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Does investor attention matter? The attention-return relation in gold futures market

Liyan Han, Yang Xu, and Libo Yin

Abstract
The authors investigate multiplicate relationships between investor attention and gold futures return. The Vector Auto Regression (VAR) estimates demonstrate that investor attention exhibits significant impact on gold futures returns and the effect can be positive or negative depending on how much time has elapsed since this effect. Reversely, VAR results demonstrate past gold return typically has a sizable impact on investor attention with a positive coefficient. Following the findings, they investigate the influences of four types of interaction terms and the results suggest that the attention-return relationship is significantly altered by past return, past trader positions, the severity of past attention, and the presence of extreme economic conditions. The authors also find that investor attention is closely associated with futures basis, indicating that investor attention incorporates meaningful information about expected futures prices, thus providing an alternative explanation of economic rationale for the attention-return relationship. The asset allocation exercise demonstrates substantial economic value by implementing information from investor attention.

JEL G12 G14 G17
Keywords gold futures return, investor attention, link to futures basis, economic value

Authors
Liyan Han, Beihang University, Beijing
Yang Xu, Beihang University, Beijing
Libo Yin, ✉ Central University of Finance and Economics, No. 39 South College RD., HaiDian DIST., Beijing, 100081, China, yinlibowsxbb@126.com

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1. Introduction

Gold has played a prominent role in the global financial systems for having multiple industrial and investment implications. Traditionally, gold is utilized as storage of value (Sherman, 1983; Baur and Mcdermott, 2010) and provides valuable diversification opportunities to investors from a portfolio management perspective (Hillier et al., 2006; Pukthuanthong and Roll, 2011; O'Connor et al., 2015) and protection against exchange rate risk for investors with U.S. dollar holdings (Reboredo, 2013). The cyclical nature of the demand for gold has underlined its role as a safe haven against inflation and during times of market turmoil (Baur and Lucey, 2010; Baur and McDermott, 2010; Białkowski et al., 2012; Agyei-Ampomah et al., 2014). It is therefore of importance to explore the determinants of gold prices. Existing literature has extensively relied on fundamental variables such as the state of the real economy (Sharma and Aggarwal, 2012), convenience yield (Schwartz, 1997; Casassus and Collin-Dufresne, 2005), interest rates (Poshakwale and Mandal, 2016), inflation (Blose, 2010; Wang et al., 2011), foreign exchange rates (Sjaastad and Scacciavillani, 1996), macroeconomic announcements (Cai et al., 2001; Smales and Yang, 2015), market structure (Hauptfleisch et al., 2016) and business cycle (Fama and French, 1988), etc. in explaining gold prices. However, some attention-grabbing events, for example, the market nervous ahead of "save our Swiss gold" vote; the Brexit's bullish effect on gold prices; Chinese "dama" rushing into gold market as the most enthusiastic investors after international gold price fell sharply in 2013; etc., imply that traditional economic variables may be not sufficient enough to instantaneously incorporate all relevant information. Therefore behavioral factors of investors must play a role in explaining the fluctuations in gold futures market and we are motivated to investigate this question from a new perspective: *investor attention*.

Previous research provides a profound theoretical framework in which limited attention can affect asset pricing statics as well as dynamics (Merton, 1987; Christie and Chaudhry, 1999; Sims, 2003; Peng and Xiong, 2006; Hautsch et al., 2011). Many empirical studies also find consistent evidence to support that investor attention has a significant impact in determining asset prices (Barber and Odean, 2008; Da et al., 2011; Yuan, 2015; Da et al, 2015). Following Da et al. (2015), we use attention search probability, which is conceived to be related with individual/retail investors, from Google Trend as proxy in this research. As illustrated in Fig.1, it depicts the dynamics of gold futures prices and the search probabilities of attention term “PRICE OF GOLD” over the full sample period. The line of gold futures prices shows an upward trend with a few spikes before 2012 and gradually declines since then. It is interesting to observe that the line of attention search probability shows a slightly upward trend with several spikes correspondent to the fluctuations in gold futures prices. Specifically, the spikes denoted by label 1,2,4,5,6,12 seem positively related to the counterparts of the line of gold futures prices while other spikes seem negatively related. In light of this, we would expect a relation between gold futures return and the attention on gold price in general.

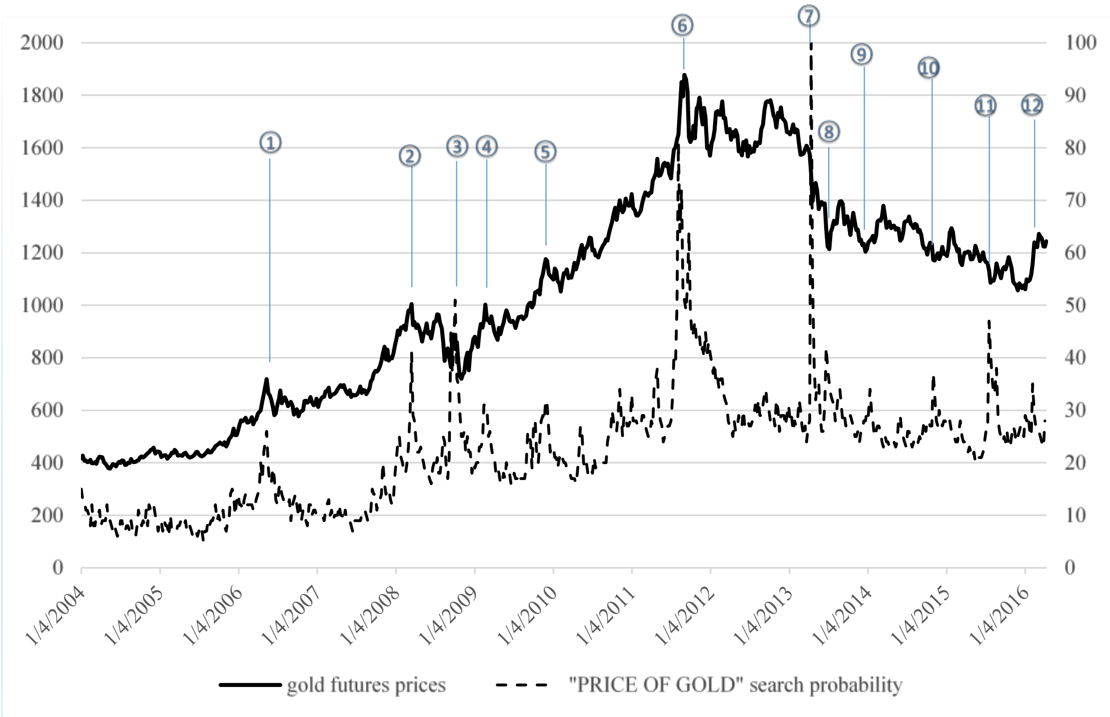

Figure 1. Dynamics of gold futures prices and attention search probability of “PRICE OF GOLD”

Note: This figure displays the dynamics of gold futures prices and Google search probability of the attention term “PRICE OF GOLD” over the full sample period of January 2004 to March 2016.

We use the aggregate search probabilities published by Google as a measure of investor attention for two reasons. First, as a novel and direct measure of investor attention, it is helpful to avoid the problem resulted from those indirect proxies, such as news and headlines (Barber and Odean, 2008; Yuan, 2015) or psychological barriers (Aggarwal and Lucey, 2007). Headlines or keywords reported in news media are not necessarily a way to guarantee attention unless people actually read it, while people who search for one specific term are undoubtedly paying attention to it (Da et al., 2011). Second, by establishing the attention search volume that captures retail investor attention, we examine the theory of Peng and Xiong (2006) who find that limited investor attention leads to category-hearing behavior, that is, investors tend to process market-wide information rather than firm-specific information.

Our main work and contributions to existing literatures are at least four folds. First, while there is explosive literature concerning the relationships between investor attention and returns in financial markets (Barber and Odean, 2008; Da et al., 2011; Yuan, 2015; Da et al., 2015), this is the first paper to consider this connection in the context of gold futures market. In light of this, we begin with the Granger Causality test and VAR model to investigate possible connection between investor attention and gold futures return. We then step further to test the attention mechanism suggested by Barber and Odean (2008) in order to find out whether the response of return in gold futures market is different from that of stock markets. They find that individual investors are net buyers of attention-grabbing stocks and thus an increase in retail investor attention results in temporary positive price pressure. This finding is based on the hypothesis that when individual investors are buying, they choose from a large set of available alternatives, while they are selling, they can only sell what they have on hand. We have a piece of consideration, however, that may be inconsistent with the above theory. The "net buyer" hypothesis is not that profound as a reasonable conjecture because investors, especially those non-sophisticated retail investors are very likely to pay more attention (search information) when make decisions for buying as well as selling. Our results indicate that investor attention can impact gold futures returns and this effect can be positive or negative depending on how much time has elapsed since this effect. Also, our results illustrate that this attention-return relationship in gold futures market typically can last as long as three or four weeks, which seems longer than those in stock markets as suggested by Da et al. (2011) where investor attention displays significant effect only in the first week and the effect dissipates fairly quickly.

