Dong
Old Dominion University

Wu He
Old Dominion University

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News and social media emotions in the commodity market

Jiancheng Shen
Department of Business, Leadership, and Management, Regent University, Virginia Beach, Virginia, USA
Mohammad Najand and Feng Dong
Finance Department, Old Dominion University, Norfolk, Virginia, USA, and
Wu He
Department of Information Technology and Decision Sciences, Old Dominion University, Norfolk, Virginia, USA

Abstract

Purpose – Emotion plays a significant role in both institutional and individual investors' decision-making process. Emotions affect the perception of risk and the assessment of monetary value. However, there is a lack of empirical evidence available that addresses how investors' emotions affect commodity market returns. The purpose of this paper is to investigate whether media-based emotions can be used to predict future commodity returns.

Design/methodology/approach – The authors examine the short-term predictive power of media-based emotion indices on the following five days' commodity returns. The research adopts a proprietary data set of commodity-specific market emotions, which is computed based on a comprehensive textual analysis of sources from newswires, internet news sources and social media. Time series econometrics models (threshold generalized autoregressive conditional heteroskedasticity and vector autoregressive) are employed to analyze 14 years (January 1998-December 2011) of daily observations of the CRB commodity market index, crude oil and gold returns, and the market-level sentiments and emotions (optimism, fear and joy).

Findings – The empirical results suggest that the commodity-specific emotions (optimism, fear and joy) have significant influence on individual commodity returns, but not on commodity market index returns. Additionally, the research findings support the short-term predictability of the commodity-specific emotions on the following five days' individual commodity returns. Compared to the previous studies of news sentiment on commodity returns (Borovkova, 2011; Borovkova and Mahakena, 2015; Smales, 2014), this research provides further evidence of the effects of news and social media-based emotions (optimism, fear and joy) in the commodity market. Additionally, this work proposes that market emotion incorporates both a sentimental effect and appraisal effect on commodity returns. Empirical results are shown to support both the sentimental effect and appraisal effect when market sentiment is controlled in crude oil and gold spot markets.

Originality/value – This paper adopts the valence-arousal approach and cognitive appraisal approach to explain financial anomalies caused by investors' emotions. Additionally, this is the first paper to explore the predictive power of investors' emotions (optimism, fear and joy) on commodity returns.

Keywords Commodity, Investors' emotion, Neurofinance, TRMI

Paper type Research paper

1. Introduction

The media plays an essential role in diffusing information in financial markets (Peress, 2014). Recently, academic researchers and industrial practitioners have adopted content analysis and data mining algorithms to detect investors' sentiments and emotions that manifest through news media and social media (Tetlock, 2007; Kothari *et al.*, 2009; Chen *et al.*, 2014; Sun *et al.*, 2016). In this research, we investigate the effects of investors'

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emotions in the commodity markets and whether the media-based emotion indices can be used to predict future commodity returns.

Developments in neuroscience over the last two decades show that human behaviors, including economic behaviors, are strongly influenced by finely tuned affective processes operated by the brain (Elster, 1998; Loewenstein, 2000; Camerer *et al.*, 2005). Emotion, as a major part of our affective processes, can produce a transient but significant impact on economic decision making and activities for both the individual and society (Loewenstein, 2000; Camerer *et al.*, 2005). Neuroeconomists in their experiments also detected that human beings' emotions and cognitive thinking are always intertwined (Lo *et al.*, 2005; Fenton-O'Creevy *et al.*, 2011). So it suggests that emotion may incorporate information of both one's feeling or cognitive appraisal toward a certain object.

This research utilizes market-level emotion indices of commodities from Thomson Reuters MarketPsych Indices (TRMI), which is built on the comprehensive textual analysis of sources from newswires, internet news sources and other social media. Then, we run time series analysis to test the significance of emotions on the returns of the commodity market index (Thomson Reuters Core Commodity CRB Index) and the two actively traded individual commodities (crude oil and gold). Furthermore, we examine the short-term predictive power of media-based emotion indices on the following five days' commodity returns, consistent with the short-term predictive model of media-based sentiment on the next five days' stock returns (Tetlock, 2007; Garcia, 2013). Comparing previous time series studies of media-based sentiment, this paper expands the single dimension of investors' sentiment index to multiple dimensions of emotion indices. More importantly, our emotion indices are built on a collection of media sources, such as internet news sources and social media, which include more than two million news articles and posts every day (Peterson, 2013). Most of the prior textual analysis studies of media contents exclusively rely on a single source. The collective media sources encompass the market-level information on all groups of market participants' emotions. The emotion index constructed on the collective sources represents the market-level emotion as the consensus of the emotion related to information from all individual sources. As a result, this cancels out clamoring opinions and rumors from some unreliable sources.

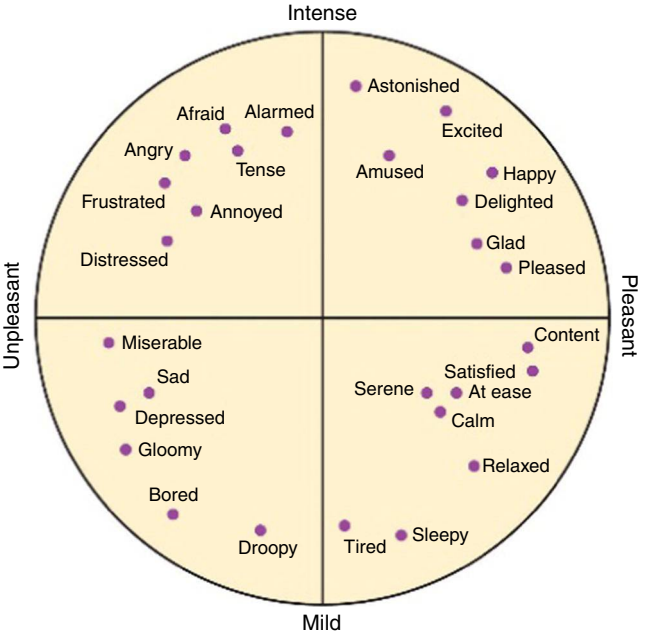
With recent launches of several powerful news analytics databases, researchers have investigated the impact of news media's sentiment on commodity markets. Borovkova (2011), Borovkova and Mahakena (2015) and Smales (2014) sequentially studied the price dynamics of crude oil, natural gas and gold that are conditional on news sentiments, as measured by the Thomson Reuters News Analytics. They found that news sentiments and news events have significant impacts on commodity futures returns, and this sentiment-return relationship appears to be asymmetric, in which negative news sentiment provokes a greater response in returns of commodity futures than positive news sentiment. TRMI include the market-level emotion indicators that can be useful to test the impact of specific emotions on commodity prices. Based on the TRMI commodity-specific emotion indicators, this research studies sentiment and the three most commonly documented emotions (optimism, fear and joy) in the existing finance literature and their effects in the commodity markets. In this research paper, we test both the contemporaneous effects and the short-term predictabilities of the sentiment, optimism, fear and joy on the CRB commodity market index, crude oil and gold returns.

The paper is organized as follows. The next section reviews the previous emotion literature. A subsequent section describes the research data and the time series econometric models. The following section provides empirical evidence that addresses the effects of media-based emotions in the commodity markets and the short-term predictive power of emotion indices on the following days' commodity prices. The paper concludes with a list of several main contributions.

2. Investors' emotion literature

Psychologists suggest that an individual's emotions play an important role in how he or she processes information and makes decisions (Feldman, 1995; Lerner and Keltner, 2000; Tiedens and Linton, 2001). The valence-arousal approach and cognitive appraisal approach are two dominating emotion theories in psychology. According to the valence-arousal model, emotions can be mapped out on a two-dimensional circular space constructed by arousal in the vertical axis (mild to intense) and valence in the horizontal axis (unpleasant to pleasant) (Feldman, 1995). Cognitive appraisal theorists contend that emotions can be distinguished at micro-level such as an individual's appraisal or cognitive response to a specific situation (Lerner and Keltner, 2000; Tiedens and Linton, 2001) (Figure 1).

