Journal of Commodity Markets 31 (2023) 100343

Contents lists available at ScienceDirect

Journal of Commodity Markets

journal homepage: www.elsevier.com/locate/jcomm

Regular article

Determinants and dynamic interactions of trader positions in the gold futures market☆

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ARTICLE INFO

JEL classification:
G10
G21
and G40

Keywords:
Gold futures
Money managers
Swap dealers
Logistic smooth transition autoregressive (LSTAR) model

ABSTRACT

We investigate the determinants of different traders' trading positions in the gold futures market. With a threshold value determined endogenously by our model, we find that when the gold futures price falls below the threshold, money managers adopt positive feedback trading strategies while swap dealers adopt negative feedback trading strategies. When the futures price rises above the threshold, money managers turn to negative feedback trading and swap dealers reduce the intensity of their negative feedback. In addition, money managers and swap dealers play the transmitter role in trading spillovers to other traders, and their trading transmitter role weakens during periods with high gold prices.

1. Introduction

This study investigates the trading activities of various trader types in the Chicago Mercantile Exchange (CME) gold futures market. It adopts the Disaggregated Commitments of Traders (DCOT) report from the Commodities Futures Trading Commission (CFTC) to classify gold traders into five categories: "producers," "swap dealers," "money managers," "other reportable traders," and "non-reportable traders (i.e., individuals)." In particular, we focus on the interaction of these trading activities with gold, stock index, bond, and foreign exchange (FX) futures markets returns and these gold traders' trading spillovers from June 20, 2006 to February 9, 2022.

Understanding and explaining the ways in which investors actually behave and which factors determine their trading decisions are crucial for academics, financial market practitioners, and policymakers (Wang, 2003). Although many studies focus on trader behavior in the stock index, VIX index, FX, and commodity futures markets (Wang, 2003; Röthig and Chiarella, 2007; Chang et al., 2013; Chen and Yang, 2021), surprisingly, little attention has been paid to investor behavior in the gold futures market (Souček, 2013; Smales,

☆ Yu-Lun Chen acknowledges financial support from the Ministry of Science and Technology, Taiwan (R.O.C.) (MOST 109-2410-H-033 -002 -MY2).

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https://doi.org/10.1016/j.jcomm.2023.100343
Received 13 July 2022; Received in revised form 3 May 2023; Accepted 30 May 2023
Available online 11 June 2023
2405-8513/

2014).[1] In addition, the previous issues regarding gold futures largely focus on the determinants of the gold futures returns, the interaction between the gold returns and the other market returns, and the safe-haven role of gold (Cai et al., 2001; Ciner et al., 2013; Bilgin et al., 2018; Hung and Vo, 2021; Drake, 2022).[2] However, these studies do not explore the trading activities of different traders in gold futures.

In the futures market, the hedging pressure theory (Keynes, 1930; Hicks, 1939; Cootner, 1960) has been widely used to explain the trading activities of hedgers and speculators. According to this theory, hedgers transfer price risks in the spot market using futures contracts. Their hedging activities tend to induce upward or downward pressure on the futures price, thereby resulting in a deviation in the futures price from the equilibrium level. Conversely, speculators participate in futures contracts and take on risk in an attempt to earn profits. They provide liquidity for hedgers to trade at any price level in the market. Speculators' activities in the futures market lead prices to revert toward the equilibrium level.

By applying the hedging pressure theory to the gold futures market, hedgers may hold the spot gold and hedge by taking short positions in the gold futures when the gold price rises. As a consequence, gold futures prices will fall below the equilibrium price level, for the reason that speculators generally take up the offsetting long position to make positive profits. Following the hedging pressure theory, we expect an inverse interacted position between hedgers (i.e., producers or swap dealers) and speculators (i.e., money managers or hedge funds). When the gold price rises, hedgers may take more short positions and speculators more long positions in gold futures.

On the other hand, some previous studies indicate that whether investors choose to buy or sell securities may depend on their past price changes and thus there is positive/negative feedback trading behavior (Nofsinger and Sias, 1999; Wang, 2003; Chau et al., 2011; Gębka and Wohar, 2013; Chen and Yang, 2021). Investors who engage in positive (negative) feedback trading activities tend to buy (sell) securities when the price moves upward and sell (buy) securities when the price moves downward. In addition, Chen and Yang (2021) find that hedgers will engage in negative feedback trading, but that speculators will engage in positive feedback trading and point out that nonlinear relationships exist between trader positions and VIX futures returns. Röthig and Chiarella (2007) also find nonlinearities in the live cattle, corn, and lean hog futures markets as speculators' trading activities react to price changes in various price regimes.