Second, we investigate multiplicate possible influences on the relationship between investor attention and gold futures returns. Firstly, we examine the influence of past return on the attention-return relationship. Intuitively, past returns function as a part of the information received by retail investors (Volyublennaia, 2014). Our results demonstrate that the interaction effect between lagged return and lagged attention is significant in the predictive regression of gold futures return, and furthermore, increased investor attention diminishes predictability of return and improves market efficiency. Barber and Odean (2008), and Da et al. (2011) provide evidence that investor attention results in increased buying pressure that pushes stock prices up temporarily, which means the stock price cannot fully reflect fundamental information due to increased investor attention. Our findings in gold futures market, however, are different from theirs. Second, we examine whether net trader positions of gold futures have influences on the relationship between investor attention and gold returns. Existing literature frequently focuses on the impact of popular trading activity measures such as trading volume (Barber and Odean, 2008). Futures traders are supposed to face various constraints in terms of position limits imposed by the exchange which may result in pricing mechanism being somewhat different to that in other financial markets. To our best knowledge, few literature accounts for the constraints in futures market and those who did result in complex findings. Clements and Todorova (2016) investigate how trader positions unrelated to information flow co-vary with realized commodity volatility and find that after controlling for the level of news flow and cross-correlations, net trader positions play only a minor role. These findings are at odds with those of Smales (2014), suggesting that net trader positions significantly impact the identified sentiment relationship with the effect greatest when traders are holding positions contrary to their natural positions. Considering the nature of futures market, we include trader positions in our analysis to better understand the impact of investor attention on gold futures return. In addition, we provide evidence that there exists non-linear relationship between attention and gold futures return. While the non-linear relationship in futures market has been demonstrated in previous studies (Aye et al., 2015; Hoang et al., 2016; Clements and Todorova, 2016), we investigate this relationship from investor attention perspective. The analysis of non-linearity of investor attention, at the same time, is consistent with existing studies about the links between attention and other securities (Akhtar et al., 2011; Kim et al., 2014; Hoang et al., 2015; Berger and Turtle, 2015). A study related to ours is Berger and Turtle (2015), who also capture the nonlinearity in relation between investor sentiment and subsequent returns by including a quadratic measure of sentiment. We find that there is nonlinear relationship between attention and gold futures return and the sign of this effect changes as time elapses, thus extending the literature on nonlinearity effect of investor attention.

Third, considering the distinctive character of gold, we provide evidence on how extreme economic condition influences the relationship between investor attention and gold futures return. Admittedly, a number of studies have modeled the trend and cycle features of gold prices in hedging extreme market movements (Brown, 1987; Baur and Lucey, 2010; Baur and McDermott, 2010; Białkowski et al., 2012; Beckmann et al. 2015). We extend the literature on examining this safe haven nature of gold from the perspective of investor attention by relating the underlying macroeconomic conditions as measured by S&P 500 Index and its volatility measured by VIX to the associated influence on price reaction to investor attention. The result is noteworthy in light of many investors turning to gold as a perceived hedge during equity market fluctuations.

Fourth, since statistical significance does not necessarily imply economic significance, we investigate the economic value of investor attention. We first attempt to interpret the economic view of investor attention as an aspect of expectation. Several studies suggest that the difference between current spot price and contemporaneous futures price, which is commonly defined as the futures basis, contains information about expected futures excess return (Fama and French, 1987; Gorton and Rouwenhorst, 2006; Gorton et al., 2013; Yang, 2013). With knowledge of this, we investigate the predictability of futures basis based on investor attention, in order to provide insights on the economic rationale for the attention-return relationship. We demonstrate that investor attention is closely associated with futures basis and our results are in accord with those findings in Li and Yu (2012) who find that attention proxies contain information about future market returns that is not captured by macroeconomic variables. Additionally, we calculate the certainty equivalent return (CER) for a mean-variance investor who optimally allocates across assets and the risk-free asset over the out-of-sample period. This exercise contributes to existing studies of investor attention that fail to incorporate risk aversion into the asset allocation decision and our results show that investor attention delivers systematic economic value.

The remainder of this paper is organized as follows: Section 2 describes data. Section 3 conducts empirical testing of the multiplicate relationships between investor attention and returns in the gold futures market. Section 4 provides insights on the economic rationale for the attention-return relationship by investigating the link between attention and futures basis. Section 5 calculates economic value of investor attention through asset allocation exercise. Section 6 concludes.

2. Data

We use the public Search Volume Index (SVI) from Google Trends (http://www.google.com/trend/) as investor attention proxy following Da et al. (2011, 2015). The numbers present search probabilities of a given keyword at a given time. We utilize four simple attention terms including GOLD, GOLD PRICE, GOLD PRICES, and PRICE OF GOLD, to which individual investors would probably pay attention when they search information from public sources. Besides that, we also consider a simple average combination of all attention probabilities as a proxy to obtain robustness. The data covers a weekly period from January 2004 to March 2016. Following the literature of Da et al. (2011, 2015), we work in logarithms of search terms for the ease of exposition and notation.

The empirical analysis in this paper considers gold futures market. The most actively traded gold futures are those traded on COMEX (through Chicago Mercantile Exchange) where the contract size is 100 troy ounces and the minimum price fluctuation is $0.10 per troy ounce. The exchange rate imposes an initial limit of 3000 (delivery month) contracts on traders. For the period of January 2004 to March 2016, a continuous series of returns is created using the settlement prices obtained from Quandl (https://www.quandl.com/) provided by SIRCA. The return is computed as the log of change in weekly prices$\left(LN\left(\frac{P_{t+1}}{P_t}\right)\right)$, where$P_{t+1}$ (P_t) refers to the settlement price of gold futures at time t $(t+1)$.

To investigate the impact of net trader positions, data is taken from the CFTC's weekly COT reports. The key feature of this dataset is that it provides a decomposition of positions held by traders categorized on the basis of whether a trader holds a reportable commercial or non-commercial position as defined by the CFTC. Traders taking commercial positions to hedge a specific risk are regarded as hedgers, and those who take noncommercial positions for reasons other than hedging are viewed as speculators. One method to standardize the COT figure is using the level of open interest to reflect the size of positions relative to the market size at that time. Note that while hedgers (speculators) are short (long) throughout the sample period the positions do not exactly offset resulting to a third classification of traders who hold positions in sizes small enough to be 'non-reportable'. The sample covers a weekly period from January 2005 to March 2016.

We consider three macroeconomic factors as controlled variables in our empirical analysis. The set of macroeconomic factors are derived from Bessembinder and Chan (1992) who demonstrate that *T*-bill, default premium, and equity dividend yield are priced risk factors in futures markets. The weekly data is collected from DataStream for the 3-month T-bill yield, Moody's BAA-rated long-term corporate bond yield, AAA-rated corporate bond yield, and S&P 500 index dividend yield over the sample period of January 2004 to March 2016. Besides that, two variables are used to investigate the influence of economic conditions on the reaction of gold futures: S&P 500 stock return and VIX index. The weekly data is obtained from Yahoo Finance and covers the period from January 2004 to March 2016.

Table 1 Summary statistics of data

	Mean	Std. dev.	Skewness	Kurtosis	Shapiro-Francia W'	Partial autocorrelation at lag			
						1	2	3	4
%Δ Gold future prices	0.003	0.027	-0.229	4.394	6.966***	0.015	-0.039	-0.0670	-0.020
GOLD (S_1)	3.941	0.140	0.708	3.843	17.106***	0.854	0.833	0.811	0.787
GOLD PRICE (S_2)	3.144	0.367	0.135	0.730	20.808***	0.933	0.915	0.906	0.889
GOLD PRICES (S_3)	2.424	0.634	-0.366	2.349	7.387***	0.966	0.938	0.918	0.905
PRICE OF GOLD (S_4)	2.964	0.525	0.275	-0.402	7.499***	0.959	0.933	0.915	0.903
Speculator net position/OI	0.872	0.029	-0.529	3.785	8.931***	0.915	0.902	0.877	0.847
Hedger net position/OI	-0.937	0.019	0.291	2.294	10.699***	0.842	0.816	0.781	0.738
RF	0.013	0.017	1.122	2.676	115.102***	0.998	0.996	0.995	0.992
DY	0.020	0.004	2.468	10.022	109.782***	0.990	0.980	0.970	0.970
CS	0.011	0.005	2.644	10.665	126.524***	0.994	0.983	0.970	0.956

Note: This table reports the summary statistics for the variables utilized in this study, adopting weekly observations for the period of 04^{th} January 2004 to 10^{th} March 2016. GOLD, GOLD PRICE, GOLD PRICES, and PRICE OF GOLD denote search probabilities for the investor attention terms of "gold", "gold price", "gold prices", and "price of gold", respectively. Speculator and hedger net positions are taken from CFTC COT dataset, and normalized by open interest (OI). RF, DY, and CS refer to 3-month T-bill yield (risk-free rate), S&P 500 index dividend yield, and credit spread between AAA-rated and BAA-rated corporate bond yield over the full sample period, respectively.

Table 1 presents summary statistics for the data utilized in this study. The weekly returns from gold futures prices are generally positive during the sample period, with no evidence of return predictability. The measures for investor attention, Google search probabilities, are marginally positive on average with large standard deviations relative to their means and significant partial autocorrelations. The magnitude of hedgers' position relative to open interest is slightly greater than that of speculators and they both experience significant partial autocorrelations over the sample period. Statistics of other macroeconomic variables are generally in line with previous literatures.

3. Relationships between investor attention and gold futures returns

To our best knowledge, the relationship between investor attention and financial assets has been examined by many studies (Merton, 1987; Sims, 2003; Peng and Xiong, 2006; Barber and Odean, 2008; Da et al., 2015), while the results are mixed. To determine whether investor attention affects gold futures returns and how, in this section, we begin our study with the Granger Causality test to find out possible connections between attention and gold futures return, then analyze the sign, timing and persistence of the relationship by employing VAR model. Next, we consider two factors that may have impact on the relationship between attention and return: one is the influence of past returns (Volyublennaia, 2014); the other is the influence of past traders positions (Smales, 2014). We also examine non-linear relationship between attention and gold futures return according to previous studies regarding the non-linearity of investor attention (Hoang et al., 2016). At last, considering the safe haven nature of gold, we test whether investor attention remains impact on gold return under extreme economic conditions.

3.1 Granger causality between investor attention and gold futures return

To investigate the possible dynamic relationship between investor attention and gold futures return, we begin our analysis with Granger Causality tests. As stated by previous literatures that changes in investor attention will caution changes in security prices and returns, and this proposition has been justified primarily for individual securities. Here, we examine this hypothesis in gold futures market. On the other hand, it is suggested that a change in security price or return can attract attention of investors. Therefore, we also consider impact in the opposite direction, where changes in gold returns caution changes in investor attention.