Research on the effect of market-level emotion has attracted a tremendous amount of interest in financial studies. Financial analysts agree that investors' psychological bias cause a large part of the financial market anomalies. The Wall Street motto "buy on fear, sell on greed" indicates that financial professionals know that emotion affects investors' trading behaviors. Academic researchers (Kuhnen and Knutson, 2011; Mayew and Venkatachalam, 2012; Price *et al.*, 2016) have found evidence to support that emotional states influence investors' risk-taking behavior and trading performance. Kuhnen and Knutson (2011) find that positive emotional states motivate investors to take risky investment portfolios, while negative emotional states hinder them to do so. In two different studies, Mayew and Venkatachalam (2012) and Price *et al.* (2016) utilized the layered voice analysis platform to isolate CEOs' vocal cues in their earnings conference calls. The research pairs also tested the investors' reactions to CEOs' vocal cues. Mayew and Venkatachalam (2012) showed that investors react to managers' vocal cues in a pattern that picked up cumulative abnormal returns around the conference calls; those returns extended out six months. Price *et al.* (2016) found that investors appear to overreact to managers' emotional vocal cues in the conference calls, whereas there is a rapid correction to this short run overreaction.



Source: Adapted from Russell (1980)

Figure 1.
Valence-arousal circumplex

The three most commonly documented emotions in the existing finance research are optimism, fear and joy. Financial optimism is defined as the overestimation of the future financial outcome, so it sometimes causes the investors' overconfidence and the assets' overpricing in the market (Balasuriya *et al.*, 2010). Ciccone (2003) reported that firms with overly optimistic expectations earn lower returns than those with pessimistic expectations. Fear interrupts the market with emotional turmoil, so that further elevates the market uncertainty. Da *et al.* (2011) established a daily fear index based on the internet search volume from millions of households. They found that the internet search-based fear index can predict asset prices, volatility and mutual fund flows. Finance researchers often regard sunshine and temperature as indicators of investors' joy. Hirshleifer and Shumway (2003) confirmed that the stock market performs better during sunny days than during cloudy days. This documented "sunlight effect" attributes to investors' joyful mood to sunshine rather than to long-term value growth.

In this paper, we are interested in studying the effects of the aforementioned three commonly documented emotions and sentiment in commodity pricing. According to cognitive appraisal hypothesis (Lerner and Keltner, 2000; Han *et al.*, 2007), specific emotions incorporate the information of an individual's perception of risk and assessment of monetary value. Because risk perception and value assessment are fundamental psychological processes, understanding them has critical implications for investors' decision making. Additionally, the valence-arousal approach proposes that both the intensity and pleasure of an individual's psychological feelings affect his or her information-processing bias. Market-level emotion research is a necessary complement to the traditional individual-level emotion theories (valence-arousal approach and cognitive appraisal approach). This paper strives to determine whether a group's feelings or appraisals could collectively influence both the commodity's volatility and returns.

3. Data and methodology

This research incorporates Thomson Reuters Core Commodity CRB Index, crude oil and gold spot price data, commodity-specific sentiment, optimism, fear and joy data during January 1, 1998 to December 31, 2011. We retrieved our daily commodity data from the Bloomberg Database and the Global Financial Database. The Bloomberg Database is a leading business commercial data powerhouse encompassing both current and historical financial information on individual equities, stock market indices, fixed-income securities, currencies, commodities and futures for both the US and international markets. The Global Financial Database provides an extensive collection of financial and economic data covering more than 200 countries extending back to centuries ago.

We obtained our daily commodity-specific sentiment and emotion data from TRMI. TRMI's content set includes millions of articles and posts that are published daily. The information comes from sources such as newswires, internet news sources and social media. TRMI utilizes content derived both from news and social media to reflect market emotion from a group of investors, analysts, journalists and economists, etc. A collection of MarketPsych sources covers *The New York Times*, *The Wall Street Journal*, *Financial Times*, Seeking Alpha, Google News among other major business news channels and more than two million social media sites. MarketPsych employs lexical analysis to extract market-level emotion indices by sweeping through all sources minutely, which includes more than two million news articles and posts every day (Peterson, 2013). TRMI emotion measures provide 24-hour rolling average score of total references in news and social media. The scores are normalized so that their values range from −1 to 1.

TRMI construction methodology is summarized from the index construction of "Trading on sentiment" (Peterson, 2016).

Each TRMI is composed of a combination of variables (Vars). First, the absolute values of all TRMI-contributing Vars, for all asset constituents, over the past 24 hours are determined. These absolute values are then summed for all constituents. This sum is called the "Buzz," and it is published in conjunction with each asset's TRMIs. More specifically, where V is the set of all Vars underlying any TRMI of the asset class, where a denotes an asset, and where $C(a)$ is the set of all constituents of a. For example, the Buzz of a is defined as the following:

$$\text{Buzz}(a) = \sum_{c \in C(a),\, v \in V} \left|\text{Var}_{c,v}\right|$$

Each TRMI is then computed as a ratio of the sum of all relevant Vars to the Buzz. $V(t)$ is defined as the set of all Vars relevant to a particular TRMI t. Next one need to define a function to determine whether a Var $v \in V(t)$ is additive or subtractive to a TRMI as the following:

$$I(t,v) = \begin{cases} +1 \text{ if additive} \\ -1 \text{ if subtractive} \end{cases}$$

Thus, the TRMI t of asset a can be computed as the following:

$$\text{TRMI}_t(a) = \frac{\sum_{c \in C(A),\, v \in V(t)} (\, I(t,v) \times \text{PsychVar}_v(c))}{\text{Buzz(Asset)}}$$

The summaries for commodities' returns and TRMI sentiments and emotions are given by Table I. Both crude oil and gold spot markets achieve the same level of mean returns, which is higher than CRB commodity market index mean return during January 1, 1998 to

	n	Mean	SD	Minimum	Maximum
CRBR	2,610	0.03991	1.11999	−6.87799	5.74666
CRUDER	2,610	0.06302	2.38341	−16.83201	12.85340
SNTMENT_CRU	2,610	−0.16407	0.11606	−0.51917	0.21377
OPTIMSM_CRU	2,610	−0.01256	0.02081	−0.12530	0.16018
FEAR_CRU	2,610	0.01549	0.01146	−0.00185	0.07748
JOY_CRU	2,610	0.01456	0.00809	−0.00097	0.05880
GOLDR	2,610	0.06465	1.16882	−7.36634	10.39191
SNTMENT_GOL	2,610	−0.11457	0.09482	−0.51779	0.16422
OPTIMSM_GOL	2,610	−0.00174	0.01928	−0.15279	0.08620
FEAR_GOL	2,610	0.01313	0.00679	−0.00069	0.04656
JOY_GOL	2,610	0.01075	0.00487	−0.00095	0.04167

Notes: This table provides summary statistics for the full sample of 2,610 daily observations from January 1, 1998 to December 31, 2011. The emotion indicators' data in the table come from the Thomson Reuters MarketPsych Indices (TRMI), and the CRB index, crude oil spot and gold spot returns in the table are calculated based on Thomson Reuters Core Commodity CRB Index, crude oil spot and gold spot last price data from Global Finance database. Among the variables, CRBR is the log of the daily Thomson Reuters Core Commodity CRB Index returns; CRUDER is the log of the daily crude oil spot returns; GOLDR is the log of the daily crude oil spot returns; SNTMENT_CRU is the daily market-level crude oil sentiment; OPTIMSM_CRU is the daily market-level crude oil optimism; FEAR_CRU is the daily market-level crude oil fear; JOY_CRU is the daily market-level crude oil joy; SNTMENT_GOL is the daily market-level gold sentiment; OPTIMSM_GOL is the daily market-level gold optimism; FEAR_GOL is the daily market-level gold fear; and JOY_GOL is the daily market-level gold joy

Source: January 1, 1998 to December 31, 2011

Table I.
Descriptive statistics

December 31, 2011. The standard deviation of crude oil spot return is 2.38 percent, which is twice as high as the standard deviation of gold spot and CRB commodity market index returns.