Since gold is traditionally a safe-haven asset, higher prices of gold futures may reflect heightened market uncertainty and market turbulence (Bilgin et al., 2018) and are analogous to VIX index futures prices which could gauge the level of market fear. Higher market uncertainty or market turbulence may affect the expected returns, risk tolerance, leverage constraints, and funding constraints of hedgers and speculators, causing them to alter their trading strategies for VIX futures in order to reduce their uncertainty (Chen and Yang, 2021). In addition, Röthig and Chiarella (2007) also show that speculators react differently to previous price changes, depending on the price regime. Hence, we argue that, as traders' trading activities respond to price changes in different gold price regimes, nonlinearities may exist in the gold futures market.

In this study, we investigate the nonlinear effect of gold futures prices on traders' trading activities by employing a logistic smooth transition autoregressive (LSTAR) model. The LSTAR model allows for two regimes (high- and low-gold price regimes) and determines the threshold level of the transition variable (gold prices) endogenously. The results of the LSTAR model show that money managers tend to positively follow market returns while swap dealers do the opposite, indicating that money managers adopt positive feedback trading strategies while swap dealers engage in negative feedback trading. However, when the gold futures price rises above the threshold level (i.e., 1366.4 as determined by the LSTAR model), money managers turn to negative feedback trading and swap dealers reduce the intensity of their negative feedback.

This may be explained by the change in the money managers' risk tolerance and their skillful anticipation of the future direction of the gold price. During a high gold price period, money managers' lower risk tolerance to trading with hedgers and better anticipation regarding the gold price will lead them to start cutting back on their holding position before gold prices collapse and turn from positive feedback trading to negative feedback trading (i.e., before the gold futures prices move upward to their highest level, money managers will start to take a short position). Swap dealers may also adjust their trading to offset the position of money managers during the high price period. In addition, a high gold price level may affect the compensation that money managers require for bearing the risk of trading with hedgers (producers or swap dealers) and may change their gold futures trading strategies.

We plot the net positions of money managers and swap dealers in the high and low gold futures price states in Fig. 1, according to the threshold value of 1366.4 determined by the LSTAR model. The horizontal dashed line represents the threshold level and gold prices lying above (below) the dashed line belong to the high (low) gold futures price period. Fig. 1 shows that the negative net position of swap dealers is mostly offset by the positive net position of money managers.

In addition, we find that money managers decrease their net long positions, and gold futures prices still rise when the gold futures prices lie above the dashed line. When gold futures prices rise above the threshold level, money managers seem to engage in negative feedback trading and reduce their long positions. Swap dealers take opposite trading positions to those of money managers. These

[1] Souček (2013) found that trading positions in gold futures react positively to shocks in crude oil futures trading. Smales (2014) found that the business cycle has an impact on the net trading positions of speculators and hedgers in gold futures.

[2] Cai et al. (2001) find that some U.S. macroeconomic news announcements have significant effects on the volatility of the gold futures market. Bilgin et al. (2018) explore the determinants of the gold price. By looking at the oil, gold, currency, bond, and stock market returns, Ciner et al. (2013) investigate the dynamic correlations between them. Drake (2022) finds a positive correlation between gold returns and stock returns during the COVID-19 pandemic. Hung and Vo (2021) investigate spillovers between the S&P 500, crude oil prices, and gold prices during the COVID-19 pandemic.

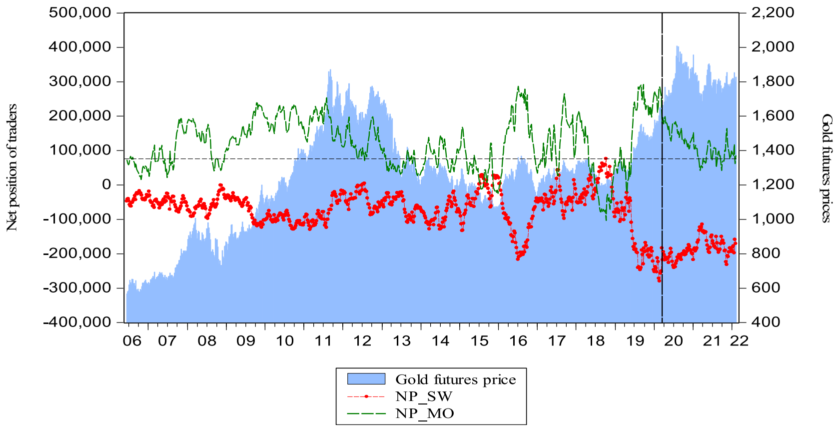

Fig. 1. Gold futures prices and net positions of different traders
Note: This figure shows the time-varying net positions held by swap dealers (Sw) and money managers (Mo). Net positions is calculated as $NP^i = Long^i - Short^i$, where $Long^i$ ($Short^i$) denote the long (short) positions held by type *i* traders. The vertical dashed line indicates March 23, 2020. The U.S. Fed announced that it would use its full range of tools to support households, businesses, and the U.S. economy overall against the coronavirus pandemic on March 23, 2020 (QE4). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

results in Fig. 1 may confirm the findings in our LSTAR analysis.