Granger Causality between gold futures return (R) and investor attention (S) with n lags is tested in the following model specifications:

$$R_t = \lambda_{01} + \lambda_{11} R_{t-1} + \ldots + \lambda_{n1} R_{t-n} + \varphi_{11} S_{t-1} + \ldots + \varphi_{n1} S_{t-n} + e_t, \quad (1)$$

$$S_t = \lambda_{01} + \lambda_{11} R_{t-1} + \ldots + \lambda_{n1} R_{t-n} + \varphi_{11} S_{t-1} + \ldots + \varphi_{n1} S_{t-n} + e_t. \quad (2)$$

We run Granger Causality test for the gold futures return and individual investor attention terms. For individual attention terms, we repeat the test plus three macroeconomic factors as controlled variables. We consider the 4 lag specifications according to the AIC result.

Table 2 VAR for investor attention and gold future return

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Granger Causality test										
H_0: S does not Granger cause R										
	0.093	0.066	0.019	0.021	0.007	0.009	0.098	0.076	0.062	0.066
H_0: R does not Granger cause S										
	0.482	0.590	0.042	0.041	0.102	0.071	0.021	0.010	0.012	0.012
Panel B: VAR estimation										
	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return
R_{t-1}	-0.010	-0.017	0.056	0.059	-0.012	-0.013	-0.009	-0.017	-0.035	-0.036
	(-0.25)	(-0.43)	(0.88)	(0.94)	(-0.22)	(-0.22)	(-0.24)	(-0.41)	(-0.74)	(-0.77)
R_{t-2}	-0.037	-0.041	-0.001	-0.001	-0.010	-0.006	-0.042	-0.047	-0.032	-0.031
	(-0.92)	(-1.03)	(-0.01)	(-0.01)	(-0.17)	(-0.10)	(-1.06)	(-1.18)	(-0.69)	(-0.66)
R_{t-3}	-0.033	-0.038	-0.105*	-0.105*	-0.049	-0.048	-0.037	-0.042	-0.064	-0.066
	(-0.84)	(-0.94)	(-1.72)	(-1.71)	(-0.89)	(-0.88)	(-0.94)	(-1.06)	(-1.37)	(-1.40)
R_{t-4}	0.005	0.003	0.082	0.084	-0.032	-0.026	-0.001	-0.003	0.024	0.024
	(0.13)	(0.07)	(1.31)	(1.34)	(-0.58)	(-0.48)	(-0.01)	(-0.06)	(0.50)	(0.49)
$S_{i,t-1}$	-0.041**	-0.044**	-0.026***	-0.026***	-0.029***	-0.029***	0.008	0.006	-0.019	-0.018
	(-2.18)	(-2.31)	(-2.70)	(-2.70)	(-2.99)	(-3.00)	(1.03)	(0.81)	(-1.59)	(-1.54)
$S_{i,t-2}$	0.032	0.034	0.041***	0.041***	0.031**	0.031**	0.003	0.006	0.031**	0.031**
	(1.32)	(1.37)	(3.27)	(3.23)	(2.43)	(2.41)	(0.37)	(0.65)	(2.00)	(2.02)
$S_{i,t-3}$	-0.028	-0.026	-0.016	-0.016	-0.013	-0.013	-0.019**	-0.019**	-0.027*	-0.026*
	(-1.13)	(-1.04)	(-1.25)	(-1.24)	(-1.03)	(-1.00)	(-2.04)	(-2.03)	(-1.73)	(-1.71)
$S_{i,t-4}$	0.024	0.021	0.004	0.004	-0.002	-0.002	0.004	0.003	0.005	0.004
	(1.27)	(1.08)	(0.39)	(0.41)	(-0.18)	(-0.18)	(0.59)	(0.36)	(0.40)	(0.31)
CS		0.085		0.041		0.019		0.212		0.173
		(0.41)		(0.06)		(0.08)		(1.00)		(0.78)
RF		-0.003		0.002		-0.002		-0.003		-0.002
		(-1.28)		(0.71)		(-0.88)		(-1.45)		(-1.02)
DY		0.005		0.037		0.060		0.006		-0.028
		(0.23)		(0.36)		(0.76)		(0.27)		(-0.46)

Constant	0.0515	0.061*	-0.007	-0.007	0.038***	0.038**	0.012**	0.012*	0.034**	0.031**
	(1.61)	(1.83)	(-0.40)	(-0.41)	(2.59)	(2.36)	(1.96)	(1.91)	(2.15)	(1.99)
R^2	0.014	0.021	0.059	0.061	0.047	0.051	0.014	0.020	0.025	0.029
	S_1	S_1	S_2	S_2	S_3	S_3	S_4	S_4	S_5	S_5
R_{t-1}	0.090	0.107	0.744*	0.727*	0.571*	0.566*	0.425**	0.462**	0.490***	0.490***
	(1.08)	(1.29)	(1.86)	(1.81)	(1.68)	(1.69)	(1.98)	(2.12)	(2.64)	(2.64)
R_{t-2}	0.042	0.043	0.039	0.042	0.228	0.220	0.554***	0.588***	0.290	0.271
	(0.50)	(0.52)	(0.10)	(0.11)	(0.67)	(0.66)	(2.59)	(2.71)	(1.56)	(1.45)
R_{t-3}	0.008	0.009	0.863**	0.874**	0.500	0.538*	0.205	0.244	0.377**	0.399**
	(0.10)	(0.11)	(2.21)	(2.24)	(1.54)	(1.67)	(0.96)	(1.12)	(2.02)	(2.14)
R_{t-4}	0.123	0.083	0.552	0.564	0.549*	0.599*	-0.101	-0.128	-0.020	0.014
	(1.48)	(1.00)	(1.39)	(1.42)	(1.69)	(1.86)	(-0.48)	(-0.59)	(-0.10)	(0.08)
$S_{i,t-1}$	0.813***	0.814***	0.777***	0.775***	0.841***	0.820***	0.739***	0.742***	0.862***	0.856***
	(20.48)	(20.83)	(12.57)	(12.54)	(14.84)	(14.51)	(18.76)	(18.62)	(18.65)	(18.54)
$S_{i,t-2}$	-0.012	-0.014	0.004	0.001	-0.054	-0.052	0.080	0.082	-0.071	-0.070
	(-0.24)	(-0.27)	(0.04)	(0.01)	(-0.72)	(-0.69)	(1.63)	(1.65)	(-1.16)	(-1.15)
$S_{i,t-3}$	-0.069	-0.076	-0.075	-0.079	-0.029	-0.034	0.012	0.008	-0.025	-0.029
	(-1.33)	(-1.49)	(-0.93)	(-0.99)	(-0.38)	(-0.46)	(0.25)	(0.17)	(-0.41)	(-0.47)
$S_{i,t-4}$	0.222***	0.221***	0.191***	0.189***	0.158***	0.161***	0.144***	0.148***	0.181***	0.192***
	(5.59)	(5.61)	(3.05)	(2.99)	(2.75)	(2.85)	(3.65)	(3.70)	(3.94)	(4.15)
CS		-0.266		2.721		-3.701***		-1.036		-1.213
		(-0.63)		(0.60)		(-2.67)		(-0.90)		(-1.38)
RF		0.008*		-0.011		-0.004		0.003		-0.002
		(1.92)		(-0.66)		(-0.27)		(0.32)		(-0.24)
DY		-0.010		0.380		-0.071		-0.008		0.275
		(-0.21)		(0.59)		(-0.15)		(-0.06)		(1.16)
Constant	0.181***	0.217***	0.329***	0.336***	0.231***	0.333***	0.072**	0.073**	0.171**	0.180***
	(2.70)	(3.14)	(2.93)	(2.98)	(2.69)	(3.54)	(2.15)	(2.18)	(2.75)	(2.88)
R^2	0.842	0.841	0.759	0.761	0.774	0.780	0.926	0.927	0.855	0.856

Note**:** Panel A reports the *p*-values for Granger Causality tests on individual investor attention and gold futures return. The first *p*-value refers to the null hypothesis: investor attention does not Granger cause gold futures return. The second *p*-value refers to the null hypothesis: gold futures return does not Granger cause investor attention. Panel B reports the VAR estimates of investor attention (S_t) and gold futures return (R_t) over the full sample period of January 2004 to March 2016. VAR estimation results are arranged in two parts: the return equation is given in the up section, and the attention equation is given in the down section. Equations 1(2), 3(4), 5(6), 7(8), and 9(10) report the results without (with) macro controls using attention search probabilities of GOLD and GOLD PRICE, GLOD PRICES, PRICE OF GOLD, and the simple average combination of all attention search probabilities, respectively. Estimated coefficients are followed by t-statistics in parenthesis, with *, **, *** denote coefficient significance level at 10%, 5%, and 1% levels, respectively.

In Table 2, equations 1(2), 3(4), 5(6), 7(8), and 9(10) report the results of above models without (with) macro controls using attention search probabilities of GOLD and GOLD PRICE, GLOD PRICES, PRICE OF GOLD, and the simple average combination of all attention search probabilities, respectively. Panel A reports *p*-values for pairwise Granger Causality tests of the relationship between investor attention and gold futures return. The first row of *p*-value is reported for the null hypothesis that investor attention does not Granger cause gold return. The second row of *p*-value is reported for the null hypothesis that gold futures return does not Granger cause investor attention. In general, it appears that gold futures return is influenced by changes in investor attention as significant relationships emerge between attention and returns in all equations. In the case of equation 1, 2 and 5, investor attention Granger causes gold returns at a conventional level of significance while gold futures return does not Granger cause correspondant investor attention. Turning to the equations using attention terms of GOLD PRICE, PRICE OF GOLD and the combination of all attention search probabilities, investor attention Granger causes gold return and in the reverse direction gold return Granger causes investor attention at a conventional level of significance as well. In other words, investor attention (gold futures return) is statistically likely to caution subsequent changes of gold futures return (investor attention) in majority of the cases.