The correlations among the TRMI crude oil and gold sentiment and emotion variables (sentiment, optimism, fear and joy) are provided in Table II. From Table II, the correlations are statistically significant among the sentiment and positive emotions (optimism and joy) and carry the same sign, and those correlations between the positive emotions and negative emotion (fear) carry the opposite sign. These findings coincide with the valence-arousal hypothesis that the measures of pleasant feelings and unpleasant feelings can be distinguished in two opposite directions. More importantly, most of the statistically significant correlations among sentiment and emotion variables fall below 40 percent. The correlation between gold sentiment and gold optimism is the highest statistically significant correlation, which is below 50 percent at 46 percent. So, the signals for multicollinearity do not appear in the multivariate framework.

The empirical analysis employs a time series study of 14 years of daily observations of the CRB commodity market index, crude oil and gold returns and TRMI commodity-specific sentiment, optimism, fear and joy. We implemented the threshold generalized autoregressive conditional heteroskedasticity (TGARCH) model to test the significance of emotions on the returns of the commodity market index and individual commodities. Then we utilized the vector autoregressive (VAR) model to examine the short-term predictive power of media-based emotion indices on the following five days' commodity returns.

GARCH models have become important tools in the analysis of time series data in academic research. These models are especially useful when the goal of the study is to analyze and forecast volatility. We utilize a TGARCH model to investigate the effect of sentiment and emotion measures on commodity mean return and volatility. The TGARCH model incorporates the leverage effect since it has a certain term for negative return innovations (Zakoian, 1994). We propose the following TGARCH (1, 1) model to investigate the effects of emotion measures on the market returns volatility:

$$R_{i,t} = \alpha_0 + \alpha_1 R_{i,t-1} + \alpha_2 \ \text{Sentiment}_t + \alpha_3 \ \text{Optimism}_t + \alpha_4 \ \text{Fear}_t + \alpha_5 \ \text{Joy}_t + \varepsilon_t \quad (1)$$

$$H_t = \omega + \left(\psi + \beta, 1_{\{\varepsilon t-1 < 0\}}\right)\varepsilon_{t-1}^2 + \gamma_1 H_{t-1} \quad (2)$$

In the model above, the coefficient to the lagged square error in a GARCH model is allowed to attain different values depending on the sign of lagged error term. In this TGARCH model, the indicator function is 1 if $\varepsilon_{t-1} < 0$, and 0 otherwise. In this model, for positive lagged errors, the coefficient is just ψ parameter, while the coefficient for negative error terms is $\psi + \beta$.

A VAR model is a general framework to describe the dynamic interrelationship among variables. The VAR model is based on the ordinary least square model, but this model studies the information transition within several variables, which is why the VAR model has an important role in econometrics. We employ the VAR model to examine the predictive power of market emotions against the future commodity returns:

$$Y_t = \lambda + \sum_{i=1}^{5} \psi Y_{t-i} + \varepsilon_t \quad (3)$$

where Y_t is a vector that contains commodity returns and sentiment, optimism, fear and joy. We estimate VAR models of up to five days, based on selection metrics such as AIC and BIC, to investigate the causal structures and forecasting capabilities of emotion measures.

Table II. Correlation coefficients

	SNTMENT_CRU	OPTIMSM_CRU	FEAR_CRU	JOY_CRU	SNTMENT_GOL	OPTIMSM_GOL	FEAR_GOL	JOY_GOL
SNTMENT_CRU	1.0000							
OPTIMSM_CRU	0.3599***	1.0000						
	< 0.0001							
FEAR_CRU	−0.0095	−0.0787***	1.0000					
	0.6277	< 0.0001						
JOY_CRU	0.1245***	0.1252***	−0.0032	1.0000				
	< 0.0001	< 0.0001	0.8711					
SNTMENT_GOL	0.2818***	0.1259***	0.0224	0.1704***	1.0000			
	< 0.0001	< 0.0001	0.2518	< 0.0001				
OPTIMSM_GOL	0.0891***	0.1010***	0.0063	0.2127***	0.4591***	1.0000		
	< 0.0001	< 0.0001	0.7480	< 0.0001	< 0.0001		< 0.0001	
FEAR_GOL	−0.0634***	−0.0267	0.1728***	−0.0552***	−0.0159	−0.1238***	1.0000	
	0.0012	0.1720	< 0.0001	0.0048	0.4178	< 0.0001		
JOY_GOL	0.0415**	0.0602***	0.0232	0.1577***	0.3052***	0.2898***	−0.1114***	1.0000
	0.0340	0.0021	0.2359	< 0.0001	< 0.0001	< 0.0001	< 0.0001	

Notes: This table provides Pearson correlation coefficients for the full sample of 2,610 daily observations from January 1, 1998 to December 31, 2011. The emotion indicators' data in the table come from the Thomson Reuters MarketPsych Indices (TRMI), and the CRB Index, crude oil spot and gold spot returns in the table are calculated based on Thomson Reuters Core Commodity CRB Index, crude oil spot and gold spot last price data from Global Finance database. Among the variables, CRBR is the log of the daily Thomson Reuters Core Commodity CRB Index returns; CRUDER is the log of the daily crude oil spot returns; GOLDR is the log of the daily crude oil spot returns; SNTMENT_CRU is the daily market-level crude oil sentiment; OPTIMSM_CRU is the daily market-level crude oil optimism; FEAR_CRU is the daily market-level crude oil fear; JOY_CRU is the daily market-level crude oil joy; SNTMENT_GOL is the daily market-level gold sentiment; OPTIMSM_GOL is the daily market-level gold optimism; FEAR_GOL is the daily market-level gold fear; and JOY_GOL is the daily market-level gold joy, 95 percent or at 99 percent levels. *,**,***Significant at 10, 5 and 1 percent levels, respectively

Source: January 1, 1998 to December 31, 2011

4. Empirical results

Mainstream finance literature documents that sentiment affects stock market prices since individual investors' sentiment fuels noise trading (Tetlock, 2007; Sun *et al.*, 2016). Cognitive theorists distinguish emotions as a person's appraisal or cognitive response to a specific situation (Lerner and Keltner, 2000; Tiedens and Linton, 2001). The wisdom of "buy on fear, sell on greed" in forming a trading strategy stems from the appraisal of the market behavioral risk. Since there are both commercial users and speculators investing in commodity markets, we expect that market emotion can affect commodity returns in two ways: the sentimental effect of market emotion – it contributes incrementally to the sentiment-driven noise trading; and the appraisal effect of market emotion – the specific emotion incorporates information of the rational investors' evaluation of certain situations. This research tests these effects of market emotion in both the univariate and multivariate framework.

4.1 Contemporaneous relationship between emotions and commodity returns

Table III presents TGARCH (1, 1) of models (1) and (2) for CRB commodity market index returns. We estimate the CRB index return and return volatility with crude oil- and gold-specific sentiment, optimism, fear and joy as exogenous variables. Both the crude oil and gold sentiments are statistically significant at the 1 percent level. Sentiment variables are positively correlated with the contemporaneous CRB index return, which is consistent with the previous studies of news sentiment in commodity market (Borovkova, 2011; Borovkova and Mahakena, 2015; Smales, 2014). Both the sentiment's regression and multiple emotions' regression have over 14 percent explanatory power, indicated by their R^2. The coefficients for the conditional volatility are highly statistically significant. So the CRB conditional volatility is influenced by the lagged volatility. Additionally, the asymmetric parameters (β in model (2)) of the lagged error terms are not significant. It suggests that there is no asymmetric effect between the positive and negative shocks in their impact on commodity market index volatilities.

The individual commodity-specific sentiment, optimism, fear and joy are not significantly correlated with commodity composite index return. This may indicate two possibilities: first, the commodity returns are not subject to the influence of investors' emotion; and second, investors' emotion may affect the commodity returns differently with investors' sentiment. We further explore the effects of investors' emotion in individual commodities' (crude oil and gold spot) markets.