In addition, individual traders tend to execute positive feedback trading strategies and take more long positions in gold futures when the S&P 500 index and bond prices decline. The trading positions of producers and other reportable traders have no relevance with regard to changes in the prices of gold, the S&P 500 index, bonds, and FX futures; they only depend on the trading positions in the previous week.

Alternatively, we not only investigate the impact of various changes in futures prices on the trading activities of different trader types, but also analyze the trading interactions and spillover transmissions among these gold traders. Following the hedging pressure theory, we expect stronger trading interactions between swap dealers and money managers. Different gold price levels may affect the required premium of speculators to provide liquidity and their changes in trading activities may affect trading interactions and transmission among all traders.

We adopt the Diebold and Yilmaz (2012 and 2014) measure, based on forecast error variance decompositions from vector autoregression (VAR), for trader positions and spillover transmissions in gold futures. We further adopt the rolling-window estimation to capture time-variation in trading spillovers and explore the determinants of the directional spillovers from different traders. We find that money managers and swap dealers play the transmitter role in trading spillovers to other traders, and individual traders are the major recipients. It is not surprising that individual traders serve as trading followers in gold futures, compared to institutional traders. Other reportable traders represent small institutional speculators and generate little interaction with the others.

Most importantly, the trading transmitter role of money managers and swap dealers also declines when the gold futures price rises above the same threshold level as the LSTAR model. This finding supports the view that a high gold price level may reduce the risk tolerance of money managers to trade with swap dealers and change their trading strategies and further decrease the trading spillover transmission from money managers and swap dealers to others. A high gold price level may affect the trading activities of money managers, swap dealers, and the whole trading transmission mechanism in gold futures. To the best of our knowledge, this paper is the first to explore the determinants and interactions of trading positions in the gold futures market, filling the gap in the extant literature. Our findings are also very important for market participants hedging or speculating in gold futures.

The remainder of this paper is organized as follows. Section 2 focuses on the hypothesis development. Section 3 provides a description of the data, and Section 4 presents the linear and LSTAR models and discusses the related empirical results. We show the results of the Diebold and Yilmaz (2012 and 2014) trading spillover measure in Section 5 and present our conclusions in Section 6.

2. Hypotheses

In this section, we develop the hypotheses for our empirical tests. From the hedging pressure theory perspective (Keynes, 1930; Hicks, 1939; Cootner, 1960), hedgers' hedging pressure drives the futures price up or down in relation to the expected value of the spot price to transfer the spot market risk, which leads to bias in futures prices. Speculators bear risk because they are on the opposite side, and they are therefore compensated by a positive expected profit on their futures position. Hence, hedgers' trading may depend on their spot exposure risk and speculators' trading depends on their expected returns, degree of risk tolerance, and funding constraints in the futures market.

On the other hand, some existing studies (De Long et al., 1990; Wang, 2003; Chen and Yang, 2021) support the view that some traders depend on past asset price changes and so they adopt a positive/negative feedback trading strategy. De Long et al. (1990) point out that when rational speculators expect that prices will move away from fundamentals, they may engage in positive feedback trading and jump on the bandwagon early by purchasing ahead of the noise traders' demand. Noise traders follow the positive feedback trading of rational speculators by buying when prices rise and selling when prices fall. These speculators go short at the peak of the asset price. In addition, Fishe and Smith (2012) support the view that money managers belong to informed traders in the gold futures market. Hence, following the studies of De Long et al. (1990) and Fishe and Smith (2012), money managers are viewed as rational speculators who engage in positive feedback trading in the lower gold futures price regime and change in the higher price regime.

In addition, Chen and Yang (2021) find that nonlinear relationships exist between the trading positions of speculators (hedgers) and changes in VIX futures prices. Röthig and Chiarella (2007) also find nonlinearities in the live cattle, corn, and lean hog futures markets as speculators' trading activities react to price changes under various price regimes. Chang et al. (2013) find the nonlinear effect of speculative trading on price discovery in the FX futures market and imply that speculators change their trading strategies across different futures price states. These studies support the view that speculators' trading activities change between lower and higher price regimes.