3.2 Sign, timing and persistence of attention impact

Following the results of Granger Causality test that gold futures returns show connections with investor attention, we seek to investigate the sign and timing of the relationship or how long the attention effect remains. To testify these questions, we continue to use the VAR models shown in Eq. (1) and Eq. (2). In Table 2, Panel B summarizes the estimates of VAR models for gold futures returns and their correspondant investor attention. The VAR results for each regression are given in two parts, first of which contains the regression coefficients with return as dependent variable, and the second of which presents the results for equations with investor attention as dependent variable. Equations 1(2), 3(4), 5(6), 7(8), and 9(10) report the results of VAR estimates without (with) macro controls using attention search probabilities of GOLD, GOLD PRICE, GOLD PRICES, PRICE OF GOLD, and combination of all attention terms, respectively.

Overall, investor attention has a significant impact on future gold returns and the signs of coefficients appear either positive or negative depending on how much time has elapsed since the effect. Typically, an increase in investor attention has an immediate negative impact at the first lag, a reversed positive impact at the second lag and a delayed negative impact at the third lag on gold futures return. Specifically, the first lag of attention is significant for six out of ten equations (with attention terms of GOLD, GOLD PRICE, and GOLD PRICES) at a conventional level of significance and this impact reverses to positive in the case of GOLD PRICE, GOLD PRICES, and combination of all attention terms at the second lag. Investor attention search probabilities of PRICE OF GOLD and combination of all attention exhibit negative impact on gold returns at the third lags. Our results are in line with those in Volyublennaia (2014) who suggests that an increase in investor attention has an initial negative impact and a reversed positive impact in subsequent periods on various asset returns. In the opposite direction, a higher gold return has a strong positive impact on the corresponding attention term from the first through fourth lags. In addition, our empirical results illustrate that the relationship between investor attention and gold futures return typically can last as long as three or four weeks, which seems longer than those between attention and stock index as suggested by Da et al. (2015) where investor attention displays significant impact only at the first lag and the effect dissipates fairly quickly. Our results are in accord with those in Volyublennaia (2014) who hypothesizes that the delayed response of gold return is due to the smaller coverage available for the index as compared to public company stocks, and therefore with scare attention, it takes longer for investors to obtain information. After controlling for macro variables, the sign and timing of investor attention coefficients are primarily the same as those in regressions without macro variables. The results so far indicate that investor attention can impact gold futures returns and the effect can be positive or negative depending on how much time has elapsed since this effect while past gold returns exhibit positive impact on investor attention and the relationships between attention and gold return typically can last as long as four weeks.

3.3 Influence of past returns on the attention-return relationship

We have observed that investor attention has an impact on gold futures return; and reversely attention may be influenced by past gold returns. Intuitively, past returns function as part of the information received by retail investors. For example, a decreasing or negative return of an asset in the past could be perceived as “bad news” by investors and thus attract considerable attention to the respective return. Empirical evidence provided by Volyublennaia (2014) suggests that investor attention can significantly alter predictability of index returns based on their own lagged values. Therefore, we would expect to find that the interaction effect between lagged return and lagged attention are significant in the predictive regressions of gold futures returns. To precisely determine how changes in lagged returns impact the magnitude of attention effect, we consider the interaction term between lagged attention search probabilities and lagged gold futures return. We adopt a predictive regression model as follow:

$$R_t = \varphi_i + \sum_{l=1}^{4}\beta_l R_{t-l} + \sum_{l=1}^{4}\gamma_{i,l} S_{i,t-l} + \sum_{l=1}^{4}\delta_{i,l} S_{i,t-l} * R_{t-l} + \varepsilon_{i,t} \,. \quad (3)$$

In the above specification, $S_{i,t-l}$ is the investor attention proxy during period $t-l$. Coefficients on the interaction terms $\delta_{i,l}$ measure the change in the effect of attention on the gold futures return conditional on a unit increase in the past return. $\beta+\delta$ measures the impact of the lagged return on the current return conditional on a unit increase in investor attention in the past. In order to alleviate the over-fitting issue resulting from a highly auto-correlated variable (Ferson et al., 2003), we consider all predictors with four lags. For individual attention predictors, we repeat the same model plus three macroeconomic factors as controlled variables.

Table 3 Influence of past return on the attention-return relationship

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	return	return	return	return	return	return	return	return	return	return
R_{t-1}	-2.930**	-2.887**	-1.406**	-1.446**	-0.386*	-0.384*	-0.869**	-0.859**	-1.263**	-1.258**
	(1.403)	(1.412)	(0.658)	(0.655)	(0.216)	(0.220)	(0.429)	(0.435)	(0.588)	(0.600)
R_{t-2}	0.825	0.800	-0.077	-0.082	0.037	0.031	-0.078	-0.091	0.060	0.031
	(1.293)	(1.305)	(0.661)	(0.674)	(0.211)	(0.211)	(0.420)	(0.414)	(0.593)	(0.587)
R_{t-3}	1.543	1.577	0.669	0.615	0.123	0.122	0.126	0.133	0.300	0.315
	(1.378)	(1.382)	(0.665)	(0.667)	(0.202)	(0.203)	(0.403)	(0.406)	(0.554)	(0.558)
R_{t-4}	-3.789***	-3.783***	-0.969	-0.968	0.010	0.005	0.014	-0.004	-0.021	-0.055
	(1.413)	(1.414)	(0.854)	(0.857)	(0.216)	(0.213)	(0.365)	(0.356)	(0.517)	(0.497)
$S_{i,t-1}$	-0.047	-0.048	-0.020	-0.020	-0.002	-0.002	0.007	0.008	-0.007	-0.007
	(0.029)	(0.029)	(0.014)	(0.013)	(0.013)	(0.013)	(0.021)	(0.021)	(0.022)	(0.022)
$S_{i,t-2}$	0.072**	0.074**	0.043***	0.042***	0.013	0.014	0.013	0.014	0.027	0.028
	(0.036)	(0.035)	(0.014)	(0.015)	(0.013)	(0.013)	(0.019)	(0.019)	(0.021)	(0.021)
$S_{i,t-3}$	-0.077**	-0.076**	-0.028*	-0.027*	-0.019*	-0.019*	-0.034**	-0.034**	-0.040**	-0.040**
	(0.032)	(0.032)	(0.015)	(0.015)	(0.011)	(0.011)	(0.016)	(0.016)	(0.018)	(0.018)
$S_{i,t-4}$	0.035	0.034	0.011	0.010	0.004	0.003	0.007	0.006	0.010	0.008
	(0.025)	(0.024)	(0.013)	(0.013)	(0.009)	(0.009)	(0.012)	(0.012)	(0.014)	(0.013)
$S_{i,t-1}*R_{t-1}$	0.737**	0.726**	0.423**	0.435**	0.139*	0.137	0.247*	0.243*	0.359**	0.357**

	(0.355)	(0.357)	(0.195)	(0.194)	(0.083)	(0.085)	(0.130)	(0.132)	(0.176)	(0.180)
$S_{i,t-2}*R_{t-2}$	-0.218	-0.210	0.020	0.021	-0.032	-0.029	0.010	0.015	-0.030	-0.020
	(0.326)	(0.329)	(0.194)	(0.198)	(0.080)	(0.080)	(0.128)	(0.126)	(0.177)	(0.175)
$S_{i,t-3}*R_{t-3}$	-0.403	-0.411	-0.237	-0.222	-0.065	-0.065	-0.056	-0.059	-0.107	-0.112
	(0.348)	(0.348)	(0.198)	(0.198)	(0.076)	(0.076)	(0.123)	(0.124)	(0.165)	(0.167)
$S_{i,t-4}*R_{t-4}$	0.964***	0.963***	0.299	0.299	0.003	0.005	-0.002	0.003	0.010	0.020
	(0.355)	(0.355)	(0.252)	(0.253)	(0.081)	(0.079)	(0.113)	(0.109)	(0.156)	(0.149)
CS		0.081		0.569		0.184		0.193		0.196
		(0.319)		(0.766)		(0.326)		(0.356)		(0.358)
RF		-0.003		0.001		-0.002		-0.003		-0.003
		(0.003)		(0.003)		(0.003)		(0.003)		(0.003)
DY		-0.031		0.021		-0.034		-0.042		-0.038
		(0.078)		(0.083)		(0.071)		(0.074)		(0.074)
Constant	0.072*	0.065*	-0.017	-0.021	0.013***	0.011**	0.023**	0.021*	0.035**	0.033*
	(0.037)	(0.038)	(0.028)	(0.029)	(0.005)	(0.005)	(0.011)	(0.012)	(0.017)	(0.017)
R^2	0.046	0.048	0.103	0.106	0.023	0.026	0.037	0.042	0.040	0.045

Note: This table reports estimation results for the effect of investor attention ($S_{i,t-l}$) on gold futures returns (R_t) conditional on past return (R_{t-l}). The regressions include interaction terms between lagged attention and lagged return. Equations 1(2), 3(4), 5(6), 7(8), and 9(10) report the results of OLS regressions without (with) macro controls using attention search probabilities of GOLD and GOLD PRICE, GLOD PRICES, PRICE OF GOLD, and the simple average combination of all attention search probabilities, respectively. The data on gold future return and attention search probabilities are obtained at weekly frequency for the sample period of January 2004 to March 2016. Estimated coefficients are followed by robust standard errors in parenthesis, with *, **, *** denote coefficient significance level at 10%, 5%, and 1% levels, respectively. 0.000 indicates a value smaller than 0.0005.