Tables IV and V report TGARCH (1, 1) of models (1) and (2) for crude oil and gold spot returns in both the univariate and multivariate regressions, respectively. In Table IV, all the sentiment and emotion variables have a statistically significant and positive correlation with crude oil return in their univariate TGARCH analyses. Crude oil-specific optimism and joy show quite similar sentimental effects on crude oil return, while the crude oil-specific fear effect on crude oil return is an appraisal effect. When commercial users of crude oil fear that there may be a shortage of supply in the near future, the required return on crude oil will be elevated to compensate the uncertainty of the supply shortage. For example, during the Iraq War in 2003 and 2004, the fear of a shortage of crude oil on the global petroleum market caused crude oil prices to spike. In our TGARCH multiple-emotion model, we see optimism is statistically significant and negatively associated with crude oil returns, and fear continues to be statistically significant and positively correlated with oil returns by controlling the effect of sentiment. The negative correlation between optimism and returns in multiple-emotion model is consistent with Ciccone's (2003) report, in which optimistic expectations lead lower returns. The explanation comes from the rational investors' tendency to hedge the risk of the crude oil overpricing caused by the investors' optimistic expectations. Additionally, we found that the asymmetric parameters in crude oil TGARCH models are all positive and significant.

Table III. CRB index returns on investors' emotions

	Intercept	SNTMENT_CRU	SNTMENT_GOL	OPTIMSM_CRU	OPTIMSM_GOL	FEAR_CRU	FEAR_GOL	JOY_CRU	JOY_GOL
Sentiment effect	0.6356***	3.0668***	0.7751***						
	18.53	19.89	4.02						
Optimism effect	0.1126***			4.7284***	1.1267				
	4.8			4.8	1.08				
Fear effect	0.0772*					−1.0502	−0.8401		
	1.65					−0.64	−0.29		
Joy effect	−0.0501							3.8687	4.2919
	−0.94							1.56	1.05
Multiple	0.6462***	3.1502***	0.9039***	−1.4125	−1.2199	−2.3006	1.9231	−0.3486	1.1872
Emotions' effect	8.99	18.99	4.08	−1.50	−1.11	−1.58	0.73	−0.16	0.31
	Lagged CRBR	TARCHA0	TARCHA1	TARCHB1	TGARCH1	*R*^2			
Sentiment effect	0.1325***	0.015***	0.0403***	−0.001705	0.9459***	0.1433			
	6.84	3.5	5.09	−0.19	107.87				
Optimism effect	0.0304	0.0172***	0.0308***	0.009952	0.9493***	0.0124			
	1.61	3.64	4.07	1.1	114.27				
Fear effect	0.0276	0.0159***	0.0275***	0.0123	0.9525***	0.0010			
	1.46	3.55	3.79	1.42	119.07				
Joy effect	0.0308	0.016***	0.0254***	0.0146*	0.9533***	0.0023			
	1.64	3.60	3.67	1.72	122.24				
Multiple	0.1352***	0.0142***	0.0394***	−0.002355	0.9478***	0.1459			
Emotions' effect	6.91	3.40	4.98	−0.27	109.44				

Notes: This table reports the results of threshold GARCH (TGARCH) model from Zakoian (1994). We employ the following TGARCH (1, 1) model to investigate the effects of investor emotions on the CRB index returns volatility in both the univariate and multivariate analyses:

$$\mathrm{CRBR}_t = \alpha_0 + \alpha_1 \mathrm{CRBR}_{t-1} + \alpha_2 \mathrm{Sentiment}_t + \alpha_3 \mathrm{Optimism}_t + \alpha_4 \mathrm{Fear}_t + \alpha_5 \mathrm{Joy}_t + \varepsilon_t$$

$$H_t = \omega + \left(\psi + \beta, 1_{\{\varepsilon t-1 < 0\}}\right)\varepsilon_{t-1}^2 + \gamma_1 H_{t-1}$$

In this TGARCH model, the indicator function is 1 if $\varepsilon_{t-1} < 0$, and 0 otherwise. In this model, for positive lagged errors, the coefficient is just ψ parameter, while the coefficient for negative error terms is $\psi + \beta$. The sample period comprised 2,610 trading days from January 1, 1998 to December 31, 2011. The emotion indicators' data in the table come from the Thomson Reuters MarketPsych Indices (TRMI), and the CRB Index returns in the table are calculated based on Thomson Reuters Core Commodity CRB Index last price data from Global Finance database. This table shows correlations between the investor emotions of crude oil and gold and CRB index returns in both the univariate and multivariate TGARCH models. Among the variables, CRBR is the log of the daily Thomson Reuters Core Commodity CRB Index returns; SNTMENT_CRU is the daily market-level crude oil sentiment; OPTIMSM_CRU is the daily market-level crude oil optimism; FEAR_CRU is the daily market-level crude oil fear; JOY_CRU is the daily market-level crude oil joy; SNTMENT_GOL is the daily market-level gold sentiment; OPTIMSM_GOL is the daily market-level gold optimism; FEAR_GOL is the daily market-level gold fear; and JOY_GOL is the daily market-level gold joy, 95 percent or at 99 percent levels. *,**,***Significant at 10, 5 and 1 percent levels, respectively

Source: January 1, 1998 to December 31, 2011

Table IV.
Crude oil spot returns on investors' emotions

	Intercept	SNTMENT_CRU	OPTIMSM_CRU	FEAR_CRU	JOY_CRU	Lagged CRUDER	TARCHA0	TARCHA1	TARCHB1	TGARCH1	R^2
Sentiment effect	1.5353***	9.0259***				0.0763***	0.1384***	0.0390***	0.0425***	0.9069***	0.2502
	24.21	29.93				3.95	6.47	5.43	3.99	97.7	
Optimism effect	0.2591***		13.6283***			−0.0092	0.1507***	0.0268***	0.0590***	0.9148***	0.0224
	5.2		6.63			−0.48	5.52	4.12	5.64	103.81	
Fear effect	−0.0264			8.1208**		−0.0134	0.1364***	0.0209***	0.0643***	0.9209***	0.0014
	−0.38			2.35		−0.71	5.22	3.48	6.31	108.44	
Joy effect	−0.1120				14.4013***	−0.0107	0.1374***	0.0263***	0.0572***	0.9189***	0.0040
	−1.27				2.67	−0.55	5.13	4.09	5.61	105.97	
Multiple emotions' effect	1.3643***	9.2425***	−3.7988**	7.9550***	2.1805	0.0794***	0.1326***	0.0375***	0.0434***	0.9092***	0.2525
	12.93	28.32	−2.09	2.66	0.49	4.08	6.33	5.34	4.21	98.22	

Notes: This table reports the results of threshold GARCH (TGARCH) model from Zakoian (1994). We employ the following TGARCH (1, 1) model to investigate the effects of investor emotions on the crude oil returns volatility in both the univariate and multivariate analyses:

$$\text{CRUDER}_t = \alpha_0 + \alpha_1\ \text{CRUDER}_{t-1} + \alpha_2 \text{Sentiment}_t + \alpha_3 \text{Optimism}_t + \alpha_4 \text{Fear}_t + \alpha_5 \text{Joy}_t + \varepsilon_t$$

$$H_t = \omega + \left(\psi + \beta, 1_{\{\varepsilon t-1 < 0\}}\right)\varepsilon_{t-1}^2 + \gamma_1 H_{t-1}$$

In this TGARCH model, the indicator function is 1 if $\varepsilon_{t-1} < 0$, and 0 otherwise. In this model, for positive lagged errors, the coefficient is just ψ parameter, while the coefficient for negative error terms is $\psi + \beta$. The sample period comprised 2,610 trading days from January 1, 1998 to December 31, 2011. The emotion indicators' data in the table come from the Thomson Reuters MarketPsych Indices (TRMI), and the crude oil spot returns in the table are calculated based on crude oil spot last price data from Global Finance database. This table shows correlations between the investor emotions of crude oil and crude oil spot returns in both the univariate and multivariate TGARCH Models. Among the variables, CRUDER is the log of the daily crude oil spot returns; SNTMENT_CRU is the daily market-level crude oil sentiment; OPTIMSM_CRU is the daily market-level crude oil optimism; FEAR_CRU is the daily market-level crude oil fear; JOY_CRU is the daily market-level crude oil joy, 95 percent or at 99 percent levels. *,**,***Significant at 10, 5 and 1 percent levels, respectively