In view of the traditional safe-haven asset characteristic, higher prices of gold futures may reflect heightened market uncertainty and market turbulence (Bilgin et al., 2018) and are analogous to VIX index futures prices which could gauge the level of market fear. Hence, we first hypothesize that a nonlinear impact of past price changes on speculators' trading activities exists in gold futures. When gold futures prices lie in the lower gold price regime, money managers will engage in positive feedback trading. In the higher gold price regime, they may change their strategy and engage in negative feedback trading.

On the other hand, to explore the dynamic trading interactions and connectedness in commodity futures, Ji et al. (2019) find that money managers (i.e., rational speculators) play a trading transmitter (trigger) role vis-à-vis other traders in the futures market. Based on the argument of De Long et al. (1990), individuals are often viewed as noise traders and follow rational speculators. Individuals should play the major trading receiver role in gold futures.

Following the first hypothesis, if different gold futures price regimes were to affect speculators' trading activities in gold futures, they would also influence other trader interactions and activities. For example, if gold futures prices rise above the threshold value, higher market uncertainty or market turbulence will affect the expected returns, risk tolerance, leverage constraints, and funding constraints of money managers. These money managers may as a result not engage in positive feedback trading to attract individual traders to follow them.

The trading spillover transmission from money managers to individuals will be reduced in a higher gold futures regime. Money managers may also not be willing to provide the liquidity for the hedging demand of swap dealers or producers in gold futures and may reduce the trading interactions among them. Hence, we also hypothesize that the trading spillovers and interactions among different traders may decrease in the higher gold futures price regime.

3. Data and descriptive statistics

Our primary objective is to investigate the effect of changes in the gold futures price on the trader positions for the gold futures contracts from June 20, 2006 to February 9, 2022. We illustrate the futures data, the DCOT report, and the descriptive statistics of these data in this section.

3.1. Futures data and DCOT report

We consider the CME gold, S&P 500 index, U.S. 10-year Treasury note, and U.S. dollar index futures prices data in this study. The gold futures contract on the CME with daily trades of nearly 27 million ounces is the world's leading benchmark for gold futures. It also provides global price discovery and opportunities for portfolio diversification in relation to the gold market. We provide more detailed contract specifications for the CME gold futures in Appendix A. We collect these transaction futures prices from the Bloomberg database. The futures price data of the most actively traded nearest-to-maturity contract is always used in this study.

The CFTC began publishing the DCOT report for commodity futures on June 13, 2006 and releases traders' positions only on a weekly basis in the DCOT report. The daily or higher frequency trading position data are not provided. Hence, to meet the weekly DCOT data, we consider the gold, S&P 500 index, Treasury note, and U.S. dollar index futures returns on a weekly basis in the following empirical analyses. According to the explanatory notes on the CFTC website, the DCOT report classifies traders into five categories, as follows. The "producers" category refers to entities that mainly engage in activities involved with the production, processing, packing, or handling of a physical commodity and manage/hedge the risks associated with those activities by using the futures markets. The "swap dealers" category refers to entities that deal with transactions primarily in swaps for a commodity and manage/hedge the risk associated with those swaps transactions by using the futures markets. The "money manager" category refers to entities that participate in managing and engaging in organized futures trading on behalf of clients, and this trader type includes a registered commodity trading advisor (CTA), a registered commodity pool operator (CPO), or an unregistered fund. Every other reportable trader other than those in the above three categories is placed into the "other reportable traders" category. Finally, the "non-reportable traders" category represents individuals or small traders.

We construct two measures as proxies for the five types of traders' positions, using the net positions (NP_t^i) and the scaled net positions (SNP_t^i) held by type i, and defined as follows:

$$NP_t^i = Long_t^i - Short_t^i, \tag{1}$$

$$SNP_t^i = \left(Long_t^i - Short_t^i\right) / \left(Long_t^i + Short_t^i + Spreading_t^i\right), \tag{2}$$

where $Long_t^i$ and $Short_t^i$ refer to the long and short positions of type i traders, and $i = Pr, Sw, Mo, Ot,$ and No denote producers, swap dealers, money managers, other reportable traders, and non-reportable traders, respectively.[3]

3.2. Descriptive statistics

Table 1 provides the summary statistics and correlation coefficients for the trading positions (net positions NP_t^i) and the log-transformation gold futures price. It shows that the average value of gold futures prices is about 7.12, and that the distribution of futures price changes has a long left tail and is leptokurtic rather than normal. The result of the augmented Dickey-Fuller (ADF) unit root test indicates that the futures price changes series is stationary. In addition, on average, producers and swap dealers take net short positions, whereas money managers, other reportable traders, and non-reportable traders take net long positions. This may imply that producers and swap dealers play a similar role in gold futures. However, we find that the volatility of the net trading position of swap dealers (66,327.7) is larger than that of producers (56,084.4) and is close to that of money managers (73,377.5), implying that swap dealers' trading is more sensitive to market conditions and involves more frequent interaction with money managers. We use the difference in the net positions data in the following regression analyses for consistency.[4]