In Table 3, equations 1(2), 3(4), 5(6), 7(8), and 9(10) report the estimates without (with) macro controls using attention search probabilities of GOLD, GOLD PRICE, GOLD PRICES, PRICE OF GOLD, and combination of all search terms, respectively. Investor attention displays significant impact on the second lag in the case of GOLD and GOLD PRICE with a positive sign and exhibits significant impact on the third lag in all cases with a negative sign. The interaction terms are significant for nine out of all ten equations at the first lag with a positive sign, indicating that increasing returns one week prior lead to a significant increase in impact of attention on current returns. This result suggests that investors would expect an increasing return when returns were rising in the past. One point need to be noted is that the sign of a significant interaction effect at the first lag typically corresponds to the opposite sign on the coefficient of past return at the same lag. Since $\beta + \delta$ measures the combined effect of returns given in past periods, more attention is likely to lead to a weaker connection between past and current return. Barber and Odean (2008), and Da et al. (2011) provide evidence that investor attention results in increased buying pressure that pushes stock prices up temporarily which means the stock price cannot fully reflect fundamental information due to increased investor attention and a long-run reversal to its intrinsic value is expected. These findings in stock market, however, are different from ours in the gold futures market. Our results are in line with those suggested by Vozlyublennaia (2014) that increased investor attention diminishes predictability of index return and therefore improves market efficiency. In other words, market operates more efficiently and returns are less predictable merely based on their past performances when investors devote more attention to lagged returns.

3.4 Influence of past traders positions on the attention-return relationship

In this subsection, we examine another factor that may have influence on the attention-return relationship. It is suggested by Smales (2014) that institutional constraints placed on both speculators and hedgers in terms of capital and position limits have significant influence on future returns. On the other hand, factors in terms of trading volume such as trader positions, transaction volume, order flow, etc., are commonly conceived as indicators of investor sentiment that have sizable impact on returns (Da et al., 2015). Thus, we hypothesis that the net positions held by traders impact the relationship between investor attention and gold futures return.

Variables denoting the net traders positions and their interactions with attention search probabilities are introduced into the predictive regression specification as follow:

$$R_t = \beta_0 + \beta_1 S_{i,t-1} + \beta_2 P_{speculator,t-1} + \beta_3 P_{hedger,t-1} + \beta_4 S_{i,t-1} * P_{speculator,t-1} + \beta_5 S_{i,t-1} * P_{hedger,t-1} + \beta_6 R_{t-1} + \varepsilon_{i,t}, \quad (4)$$

where $S_{i,t-1}$ is the investor attention proxy during period $t-1$, $P_{speculator,t-1}$ and $P_{hedger,t-1}$ reflect the net position of speculators and hedgers normalized by open interest at time $t-1$, and $\varepsilon_{i,t}$ is the error term. We replicates the above equation for individual attention terms with and without macro control variables.

Table 4 Influence of net traders positions on the attention-return relationship

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	return	return	return	return	return	return	return	return	return	return
R_{t-1}	-0.044	-0.044	-0.036	-0.036	-0.040	-0.042	-0.031	-0.033	-0.036	-0.037

	(0.052)	(0.041)	(0.050)	(0.040)	(0.051)	(0.040)	(0.050)	(0.040)	(0.050)	(0.040)
$S_{i,t-1}$	-0.015**	-0.015*	0.002	0.002	-0.004**	-0.003*	-0.003	-0.003	-0.004	-0.003
	(0.008)	(0.008)	(0.004)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
$P_{speculator,t-1}$	7.132**	6.688*	3.552***	3.515***	0.886***	0.872***	1.717***	1.687***	2.963***	2.942***
	(3.142)	(3.418)	(1.080)	(0.844)	(0.309)	(0.326)	(0.511)	(0.491)	(0.784)	(0.730)
$P_{hedger,t-1}$	11.130***	11.000***	1.844	1.896**	1.076***	1.067***	1.911***	1.906***	2.945***	2.952***
	(3.064)	(3.268)	(1.222)	(0.871)	(0.320)	(0.372)	(0.547)	(0.563)	(0.810)	(0.808)
$S_{i,t-1}$* $P_{speculator,t-1}$	-1.966**	-1.849**	-1.381***	-1.364***	-0.688***	-0.677***	-0.844***	-0.829***	-1.204***	-1.195***
	(0.807)	(0.881)	(0.370)	(0.278)	(0.157)	(0.151)	(0.199)	(0.181)	(0.280)	(0.249)
$S_{i,t-1}$* $P_{hedger,t-1}$	-2.981***	-2.947***	-0.762*	-0.776***	-0.700***	-0.694***	-0.852***	-0.847***	-1.136***	-1.137***
	(0.789)	(0.837)	(0.406)	(0.275)	(0.151)	(0.157)	(0.203)	(0.194)	(0.281)	(0.264)
CS		0.003		-0.016		0.061		0.060		0.064
		(0.207)		(0.226)		(0.206)		(0.208)		(0.208)
RF		-0.002		-0.002		-0.002		-0.002		-0.002
		(0.002)		(0.002)		(0.002)		(0.002)		(0.002)
DY		0.000		0.006		0.003		0.005		0.005
		(0.024)		(0.024)		(0.023)		(0.023)		(0.023)
Constant	0.063**	0.061*	-0.005	-0.004	0.011**	0.010**	0.011*	0.011	0.015	0.010
	(0.030)	(0.033)	(0.012)	(0.010)	(0.004)	(0.005)	(0.007)	(0.007)	(0.011)	(0.007)
R^2	0.090	0.090	0.097	0.098	0.110	0.110	0.107	0.108	0.108	0.109

Note: This table reports estimates of the effect of attention search probabilities ($S_{i,t-l}$) on gold future return (R_t) conditional on past net trader positions ($P_{speculator,t-l}$ *and* $P_{hedger,t-l}$). The regressions include interaction terms between lagged trader positions $P_{speculator,t-l}$ ($P_{hedger,t-l}$) and a lagged return. Equations 1(2), 3(4), 5(6), 7(8), and 9(10) report the results of OLS regressions without (with) macro controls using attention search probabilities of GOLD and GOLD PRICE, GLOD PRICES, PRICE OF GOLD, and the simple average combination of all attention search probabilities, respectively. The data on gold future return, attention search probabilities, and net trader positions are obtained at weekly frequency for the sample period of January 2005 to March 2016. Estimated coefficients are followed by robust standard errors in parenthesis, with *, **, *** denote coefficient significance level at 10%, 5%, and 1% levels, respectively. 0.000 indicates a value smaller than 0.0005.

In Table 4, equations 1(2), 3(4), 5(6), 7(8), and 9(10) report the estimates without (with) macro controls using attention search probabilities of GOLD, GOLD PRICE, GOLD PRICES, PRICE OF GOLD, and combination of all search terms, respectively. Considerable positive relationships exist between the net positioning of both trader types and returns. In other words, when traders currently enter long (short) positions, the gold futures return in subsequent period tend to increase (decrease). The interaction term between the net position of hedgers and investor attention suggests that an increase in past attention lead to more active hedge activity by selling their futures and dragging returns lower. The negative and significant interaction term between investor attention and speculator net position supports the intuition that speculators who face this margin calls are supposed to close positions by selling futures and pushing returns lower. Besides, the sign of a significant speculator (hedger) position interaction term typically corresponds to the opposite sign on the coefficient of speculator (hedger) position. In this case, given the past change in positions, higher attention will perhaps generate a weaker connection between past position and current return. The gold futures return is then less predictable marginally based on past trader positions when investors devote more attention.

3.5 Non-linear relationship between investor attention and gold futures return

After examining the influence of past returns and past trader positions on the attention-return relationship, we continue to investigate the non-linearity of investor attention. The nonlinear relationship between investor sentiment and future asset return is empirically tested by many literatures (Yu and Yuan, 2011; Kim et al., 2014; Hoang et al., 2016). In this study, to accurately determine the how gold returns response to the non-linearity of investor attention we consider the square effect of lagged attention probabilities. We adopt a predictive regression model as follow:

$$R_t = \varphi_i + \sum_{l=1}^{4}\beta_l R_{t-l} + \sum_{l=1}^{4}\gamma_{i,l} S_{i,t-l} + \sum_{l=1}^{4}\delta_{i,l} S_{i,t-l} * S_{i,t-l} + \varepsilon_{i,t}\,. \quad (5)$$

In the above specification, the coefficient on the interaction terms $\delta_{i,l}$ measures the square effect of attention on future return. $\gamma+\delta$ measures the combined impact of lagged investor attention on the current return. For individual predictors, we replicate the same model plus three macroeconomic variables as control.