Source: January 1, 1998 to December 31, 2011

Table V. Gold spot returns on investors' emotions

	Intercept	SNTMENT_GOL	OPTIMSM_GOL	FEAR_GOL	JOY_GOL	Lagged GOLDR	TARCHA0	TARCHA1	TARCHB1	TGARCH1	R^2
Sentiment effect	0.4649***	3.4210***				0.1282***	0.0233***	0.0753***	−0.0205**	0.9170***	0.1153
	16.92	18.19				5.92	5.74	9.33	−2.23	123.54	
Optimism effect	0.0898***		6.8145***			0.0493**	0.0178***	0.0936***	−0.0477***	0.9208***	0.0117
	4.83		8.8			2.33	5.12	13.72	−5.53	162.67	
Fear effect	0.0569			1.0564		0.0318	0.0219***	0.0951***	−0.0531***	0.9185***	0.0005
	1.38			0.39		1.46	6.62	16.06	−6.83	175.97	
Joy effect	−0.0176				8.4603**	0.0369*	0.0212***	0.0955***	−0.0532***	0.9188***	0.0015
	−0.39				2.2	1.71	6.18	15.31	−6.83	170.06	
Multiple emotions' effect	0.6295***	3.7443***	−0.1189	1.8757	−14.2909***	0.1337***	0.0237***	0.0704***	−0.0162	0.9187***	0.1219
	8.97	16.62	−0.13	0.73	−3.47	6.02	5.51	7.77	−1.51	114.05	

Notes: This table reports the results of threshold GARCH (TGARCH) model from Zakoian (1994). We employ the following TGARCH (1, 1) model to investigate the effects of investor emotions on the gold returns volatility in both the univariate and multivariate analyses:

$$\mathrm{GOLDR}_t = \alpha_0 + \alpha_1 \mathrm{GOLDR}_{t-1} + \alpha_2 \mathrm{Sentiment}_t + \alpha_3 \mathrm{Optimism}_t + \alpha_4 \mathrm{Fear}_t + \alpha_5 \mathrm{Joy}_t + \varepsilon_t$$

$$H_t = \omega + \left(\psi + \beta, 1_{\{\varepsilon t-1 < 0\}}\right)\varepsilon_{t-1}^2 + \gamma_1 H_{t-1}$$

In this TGARCH model, the indicator function is 1 if $\varepsilon_{t-1} < 0$, and 0 otherwise. In this model, for positive lagged errors, the coefficient is just ψ parameter, while the coefficient for negative error terms is $\psi+\beta$. The sample period comprised 2,610 trading days from January 1, 1998 to December 31, 2011. The emotion indicators' data in the table come from the Thomson Reuters MarketPsych Indices (TRMI), and the GOLD spot returns in the table are calculated based on GOLD spot last price data from Global Finance database. This table shows correlations between the investor emotions of gold and gold spot returns in both the univariate and multivariate TGARCH Models. Among the variables, GOLDR is the log of the daily gold spot returns; SNTMENT_GOL is the daily market-level gold sentiment; OPTIMSM_GOL is the daily market-level gold optimism; FEAR_GOL is the daily market-level gold fear; and JOY_GOL is the daily market-level gold joy. *,**,***Significant at 10, 5 and 1 percent levels, respectively

Source: January 1, 1998 to December 31, 2011

The results support strong leverage effects, where negative shocks have larger effect on volatility of crude oil returns. When ε_{t-1} is negative, the total effects are given by $(\psi+\beta)\varepsilon_{t-1}^2$. One expects β to be positive for bad news, so the bad news would have larger impacts on conditional volatility. Since $\psi > 0$, the conditional volatility was increased more by the negative shocks than positive shocks at an equal size. This further supports that fear fueled by bad news amplifies conditional volatility, and in turn increases crude oil current return.

From Table V, optimism, joy and sentiment are statistical significantly and positively correlated with gold return in their univariate TGARCH regressions, while fear is insignificant. Again, it seems that gold-specific optimism and joy show quite similar sentimental effects on gold return. It seems that our findings, from the univariate emotion models, confirm Hirshleifer and Shumway's (2003) "sunlight effect" that investors in the joyful mood perform better in their investments. However, the joy significantly and negatively correlates with gold return by controlling for the sentiment effect in the multiple mean regression TGARCH emotion model. Interestingly, this finding suggests that the market reaction to the emotion of joy, in the condition of market sentiment being controlled, contradicts to Hirshleifer and Shumway's (2003) earlier hypothesis. The explanation is that the appraisal of an emotion is in effect when its sentiment effect is purged. Institutional investors would take the opportunity to arbitrage the overpriced gold caused by individual investors' joyful mood, in turn, to depress the gold price. Additionally, we find that the asymmetric parameters (β in model (2)) in gold TGARCH models are negative and significant in the four univariate regressions but not significant in the multiple TGARCH emotion model. Since $\psi > 0$, the conditional volatility was increased more from positive shocks than negative shocks at an equal size. The coefficients of the threshold ARCH terms suggest two opposite scenarios between gold and crude oil. The conditional volatility of gold is more sensitive to positive shocks than negative shocks, but the conditional volatility of crude oil is affected more by negative shocks than positive shocks.

Overall, we summarize that commodity-specific emotions, such as optimism, fear and joy, do not significantly influence commodity market index returns. However, commodity-specific sentiments significantly influence the contemporaneous market index returns. In the individual commodities' (crude oil and gold) TGARCH analyses, the empirical results support both a sentimental effect in univariate framework and appraisal effect in multivariate model when sentiment effect is controlled.

4.2 Short-term predictability of emotions on commodity returns

This section tests the predictive power of sentiment and emotions on both the CRB commodity market index and crude oil and gold commodity returns for up to five days, consistent with the mainstream use of sentiment in predicting the next five days' returns (Tetlock, 2007; Garcia, 2013). Table VI presents the estimated daily parameters for the VAR (5) model (model (3)) with commodity-specific sentiment, optimism, fear, joy and CRB index returns. The table reports that the CRB market return is influenced by one-day lagged crude oil sentiment, optimism and joy; two-day lagged crude oil fear; three-day lagged crude oil optimism and gold joy; and five-day lagged crude oil optimism and gold optimism. However, the signs of coefficients of the predictors are not persistent throughout the five-day predicting time window. This indicates that individual commodity-specific emotions are not efficient in predicting the directional movements of commodity market index returns, similar to the pattern that individual stock sentiments are not reliable in predicting stock market index movements. So, more evidence is required on short-term predictability of emotions on individual commodities' (crude oil and gold) markets. Additionally, Figure 2 shows plots of the impulse response functions of the return on the commodity market due to emotion measures. The impulse responses are plotted for the increasing lag lengths for a push to the market return.

Table VI.
Predicting CRB index returns using TRMI commodities' emotions

Parameter	CRBR	Parameter	CRBR	Parameter	CRBR	Parameter	CRBR	Parameter	CRBR
CRBR($t-1$)	−0.04592**	CRBR($t-2$)	−0.0168	CRBR($t-3$)	0.03985*	CRBR($t-4$)	−0.02676	CRBR($t-5$)	−0.0442**
	−2.11		−0.72		1.73		−1.16		−1.97
SNTMENT_CRU($t-1$)	0.51328*	SNTMENT_CRU($t-2$)	−0.04301	SNTMENT_CRU($t-3$)	−0.07068	SNTMENT_CRU($t-4$)	0.42767	SNTMENT_CRU($t-5$)	−0.1653
	1.95		−0.16		−0.26		1.58		−0.67
OPTIMSM_CRU($t-1$)	−2.4861**	OPTIMSM_CRU($t-2$)	−1.3343	OPTIMSM_CRU($t-3$)	2.45433**	OPTIMSM_CRU($t-4$)	1.72862	OPTIMSM_CRU($t-5$)	2.16015*
	−2.13		−1.14		2.09		1.47		1.86
FEAR_CRU($t-1$)	−0.60379	FEAR_CRU($t-2$)	−4.45334*	FEAR_CRU($t-3$)	−0.85291	FEAR_CRU($t-4$)	1.69384	FEAR_CRU($t-5$)	1.42774
	−0.26		−1.86		−0.36		0.71		0.62
JOY_CRU($t-1$)	−5.97054*	JOY_CRU($t-2$)	2.62823	JOY_CRU($t-3$)	4.91858	JOY_CRU($t-4$)	0.47445	JOY_CRU($t-5$)	−4.87106
	−1.66		0.71		1.33		0.13		−1.35
SNTMENT_GOL($t-1$)	−0.06438	SNTMENT_GOL($t-2$)	−0.10166	SNTMENT_GOL($t-3$)	−0.31679	SNTMENT_GOL($t-4$)	−0.12822	SNTMENT_GOL($t-5$)	−0.3341
	−0.21		−0.32		−1.00		−0.40		−1.12
OPTIMSM_GOL($t-1$)	0.48825	OPTIMSM_GOL($t-2$)	−0.46525	OPTIMSM_GOL($t-3$)	0.6122	OPTIMSM_GOL($t-4$)	−0.35454	OPTIMSM_GOL($t-5$)	−2.32887*
	0.35		−0.34		0.44		−0.26		−1.69
FEAR_GOL($t-1$)	−2.77274	FEAR_GOL($t-2$)	−2.49792	FEAR_GOL($t-3$)	4.67403	FEAR_GOL($t-4$)	−2.70748	FEAR_GOL($t-5$)	−1.22818
	−0.76		−0.66		1.23		−0.72		−0.34
JOY_GOL($t-1$)	5.22018	JOY_GOL($t-2$)	3.38856	JOY_GOL($t-3$)	9.89728*	JOY_GOL($t-4$)	3.47969	JOY_GOL($t-5$)	4.18877
	1.01		0.65		1.88		0.66		0.81

Notes: The table reports the results of vector autoregressive model estimates of the CRB core commodity index returns on investor emotional indicators to its five-day lag:

$$Y_{\mathrm{t}} = \lambda + \sum_{i=1}^{5} \psi Y_{t-i} + \mathscr{E}_t$$

where Y_t is a vector that contains core commodity index returns and investor emotions (sentiment, optimism, fear and joy). The sample period comprised 2,610 days from January 1, 1998 to December 31, 2011. The emotion indicators' data in the table come from the Thomson Reuters MarketPsych Indices (TRMI), and the CRB Index returns in the table are calculated based on Thomson Reuters Core Commodity CRB Index last price data from Global Finance database. Among the variables, CRBR is the log of the daily Thomson Reuters Core Commodity CRB Index returns; SNTMENT_CRU is the daily market-level crude oil sentiment; OPTIMSM_CRU is the daily market-level crude oil optimism; FEAR_CRU is the daily market-level crude oil fear; JOY_CRU is the daily market-level crude oil joy; SNTMENT_GOL is the daily market-level gold sentiment; OPTIMSM_GOL is the daily market-level gold optimism; FEAR_GOL is the daily market-level gold fear; and JOY_GOL is the daily market-level gold joy, 95 percent or at 99 percent levels. *,**,***Significant at 10, 5 and 1 percent levels, respectively

Source: January 1, 1998 to December 31, 2011

The results of the VAR (5) model for crude oil and gold commodity returns are exhibited in Tables VII and VIII. Based on the *t* statistics from Tables VII and VIII, most commodity-specific emotions are capable of predicting the commodity returns for up to five days in individual commodity markets, such as crude oil and gold spot markets. Table VII reports that crude oil return is positively influenced by sentiment at the lag of one day, optimism at the lag of four and five days, and joy at the lag of three days; however, crude oil return is negatively influenced by

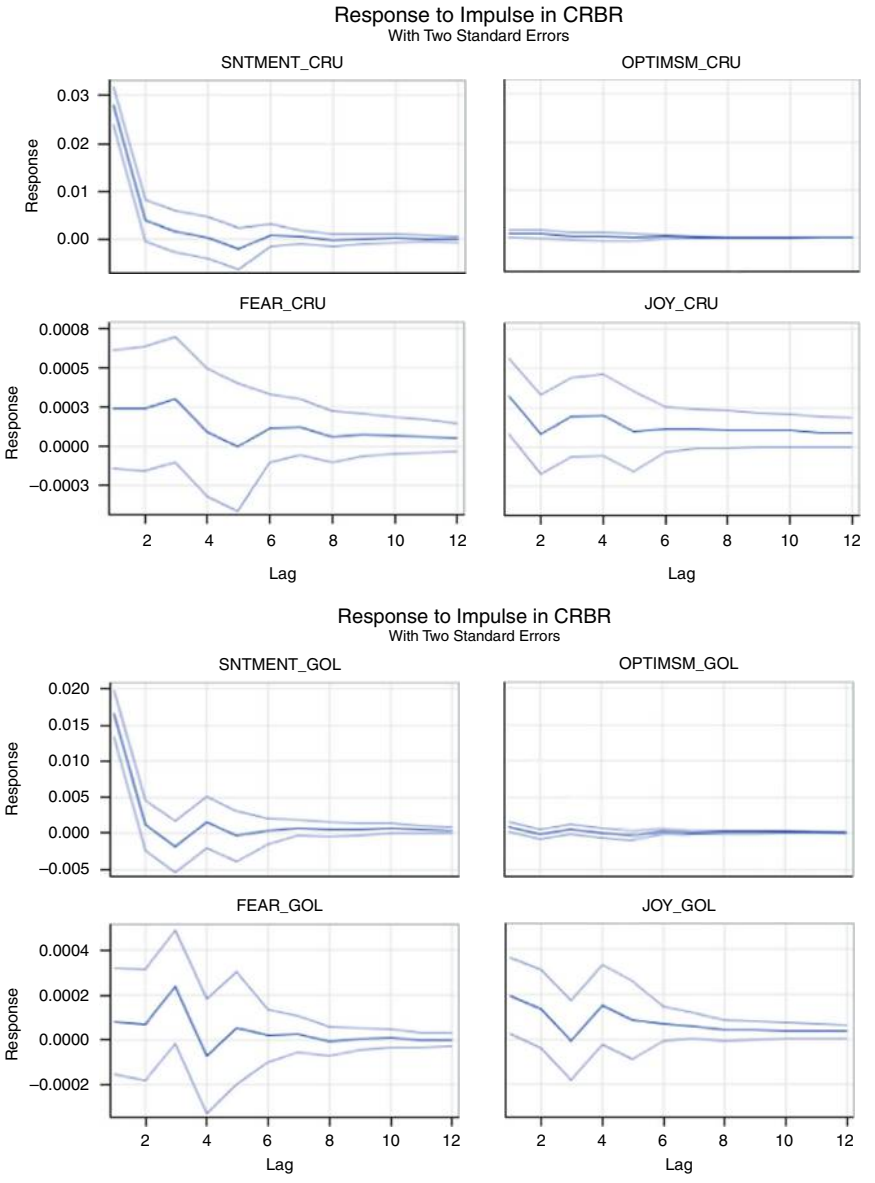


Figure 2.
Response to impulse in CRB index returns

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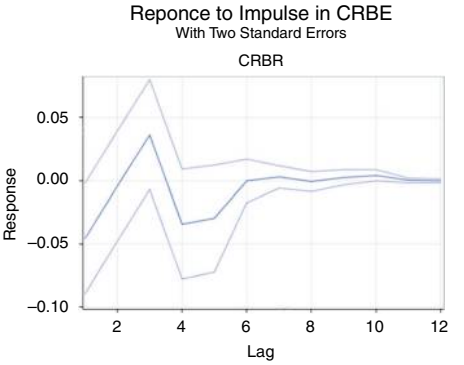


Notes: This figure provides response to impulse of the CRB Index returns on commodity specific emotions to its 12-day lag. The sample period comprised 2,610 trading days from January 1, 1998 to December 31, 2011. The emotion indicators' data in the table come from the Thomson Reuters MarketPsych Indices (TRMI), and the CRB Index return in the table are calculated based on Thomson Reuters Core Commodity CRB Index last price data from Global Finance database. Among the variables, SNTMENT_CRU is the daily market-level crude oil sentiment; OPTIMSM_CRU is the daily market-level crude oil optimism; FEAR_CRU is the daily market-level crude oil fear; JOY_CRU is the daily market-level crude oil joy; SNTMENT_GOL is the daily market-level gold sentiment; OPTIMSM_GOL is the daily market-level gold optimism; FEAR_GOL is the daily market-level gold fear; and JOY_GOL is the daily market-level gold joy; and CRBR is the log of the daily Thomson Reuters Core Commodity CRB Index returns
Source: January 1, 1998 to December 31, 2011

Figure 2.

fear at the lag of one and three days. These findings suggest a sentimental carryover effect of market emotion in predicting future returns. Figure 3 shows plots of the impulse response functions of the return on the crude oil spot market due to emotion measures.