Table 5 Non-linear effect of investor attention on gold future return

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	return	return	return	return	return	return	return	return	return	return
R_{t-1}	-0.026	-0.027	0.046	-0.027	-0.044	-0.044	-0.032	-0.045	-0.036	-0.038
	(0.058)	(0.058)	(0.061)	(0.058)	(0.063)	(0.063)	(0.061)	(0.065)	(0.063)	(0.063)
R_{t-2}	-0.013	-0.010	-0.007	-0.010	-0.025	-0.020	-0.023	-0.008	-0.021	-0.018
	(0.054)	(0.052)	(0.058)	(0.052)	(0.060)	(0.058)	(0.056)	(0.056)	(0.058)	(0.057)
R_{t-3}	-0.042	-0.042	-0.118*	-0.042	-0.048	-0.048	-0.053	-0.054	-0.046	-0.046
	(0.053)	(0.053)	(0.063)	(0.053)	(0.055)	(0.054)	(0.054)	(0.056)	(0.055)	(0.054)

R_{t-4}	0.018	0.020	0.079	0.020	0.008	0.009	0.004	0.002	0.012	0.013
	(0.061)	(0.059)	(0.066)	(0.059)	(0.061)	(0.059)	(0.061)	(0.060)	(0.061)	(0.058)
$S_{i,t-1}$	1.167**	1.166**	0.066	1.166**	0.100***	0.100***	0.084	0.131*	0.249***	0.249***
	(0.586)	(0.581)	(0.130)	(0.581)	(0.025)	(0.025)	(0.052)	(0.070)	(0.083)	(0.085)
$S_{i,t-2}$	-1.386**	-1.364**	-0.161	-1.364**	-0.090***	-0.090***	-0.124**	-0.186**	-0.278***	-0.280***
	(0.637)	(0.646)	(0.110)	(0.646)	(0.024)	(0.024)	(0.048)	(0.077)	(0.085)	(0.086)
$S_{i,t-3}$	-0.684	-0.677	0.040	-0.677	-0.009	-0.010	0.046	0.017	0.025	0.022
	(0.567)	(0.567)	(0.096)	(0.567)	(0.024)	(0.024)	(0.042)	(0.066)	(0.074)	(0.076)
$S_{i,t-4}$	0.786*	0.758*	0.136*	0.758*	0.019	0.019	0.016	0.036	0.060	0.060
	(0.450)	(0.444)	(0.082)	(0.444)	(0.022)	(0.022)	(0.037)	(0.049)	(0.063)	(0.063)
$S_{i,t-1}*S_{i,t-1}$	-0.149**	-0.149**	-0.013	-0.149**	-0.019***	-0.019***	-0.012	-0.019	-0.039***	-0.037***
	(0.069)	(0.068)	(0.018)	(0.068)	(0.004)	(0.004)	(0.010)	(0.012)	(0.012)	(0.013)
$S_{i,t-2}*S_{i,t-2}$	0.176**	0.174**	0.028*	0.174**	0.019***	0.019***	0.021**	0.030**	0.042***	0.042***
	(0.075)	(0.076)	(0.015)	(0.076)	(0.004)	(0.004)	(0.008)	(0.012)	(0.012)	(0.012)
$S_{i,t-3}*S_{i,t-3}$	0.077	0.077	-0.007	0.077	-0.001	-0.001	-0.010	-0.006	-0.006	-0.006
	(0.067)	(0.067)	(0.013)	(0.067)	(0.004)	(0.004)	(0.007)	(0.010)	(0.010)	(0.011)
$S_{i,t-4}*S_{i,t-4}$	-0.093*	-0.090*	-0.019*	-0.090*	-0.004	-0.004	-0.003	-0.005	-0.009	-0.009
	(0.053)	(0.053)	(0.011)	(0.053)	(0.004)	(0.004)	(0.006)	(0.007)	(0.009)	(0.009)
CS		0.060		0.060		0.083		0.152		0.146
		(0.345)		(0.345)		(0.365)		(0.363)		(0.360)
RF		-0.003		-0.003		-0.004		-0.004		-0.004
		(0.004)		(0.004)		(0.004)		(0.004)		(0.004)
DY		-0.036		-0.036		-0.046		-0.049		-0.036
		(0.075)		(0.075)		(0.072)		(0.072)		(0.073)
Constant	0.273	0.270	-0.141	0.270	-0.013	-0.012	-0.020	0.015	-0.073	-0.063
	(0.794)	(0.815)	(0.114)	(0.815)	(0.014)	(0.014)	(0.038)	(0.056)	(0.073)	(0.076)
R^2	0.044	0.047	0.087	0.047	0.059	0.062	0.037	0.050	0.046	0.050

Note: This table reports estimation results for the square effect of investor attention (S_{t-l}) on gold futures returns (R_t). The regressions include interaction terms between lagged attention and lagged attention. Equations 1(2), 3(4), 5(6), 7(8), and 9(10) report the results of OLS regressions without (with) macro controls using attention search probabilities of GOLD and GOLD PRICE, GLOD PRICES, PRICE OF GOLD, and the simple average combination of all attention search probabilities, respectively. The data on gold future return and attention search probabilities are obtained at weekly frequency for the sample period of January 2004 to March 2016. Estimated coefficients are followed by robust standard errors in parenthesis, with *, **, *** denote coefficient significance level at 10%, 5%, and 1% levels, respectively. 0.000 indicates a value smaller than 0.0005.

Table 5 illustrates the results of above specification. Equations 1(2), 3(4), 5(6), 7(8), and 9(10) report the results without (with) macro controls using attention search probabilities of GOLD, GOLD PRICE, GOLD PRICES, PRICE OF GOLD, and combination of all search terms, respectively. The interaction terms are significant for seven out of ten equations with a negative sign at the first lag and significant in all cases with a positive sign at the second lag. There is an inverted U-shaped relation between investor attention and gold futures returns at the first lag while this effect reverses to U-shaped in the second lag. The evidence provided by Baker and Wurgler (2006), Yu (2011) suggests that high sentiment may be associated with high levels of uncertainty and volatility and thus high sentiment frequently leads to relatively low subsequent returns and vis-à-vis (Baker and Wugler, 2006; Kim et al., 2014). Our result in the first lag supports this hypothesis as it indicates that current return is likely to increase when investor attention is lower than a critical value while decrease if past investor attention exceeds the critical value. The result in the second lag which suggests an U-shaped relation between attention and return, however, is not necessarily the case. According to our results, the sign of a significant interaction effect typically corresponds to the opposite sign on the coefficient of lagged attention at the same lag. Since $\gamma + \delta$ measures the predictability of returns given the past severity of attention, attention is likely to lead to a weaker connection between past attention and current return. Generally, there exists non-linear relationship between attention and gold futures return and the sign of this effect changes as time elapses.

3.6 Safe haven: influence of economic conditions on the attention-return relationship

Given the safe haven nature of gold (Brown, 1987; Baur and Lucey, 2010; Baur and McDermott, 2010; Białkowski et al., 2012; Beckmann et al., 2015), it is natural to investigate if economic conditions significantly influence the attention-return relationship. Intuitively, attention is likely to be more intensive during market stress condition or in highly volatile period. We employ two commonly used variables as proxies for economic conditions: the return of S&P 500 stock index and VIX index. To better reflect the extreme situation of economy, we introduce a set of dummy variables $\{Stock\_high, Stock\_low\}$ and $\{VIX\_high, VIX\_low\}$ which take a value of 1 if the data indicates the highest quintile or the lowest quintile and 0 otherwise, where the quintiles are determined by sorting across time for the whole sample period. The regression specifications of the following form is utilized:

$$\begin{aligned} R_t = {} & \beta_0 + \beta_{1,i} S_{i,t} + \beta_{2,i} Stock\_high_t + \beta_{3,i} Stock\_low_t \\ & + \beta_{4,i} S_{i,t} * Stock\_high_t + \beta_5 S_{i,t} * Stock\_low_t + \beta_6 X_t + \varepsilon_{i,t} \end{aligned}, \quad (6)$$

$$R_t = \beta_0 + \beta_{1,i} S_{i,t} + \beta_{2,i} VIX\_high_t + \beta_{3,i} VIX\_low_t + \beta_{4,i} S_{i,t} * VIX\_high_t + \beta_5 S_{i,t} * VIX\_low_t + \beta_6 X_t + \varepsilon_{i,t}, \quad (7)$$

where $S_{i,t}$ is the investor attention search probabilities at time t, $Stock\_high_t$, $Stock\_low_t$, VIX_high_t, VIX_low_t are dummy variables indicating whether the S&P 500 stock return or VIX index is in the highest/lowest quantile (1) or not (0), $S_{i,t} * Stock\_high_t$, $S_{i,t} * Stock\_low_t$, $S_{i,t} * VIX\_high_t$ and $S_{i,t} * VIX\_low_t$ are interaction terms between attention and economic condition dummies, X_t is a vector of control variables including three macroeconomic factors suggested by Bessembinder and Chan (1992).

Table 6 Safe haven: Influence of economic condition on the attention-return relationship

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	return	return	return	return	return	return	return	return	return	return
$S_{i,t}$	-0.038	-0.015**	-0.003	-0.003	-0.006	-0.033	-0.002	-0.001	-0.0003	-0.002
	(0.027)	(0.007)	(0.004)	(0.004)	(0.006)	(0.023)	(0.006)	(0.003)	(0.003)	(0.005)
$SP500\_high_t$	-0.294*	-0.082**	-0.029*	-0.049**	-0.078**					
	(0.174)	(0.038)	(0.016)	(0.022)	(0.035)					
$SP500\_low_t$	-0.407**	-0.070*	-0.021	-0.029	-0.062*					
	(0.173)	(0.038)	(0.014)	(0.021)	(0.033)					
$SP500\_high_t * S_{i,t}$	0.077*	0.026**	0.015**	0.019**	0.027**					
	(0.045)	(0.012)	(0.007)	(0.008)	(0.012)					
$SP500\_low_t * S_{i,t}$	0.108**	0.024*	0.014**	0.014*	0.024**					
	(0.045)	(0.012)	(0.007)	(0.008)	(0.011)					
VIX_high_t						-0.433***	-0.065*	-0.033**	-0.053**	-0.074**
						(0.161)	(0.038)	(0.016)	(0.022)	(0.036)
VIX_low_t						-0.515***	-0.063**	-0.028**	-0.039**	-0.078***
						(0.136)	(0.028)	(0.012)	(0.017)	(0.027)
$VIX\_high_t * S_{i,t}$						0.111***	0.018	0.014*	0.017**	0.023*
						(0.042)	(0.012)	(0.008)	(0.008)	(0.012)
$VIX\_low_t * S_{i,t}$						0.136***	0.022**	0.017***	0.017***	0.029***
						(0.035)	(0.009)	(0.006)	(0.007)	(0.009)
CS	-0.155	-0.035	-0.301	-0.305	-0.293	-0.090	-0.182	-0.275	-0.275	-0.260
	(0.357)	(0.376)	(0.377)	(0.373)	(0.374)	(0.322)	(0.339)	(0.341)	(0.338)	(0.338)
RF	-0.013	-0.003	-0.013	-0.012	-0.013	-0.012*	-0.012*	-0.012*	-0.012*	-0.012*
	(0.008)	(0.004)	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
DY	-0.091	-0.074	-0.090	-0.092	-0.094	-0.077	-0.075	-0.076	-0.082	-0.080
	(0.098)	(0.088)	(0.097)	(0.097)	(0.098)	(0.089)	(0.089)	(0.088)	(0.091)	(0.089)
Constant	0.148	0.049**	0.012	0.012	0.024	0.132	0.013	0.008	0.008	0.011