Table VIII presents gold return as negatively affected by the last four and five days' optimism and the previous day's fear. The findings support a sentimental carryover effect on fear but a behavioral risk hedging tendency on optimism. Figure 4 shows plots of the impulse response functions of the return on the gold spot market due to emotion measures.

Overall, we conclude that commodity-specific emotional variables are not reliable in predicting market composite index returns, but can be used to predict the next five days' commodity returns for individual commodities. The supported emotional carryover effects suggest that investors carry psychological feelings on a certain commodity into its future risk and return valuation. Further, the findings regarding the short-term predictability of emotion confirm that the valence-arousal approach (Feldman, 1995) is applicable in a collective market-level emotion research setting.

5. Conclusion

The empirical research examines the contemporaneous effect and predictive power of news and social media emotions in commodity returns. This paper contributes to the emotional finance literature in several important ways. First, the market-level emotion research investigates the effects of specific emotions (optimism, fear and joy) in commodity markets. The empirical evidence supports both the sentimental effect of emotion (valence-arousal framework) and the appraisal effect of emotion (cognitive appraisal theory) when sentiment is controlled. The evidence further enriches the emotion literatures from the perspective of

Table VII.
Predicting crude oil spot returns using TRMI commodities' emotions

Parameter	CRUDER	Parameter	CRUDER	Parameter	CRUDER	Parameter	CRUDER	Parameter	CRUDER
CRUDER($t-1$)	−0.03207	CRUDER($t-2$)	−0.08315***	CRUDER($t-3$)	0.05139**	CRUDER($t-4$)	−0.01849	CRUDER($t-5$)	−0.01317
	−1.38		−3.53		2.19		−0.79		−0.58
SNTMENT_CRU ($t-1$)	2.28181***	SNTMENT_CRU ($t-2$)	0.32451	SNTMENT_CRU ($t-3$)	−0.56948	SNTMENT_CRU ($t-4$)	0.80515	SNTMENT_CRU ($t-5$)	−0.84126
	4.00		0.56		−0.98		1.38		−1.56
OPTIMSM_CRU ($t-1$)	−3.30337	OPTIMSM_CRU($t-2$)	−2.62497	OPTIMSM_CRU ($t-3$)	4.03706	OPTIMSM_CRU ($t-4$)	6.38621***	OPTIMSM_CRU ($t-5$)	4.94347**
	−1.35		−1.06		1.63		2.58		2.01
FEAR_CRU($t-1$)	−7.99724*	FEAR_CRU($t-2$)	4.46256	FEAR_CRU($t-3$)	−10.72672**	FEAR_CRU($t-4$)	7.1882	FEAR_CRU($t-5$)	2.35798
	−1.65		0.88		−2.12		1.42		0.49
JOY_CRU ($t-1$)	−9.76003	JOY_CRU($t-2$)	0.6824	JOY_CRU($t-3$)	14.93526*	JOY_CRU($t-4$)	−6.86617	JOY_CRU($t-5$)	−1.32945
	−1.29		0.09		1.92		−0.89		−0.18

Notes: The table reports the results of vector autoregressive model estimates of the crude oil spot returns on investor emotional indicators to its five-day lag:

$$Y_t = \lambda + \sum_{i=1}^{5} \psi Y_{t-i} + \mathcal{E}_t$$

where Y_t is a vector that contains crude oil spot returns and investor emotions (sentiment, optimism, fear and joy). The sample period comprised 2,610 days from January 1, 1998 to December 31, 2011. The emotion indicators' data in the table come from the Thomson Reuters MarketPsych Indices (TRMI), and the crude oil spot returns in the table are calculated based on crude oil spot last price data from Global Finance database. Among the variables, CRUDER is the log of the daily crude oil spot returns; SNTMENT_CRU is the daily market-level crude oil sentiment; OPTIMSM_CRU is the daily market-level crude oil optimism; FEAR_CRU is the daily market-level crude oil fear; JOY_CRU is the daily market-level crude oil joy. *,**,***Significant at 10, 5 and 1 percent levels, respectively

Source: January 1, 1998 to December 31, 2011

Table VIII.
Predicting gold spot returns using TRMI commodities' emotions

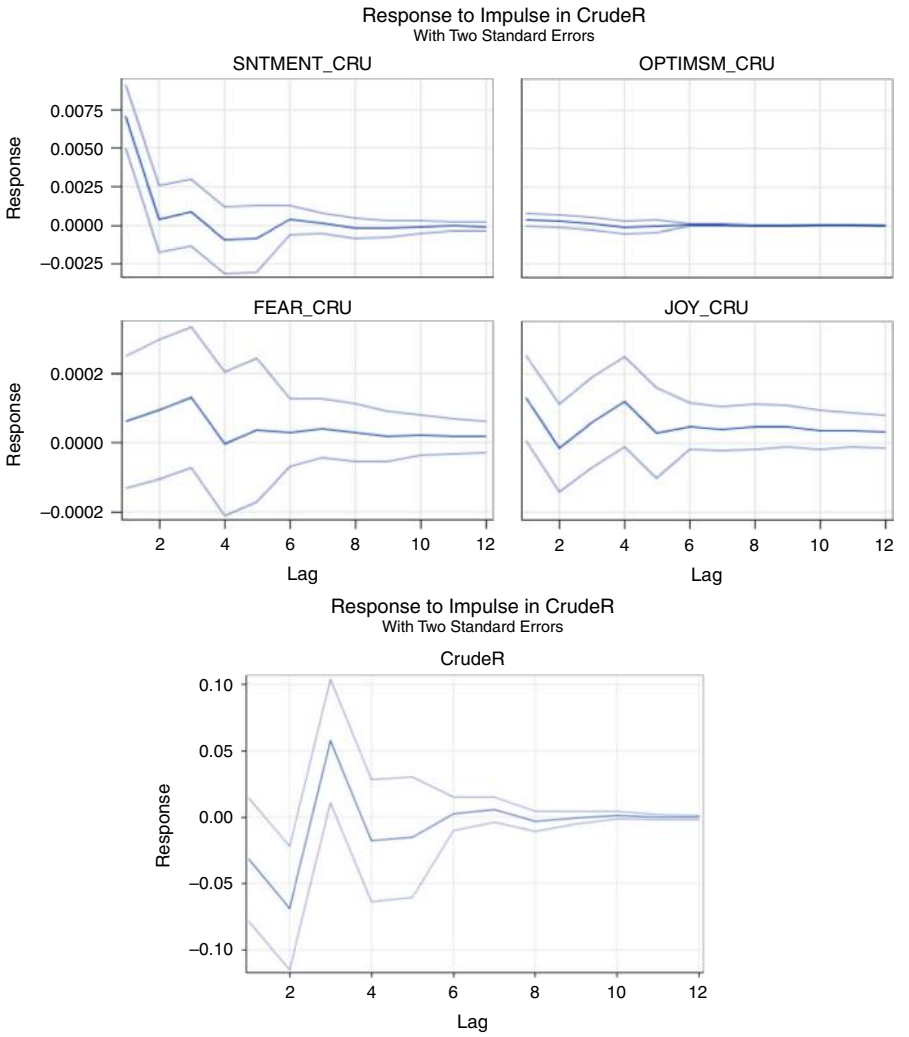
Parameter	GOLDR	Parameter	GOLDR	Parameter	GOLDR	Parameter	GOLDR	Parameter	GOLDR
GOLDR($t-1$)	−0.02484	GOLDR($t-2$)	0.00471	GOLDR($t-3$)	0.00262	GOLDR($t-4$)	0.01635	GOLDR($t-5$)	0.00394
	−1.16		0.20		0.11		0.71		0.17
SNTMENT_GOL ($t-1$)	−0.11533	SNTMENT_GOL($t-2$)	0.1289	SNTMENT_GOL($t-3$)	−0.03196	SNTMENT_GOL ($t-4$)	−0.1163	SNTMENT_GOL ($t-5$)	0.05274
	−0.33		0.36		−0.09		−0.33		0.17
OPTIMSM_GOL ($t-1$)	1.52346	OPTIMSM_GOL($t-2$)	0.3071	OPTIMSM_GOL($t-3$)	0.94036	OPTIMSM_GOL ($t-4$)	−2.63537*	OPTIMSM_GOL ($t-5$)	−2.74131*
	1.07		0.21		0.65		−1.83		−1.92
FEAR_GOL($t-1$)	−8.23212**	FEAR_GOL($t-2$)	0.79682	FEAR_GOL($t-3$)	0.91665	FEAR_GOL($t-4$)	−3.55308	FEAR_GOL($t-5$)	−0.04407
	−2.17		0.20		0.23		−0.90		−0.01
JOY_GOL($t-1$)	2.50123	JOY_GOL($t-2$)	5.27787	JOY_GOL($t-3$)	7.37307	JOY_GOL($t-4$)	0.86357	JOY_GOL($t-5$)	4.96959
	0.47		0.96		1.35		0.16		0.93

Notes: The table reports the results of vector autoregressive model estimates of the gold spot returns on investor emotional indicators to its five-day lag:

$$Y_t = \lambda + \sum_{i=1}^{5} \psi Y_{t-i} + \mathcal{E}_t$$

where Y_t is a vector that contains gold spot returns and investor emotions (sentiment, optimism, fear and joy). The sample period comprised 2,610 days from January 1, 1998 to December 31, 2011. The emotion indicators' data in the table come from the Thomson Reuters MarketPsych Indices (TRMI), and the gold spot returns in the table are calculated based on gold spot last price data from Global Finance database. Among the variables, GOLDR is the log of the daily gold spot returns; SNTMENT_GOL is the daily market-level gold sentiment; OPTIMSM_GOL is the daily market-level gold optimism; FEAR_GOL is the daily market-level gold fear; and JOY_GOL is the daily market-level gold joy. *,**,***Significant at 10, 5 and 1 percent levels, respectively

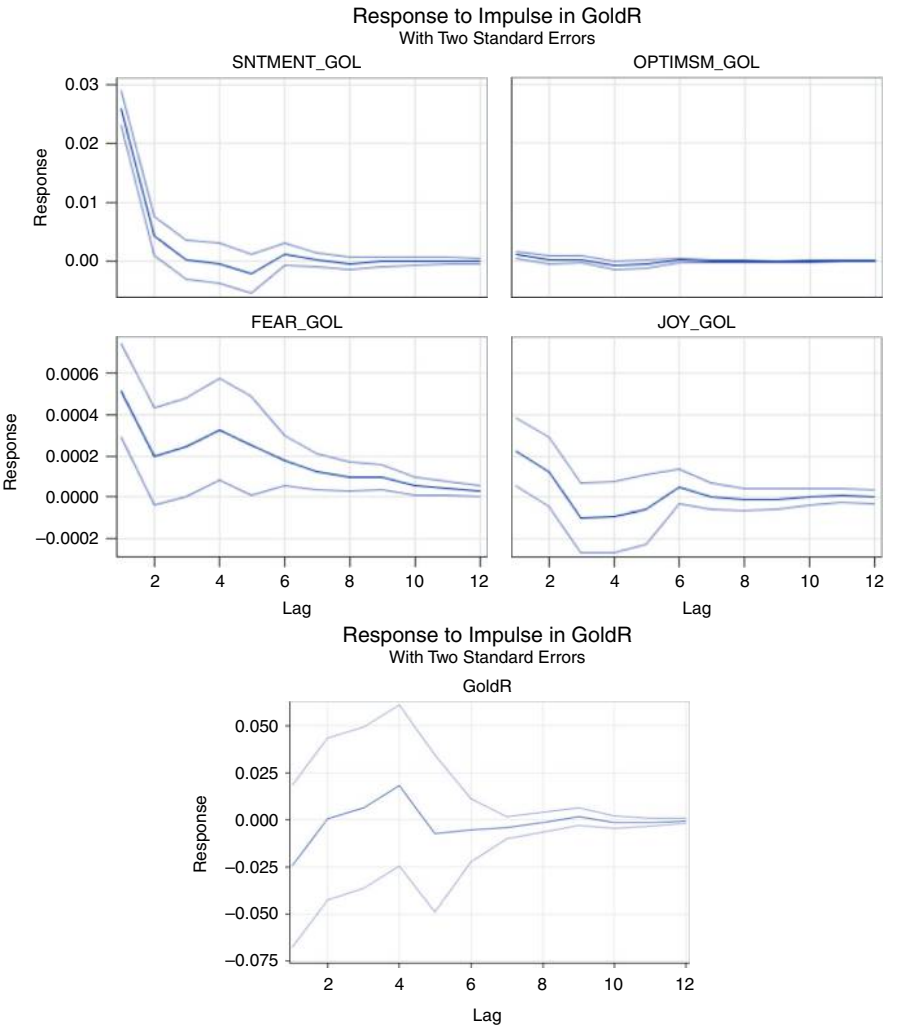
Source: January 1, 1998 to December 31, 2011



Notes: This figure provides response to impulse of the crude oil returns on crude oil specific emotions to its 12-day lag. The sample period comprised 2,610 trading days from January 1, 1998 to December 31, 2011. The emotion indicators' data in the table come from the Thomson Reuters MarketPsych Indices (TRMI), and the crude oil return in the table are calculated based on the crude oil last price data from Global Finance database. Among the variables, SNTMENT_CRU is the daily market-level crude oil sentiment; OPTIMSM_CRU is the daily market-level crude oil optimism; FEAR_CRU is the daily market-level crude oil fear; JOY_CRU is the daily market-level crude oil joy; and CRUDER is the log of the daily crude oil Spot Returns
Source: January 1, 1998 to December 31, 2011

Figure 3.
Response to impulse in crude oil spot returns

experimental research of individual emotions to the empirical study of market emotions. Second, this work extends the investors' sentiment study to the study of multiple specific emotions. Comparing to the previous studies of news sentiment on commodity returns (Borovkova, 2011; Borovkova and Mahakena, 2015; Smales, 2014), this research



Notes: This figure provides response to impulse of the gold returns on Gold specific emotions to its 12-day lag. The sample period comprised 2,610 trading days from January 1, 1998 to December 31, 2011. The emotion indicators' data in the table come from the Thomson Reuters MarketPsych Indices (TRMI), and the gold return in the table are calculated based on the gold last price data from Global Finance database. Among the variables, SNTMENT_GOL is the daily market-level gold sentiment; OPTIMSM_GOL is the daily market-level gold optimism; FEAR_GOL is the daily market-level Gold fear; and JOY_GOL is the daily market-level gold joy; and GOLDR is the log of the daily gold Spot Returns
Source: January 1, 1998 to December 31, 2011

Figure 4.
Response to impulse in gold spot returns

provides more empirical evidences about the influence of news and social media-based emotions (optimism, fear and joy) in commodity markets. Third, this research integrates news and social media emotion indices of commodities from TRMI into media-based research. While most of the prior textual analysis studies of media contents exclusively rely

on a single source, TRMI emotion indices are constructed on a collection of media sources that cover more than two million news articles and social media posts daily (Peterson, 2013). The all-encompassed media approach helps to cancel out clamoring opinions and rumors from some unreliable sources.

The findings of this research also provide risk management implications, specifically highlighting the value of media-based emotion in reflecting and forecasting commodity price changes. Researchers and institutional investors should pay more attention to the valuable information contained in media-based information. Based on media-based emotion data, institutional investors are able to construct strategies or use financial futures to hedge against the emotion-based bias in commodity pricing. Furthermore, companies should consider to deploy real-time surveillance and big-data analytics, in turn, to monitor and respond quickly to the messages of high-arousal emotions, and to take corrective actions to mitigate the potential adverse effects of high-arousal emotions.

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Corresponding author
Jiancheng Shen can be contacted at: jshen@regent.edu