	(0.104)	(0.022)	(0.007)	(0.011)	(0.017)	(0.086)	(0.018)	(0.006)	(0.008)	(0.014)
R^2	0.053	0.033	0.052	0.055	0.055	0.064	0.049	0.055	0.060	0.058

Note: This table reports estimation results for the effect of investor attention ($S_{i,t}$) on gold future return (R_t) conditional on extreme economic conditions ($SP500\_high_t$, $SP500\_low_t$, VIX_high_t, and VIX_low_t). The regressions include interaction terms between a dummy variable $SP500\_high_t$ or $SP500\_low_t$ (VIX_high_t or VIX_low_t) and an attention proxy. Equations 1(6), 2(7), 3(8), 4(9), and 5(10) report the results of OLS regressions using attention search probabilities of GOLD and GOLD PRICE, GLOD PRICES, PRICE OF GOLD, and the simple average combination of all attention search probabilities, respectively. The data on gold future return, attention search probabilities, S&P500 market return, and VIX index are obtained at weekly frequency for the sample period of January 2004 to March 2016. Estimated coefficients are followed by robust standard errors in parenthesis, with *, **, *** denote coefficient significance level at 10%, 5%, and 1% levels, respectively. 0.000 indicates a value smaller than 0.0005.

The second through fifth columns in Table 6 present the results for Eq. (6) using individual attention terms of GOLD, GOLD PRICE, GOLD PRICES, PRICE OF GOLD and combination of all attention terms, respectively. Holding other variables constant, investor attention provides negative impact on gold returns with coefficients ranging from -0.038 to -0.003, indicating that when more attention is paid to gold, future return is likely to be smaller. This finding is consistent with those in previous subsections. The high/low stock return dummy variables generally display significant negative impact on future gold returns. Notably, the interaction terms between investor attention and high/low stock return dummy factors indicate that investor attention has an additional impact throughout the extremely high/low stock return period. With one unit increase of attention in the interaction terms, returns are significantly higher during the extreme market return period, perhaps indicative of the safe haven nature of gold.

The sixth and eleventh columns in Table 6 report the results for Eq. (7) using individual attention terms search probabilities. The high/low VIX dummy variables exhibit sizable negative influence on gold future returns, indicating that significantly lower returns are expected when the economy undergoes extremely high/low volatility. In accord with previous results, it appears that interaction terms between investor attention and high/low VIX dummy variables are significant with positive signs, suggesting that when financial market is under the condition of extremely high/low volatility, gold is likely to play a role of hedge market volatility. The presence of extreme economic conditions will significantly impact the response of gold futures market to relevant investor attention.

In summary, we examine multiplicate relationships between investor attention and gold futures return. Typically, investor attention has significant impact on gold futures returns and this effect can be positive or negative depending on when it occurs while past gold returns exhibit positive impact on investor attention. By adopting four types of interaction terms, we investigate what type of information is perceived by market and eventually has influence on the attention-return relationship. Past return determines the impact of investor attention on future returns and the returns are less predictable merely based on their past performances when investors devote more attention to lagged returns. Net positions held by traders significantly alter the relationship between investor attention and gold futures return and the return is less predictable marginally based on past trader positions when investors devote more attention. In addition, there exists nonlinear relationship between attention and gold futures return and the sign of this effect changes as time elapses. At last, we relate the underlying economic conditions as measured by S&P 500 Index and its volatility measured by VIX index to the associated influence on reaction to investor attention. The presence of extreme economic conditions will significantly impact the response of gold futures market to relevant investor attention. In all cases, increasing investor attention on gold significantly impact gold futures returns.

4. Link to futures basis

Several studies suggest that the difference between current spot price and contemporaneous futures price, which is commonly known as the futures basis, contains information about expected futures excess returns (Fama and French, 1987; Gorton and Rouwenhorst, 2006; Gorton et al., 2013; Yang, 2013, and references therein). In light of this, we attempt to investigate the link between investor attention and the predictability of expectation in terms of futures basis, thus providing insights on the economic rationale for the attention-return relationship.

We attempt to explain the economic view of investor attention as an aspect of expectation. Gold price is fundamentally determined by future supply and demand, unlike other securities such as stocks and bonds, and thus it is forward-looking. If investor attention predicts futures basis which entails information of future asset's prices, this suggests that the impact of investor attention on gold returns stems in part from its link to expectation. Consistent with the standard practice in literature (Gorton et al., 2013; Yang, 2013), we compute the gold futures basis as the difference in log prices between the gold spot prices and gold futures prices:

$$Basis_t = log(F_t^{spot}) - \log(F_t^{future}), \quad (8)$$

where F_t^{spot} and F_t^{future} are the spot prices and futures prices at time t, respectively. We adopt a predictive regression model as follow:

$$Basis_t = \alpha_i + \sum_{l=1}^{4} \beta_l Basis_{t-l} + \sum_{l=1}^{4} \gamma_{i,l} S_{i,t-l} + \varepsilon_{i,t}, \quad (9)$$

where $S_{i,t-l}$ is the investor attention during period $t-l$. In line with previous specifications we employ four lags of basis as well as attention in order to alleviate over-fitting issue resulting from a highly auto-correlated variable (Ferson et al., 2003). We replicates the above equation for individual attention terms with and without macro controls.

Table 7 Link to futures basis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Basis	Basis	Basis	Basis	Basis	Basis	Basis	Basis	Basis	Basis
$Basis_{t-1}$	0.138***	0.132***	0.191***	0.185***	0.018	0.018	0.141***	0.109**	0.124**	0.118**
	(0.046)	(0.045)	(0.047)	(0.046)	(0.051)	(0.049)	(0.047)	(0.046)	(0.048)	(0.048)
$Basis_{t-2}$	0.030	0.027	0.081	0.080	0.0058	-0.001	0.035	0.025	0.039	0.035
	(0.060)	(0.060)	(0.062)	(0.062)	(0.079)	(0.078)	(0.057)	(0.058)	(0.060)	(0.060)
$Basis_{t-3}$	0.059	0.062	0.108**	0.111**	0.034	0.033	0.064	0.047	0.060	0.061
	(0.053)	(0.053)	(0.052)	(0.052)	(0.060)	(0.064)	(0.051)	(0.054)	(0.051)	(0.054)
$Basis_{t-4}$	0.037	0.045	0.077	0.084*	-0.011	-0.013	0.038	0.018	0.028	0.029
	(0.050)	(0.051)	(0.051)	(0.051)	(0.071)	(0.070)	(0.053)	(0.053)	(0.056)	(0.054)
$S_{i,t-1}$	0.002	0.004*	0.0003	0.0004	0.001	0.001	0.001	0.001	0.001	0.001
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$S_{i,t-2}$	0.006**	0.005**	0.001	0.001	0.003**	0.003**	0.002*	0.002**	0.003*	0.003*
	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$S_{i,t-3}$	-0.004**	-0.004*	-0.002**	-0.002**	-0.002	-0.002	-0.002**	-0.003**	-0.003*	-0.003*
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
$S_{i,t-4}$	0.002	0.002	0.001	0.001	0.001	0.0008	0.001	0.001	0.001	0.002
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
CS		-0.004		-0.022		-0.032		-0.040		-0.046
		(0.036)		(0.039)		(0.042)		(0.037)		(0.037)
RF		-0.0002		-0.0002		-0.001		-0.0002		-0.0002
		(0.0002)		(0.0002)		(0.0004)		(0.0002)		(0.0002)
DY		-0.0003		-0.002		-0.007		-0.002		-0.002
		(0.002)		(0.001)		(0.007)		(0.001)		(0.001)
Constant	-0.024***	-0.026***	-0.002	-0.002	-0.008***	-0.008***	-0.005***	-0.007***	-0.010***	-0.010***
	(0.004)	(0.005)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)

R^2	0.133	0.137	0.096	0.098	0.143	0.153	0.138	0.162	0.145	0.149

Note: This table reports estimate results for the predictive ability of investor attention ($S_{i,t-l}$) on gold futures basis ($Basis_t$). Equations 1(2), 3(4), 5(6), 7(8), and 9(10) report the results of OLS regressions without (with) macro controls using attention search probabilities of GOLD and GOLD PRICE, GLOD PRICES, PRICE OF GOLD, and the simple average combination of all attention search probabilities, respectively. The data on gold future basis and attention search probabilities are obtained at weekly frequency for the sample period of January 2004 to March 2016. Estimated coefficients are followed by robust standard errors in parenthesis, with *, **, *** denote coefficient significance level at 10%, 5%, and 1% levels, respectively. 0.000 indicates a value smaller than 0.0005.

Table 7 summarizes estimate results for futures basis based on investor attention search probabilities. Taken as a whole, investor attention evinces significant predictive ability for futures basis with and without macro controls. Investor attention generally displays significant predictability of futures basis with a positive coefficient at the second lag and this effect reverse to negative at the third lag. Typically the predictive ability of investor attention lasts roughly within three weeks. Our results are in accord with those findings in Li and Yu (2012) who suggest that attention proxies contain information about future market returns that is not captured by macroeconomic variables. Overall, we demonstrate that investor attention are closely associated with the futures basis. From an economic perspective, investor attention on gold incorporates meaningful information about expected futures prices.

5. Asset allocation exercise

In Section 3.1 through 3.6, we examine multiplicate relationships between investor attention and gold futures return and the empirical results indicate that investor attention does have statistically and economically significant impact on gold futures return.

In this section, we seek to calculate the economic value of investor attention based on gold futures return forecast to account for the risk faced by an investor over the out-of-sample period. We compute the certainty equivalent return (CER) for a mean-variance investor who optimally allocates across assets and the risk-free asset using the out-of-sample forecasts, following Kandel and Stambaugh (1996), Campbell and Thompson (2008) and Ferreira and Santa-Clara (2011), among others. This exercise contributes to existing studies of investor attention that fail to incorporate risk aversion into the asset allocation decision. At the end of period t, investor optimally allocates

$$w_t = \frac{1}{\gamma}\frac{\hat{R}_{t+1}}{\hat{\sigma}^2_{t+1}}, \qquad (10)$$

of the portfolio to gold futures during period $t+1$,where γ is the risk aversion coefficient, $\hat{R}_{t+1}$is the out-of-sample forecast of gold return, and $\hat{\sigma}^2_{t+1}$is the variance forecast. The investor then allocates $1-w_t$of the portfolio to risk-free bills, and the $t+1$realized portfolio return is

$$r^p_{t+1} = w_t\hat{D}_{t+1} + r^f_{t+1}, \qquad (11)$$

where $r^f_{t+1}$is the risk-free return[1].

The CER of the portfolio is

$$CER_p = \hat{\mu}_p - 0.5\gamma\hat{\sigma}^2_p, \qquad (12)$$

where $\hat{\mu}_p$and $\hat{\sigma}^2_p$are the sample mean and variance, respectively, for the investor portfolio over the q forecast evaluation periods. The CER gain is the difference between the CER for an investor who uses a predictive regression forecast of market return and the CER for an investor who uses the historical average forecast. This difference can be interpreted as the portfolio management fee that an investor would be willing to pay to have access to the predictive regression forecast instead of historical average forecast. To examine the effect of risk aversion, we consider portfolio rules based on the risk aversion coefficient of 2. In addition, the costs are calculated using the weekly turnover measures and assuming a proportional transaction cost equal to 50 bps per transaction which is generally considered as a relatively high number.

For assessing the statistical significance, we test whether the CER gain is indistinguishable from zero by applying the standard asymptotic theory (DeMiguel et al., 2009a, b). In addition, we also calculate the Sharpe ratio of the portfolio which is the mean portfolio return in excess of the risk-free rate divided by the standard deviation of the excess portfolio return. Following again DeMiguel et al. (2009a), we test whether the Sharpe ratio of the portfolio strategy based on predictive regression is statically indifferent from that of the portfolio strategy based on historical average.

We generate out-of-sample forecast of gold futures returns by running the predictive

[1] We assume that investors use a four-week moving window of past weekly returns to estimate the variance of the exchange rates and constrains $w_t$to lie between 0 and 1.5 to exclude short sales and to allow for at most 50% leverage.

regression model based on individual investor attention predictor. We first divide the full sample of T observations for R_{t+1} and $S_{i,t}$ into an in-sample period consisting of the initial m observations and an out-of-sample period consisting of the last q observations. The beginning out-of-sample forecast of the gold futures return based on the investor attention predictor $S_{i,t}$ is specified as

$$\hat{R}_{m+1} = \hat{\alpha}_{i,m} + \hat{\beta}_i S_{i,m}, \tag{13}$$

where $\hat{\alpha}_{i,m}$ and $\hat{\beta}_i$ are the ordinary least squares estimates by regressing $\{R_t\}_{t=2}^{m}$ on $\{S_{i,t}\}_{t=1}^{m-1}$ and a constant. By proceeding in this manner through the end of the out-of-sample period, we obtain a series of q out-of-sample forecasts of the gold futures return$\{\hat{R}_{t+1}\}_{t=m}^{T-1}$based on individual investor attention predictor$S_{i,t}$. We use the data covering January 4th 2004to December 26th 2010 as the initial estimation period so that the forecast evaluation period spans January 2nd 2011 to December 27th 2015.

Table 8 Asset allocation exercise

	CER (%)	**Sharpe ratio**	**Turnover ratio**	**CER-cost(=50bps) (%)**
Historical average	-2.612	-0.123	4.503	-2.657
Panel A: VAR specification				
GOLD	1.291	-0.064	41.948	-0.546
GOLD PRICE	1.544	-0.042	35.042	0.017
GOLD RICES	1.193	-0.066	43.628	-0.713
PRICE OF GOLD	1.900	-0.027	39.934	0.156
All	0.929	-0.083	43.113	-0.954
Panel B: return effect specification				
GOLD	2.166	-0.012	48.804	0.009
GOLD PRICE	4.753	0.161	37.842	3.093
GOLD RICES	4.436	0.142	40.956	2.622
PRICE OF GOLD	1.881	-0.035	33.959	0.403
All	3.176	0.052	33.163	1.731
Panel C: traders positions effect specification				
GOLD	4.679	0.195	35.690	2.929
GOLD PRICE	3.130	0.094	27.645	1.796
GOLD RICES	4.856	0.206	36.535	3.062
PRICE OF GOLD	4.752	0.200	37.567	2.907
All	4.606	0.190	37.072	2.788
Panel D: nonlinear effect specification				
GOLD	3.132	0.049	45.713	1.114

GOLD PRICE	5.290	0.201	31.377	3.905
GOLD RICES	3.665	0.086	37.904	2.000
PRICE OF GOLD	2.565	0.012	36.188	0.984
All	2.647	0.017	31.875	1.258

Note: This table reports portfolio performance measures for an investor with mean-variance preferences and relative risk-aversion coefficient of two who weekly allocates between gold futures and risk-free bills using either an historical average (HA) or predictive regression models in Eq. (1), (3), (4), and (5), respectively. The second through fifth columns present the results of the average utility gains, Sharpe ratio, turnover ratio, and utility gains net of transaction cost, respectively. The first row of this table reports the asset allocation result based on the historical average forecast as benchmark. We use the data covering January 4th 2004 to December 26th 2010 as the initial estimation period and out-of-sample forecast evaluation period spans January 2nd 2011 to December 27th 2015.

Panel A through Panel D of Table 8 report the portfolio performance measures for each of the predictive regression models in Eq.(1), (3), (4), and (5), respectively. The second through fifth columns of Table 8 present the results of the monthly average utility gains, Sharpe ratio, turnover ratio, and monthly utility gains net of transaction cost, respectively. As shown in the first row, the CER gain for the portfolio based on historical average forecast is -261 with a negative Sharpe ratio and a turnover ratio of 4.503, for the out-of-sample period of January 2nd 2011 to December 27th 2015. After accounting for transaction cost, the average utility gains of the portfolio based on historical average declines to -266 basis points. Compared to the historical benchmark, investor attention generate positive utility gains in all specifications ranging from 93 to 529 basis points. Portfolios based on investor attention turn over approximately 7 to 10 times more often than those based on historical average forecast. Accounting for this turnover, there are 17 out of 20 portfolios based on investor attention deliver sizable net-of-transactions-costs CER gains in the fifth column, reaching a maximum of 391 basis points. 13 out of 20 portfolios generate positive Sharpe ratios, with the investor attention term GOLD PRICES in Panel C delivering the highest ratio of 0.206. Portfolios based on the VAR model provide relatively weak performance in terms of Sharp ratio compared to portfolios based on other specifications. In sum, investor attention in various specifications generate significantly stronger performance in terms of utility gains, Sharpe ratio and net-of-transaction utility gains than those of the historical average benchmark. The asset allocation exercise demonstrates substantial economic value of combining information from investor attention.

6. Conclusion

We investigate multiplicate relationships between investor attention and gold futures return. The results of VAR suggest that investor attention exhibits significant impact on gold futures returns and the effect can be positive or negative depending on how much time has elapsed since this effect, and in the reverse direction, past gold return typically has a sizable impact on investor attention with a positive coefficient. By adopting four types of interaction terms, we investigate what type of information is perceived by market and eventually has influence on the attention-return relationship. In particular: (1) past return determines the impact of investor attention on future returns and the returns are less predictable merely based on their past performances when investors devote more attention to lagged returns; (2) net positions held by traders significantly alter the relationship between investor attention and gold futures return and the return is less predictable marginally based on past trader positions when investors devote more attention; (3) there exists nonlinear relationship between attention and gold futures return and the sign of this effect changes as time elapses; (4) the presence of extreme economic conditions significantly influences the response of gold futures return to relevant investor attention.

In terms of economic significance, we find that attention is closely associated with the futures basis, which means that it incorporates meaningful information about expected futures prices, thus providing an alternative explanation of economic rationale for the attention-return relationship. The asset allocation exercise demonstrates substantial economic value by implementing information from investor attention.

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Supplementary information for MS 2145, entitled

"Does investor attention matter? The attention-return relation in gold futures market"

We use Google Search Volume as the proxy for investor attention in this study. Regarding the attention data, the normalization methodology for Google Trend has experienced couple of adjustments since 2004. About 3-4 years ago, Google reports the percentage of searches for a given keyword of the total number of searches over time. The number thus represent search probabilities of a given keyword at a given time. Currently, the numbers representing search interest is computed relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. Likewise a score of 0 means the term was less than 1% as popular as the peak. Therefore, it is likely for readers who intend to replicate this empirical tests to find that the time series of Search Volume Index they obtained at one time may be a little bit different from those obtained at another point of time. They may not be able to get exactly the same results as we report, but they will definitely have similar results as we do which can demonstrate the effect of investor attention in the gold futures market. If any more information is needed, please contact us. We would love to provide the original attention Search Volume data and have more detailed discussions.

In this study, we utilize SATA 12.0 to conduct the empirical tests. The regression models are clear and direct such as VAR and OLS regression and therefore simple programing code are considered, for example, "reg", "var", "sum", etc.. We believe this would be helpful for readers if someone wants to replicate this study.