Table 1 reports the results of the bilateral correlation between the gold futures prices and the net positions of the five types of traders. From the pairwise correlation analysis, we gain some preliminary insights into the associations between the trading activities of various traders and the gold market conditions. Table 1 shows that changes in the gold futures prices are negatively correlated with the net positions of producers and swap dealers, but they are positively correlated with the net positions of money managers, other reportable traders, and non-reportable traders.

Producers' and swap dealers' use of gold futures for hedging purposes may explain the inverse correlation between gold futures prices and the net positions of these two traders. When the gold price rises, the higher hedging demand of producers and swap dealers may drive them to take more short positions, which also offset the speculative long positions of money managers, other reportable traders, and non-reportable traders in gold futures. Dedi and Mandilaras (2022) investigate trader positions in Brent oil futures and also find that producers and swap dealers reduce their net positions when the oil futures price rises, whereas money managers increase their net positions.

In particular, the extremely negative correlation between the net positions of swap dealers and money managers is as high as −0.885, indicating that both types of traders generally take opposite positions in the gold futures market.

4. Determinants of trading positions

In this section, we begin with a test for linearity against nonlinearity that exists between the trading positions and price changes in gold futures. We then explore the determinants of trading positions in the linear and nonlinear regression models.

4.1. Specification and linearity test of STAR models

We follow the methodology proposed by Teräsvirta (1994) and test for linearity against the smooth transition nonlinearity that at first exists between the trader positions and price changes in gold futures. The smooth transition autoregressive (STAR) model for a univariate time-series variable, y_t, is given by

$$y_t = \alpha_0 + \alpha_1' x_t + \left(\beta_0 + \beta_1' x_t\right) \mathrm{F}(\gamma, \mathrm{c}, S_t) + u_t, \tag{3}$$

where $x_t = (y_{t-1}, \cdots, x_{1,t}, \cdots x_{k,t})$ and $u_t \sim iid(0, \sigma^2)$. In addition, F is the transition function; S_t is the transition variable; γ denotes the smoothness parameter and determines the slope of the transition function; while c governs where the transition occurs. The function $\mathrm{F}(\gamma, \mathrm{c}, S_t) = \left(1 + \exp\left\{\frac{-\gamma}{\sigma_{S_t}}(S_t - c)\right\}\right)^{-1}$ yields the logistic STAR model (LSATR) and $\mathrm{F}(\gamma, \mathrm{c}, S_t) = \left(1 + \exp\left\{\frac{-\gamma}{\sigma_{S_t}}(S_t - c)^2\right\}\right)$ defines the exponential STAR model (ESTAR). LSATR (ESTAR) represents one (two) threshold(s) in the regression model.

The execution of the STAR models consists of three stages as follows[5]

(a) Specification of a linear model. Regress y_t on x_t by ordinary least squares (OLS) and compute the residuals $\widehat{v}_t$.and the regression SSR_0.

(b) Test for linearity against the STAR models using the linear model specified in (a). To carry out this test, following Sarantis (1999), we estimate the auxiliary regression below and compute the regression SSR:

[3] $Spreading^i$ measures the extent to which type i traders hold equal long and short futures positions.

[4] The empirical analyses for SNP_t^i lead to similar results to those for NP_t^i. Due to space constraints, the empirical results of SNP_t^i are not reported in this study but are available on request.

[5] Please see Teräsvirta (1994) for the details.

Table 1
Summary statistics and bilateral correlations on the gold futures and net positions.

Panel A. Summary statistics on the gold futures price and net positions

Variables	Mean	S.D.	Sk.	Ku.	ADF
Futures					
P_t^{GC}	7.12	0.28	−0.74	3.07	−2.33
ΔP_t^{GC} (× 100)	0.14	2.43	−0.20	6.23	−30.28***
Net Positions					
NP_t^{Pr}	−112475.1	56,084.4	0.03	1.95	−3.26**
NP_t^{Sw}	−83333.8	66,327.7	−0.63	2.92	−2.94**
NP_t^{Mo}	119,779.9	73,377.5	−0.04	2.68	−4.43***
NP_t^{Ot}	48,499.9	29,801.1	1.39	4.34	−1.84
NP_t^{No}	27,529.0	15,726.9	−0.32	2.32	−3.28**

Panel B. Correlations between the gold futures return and net positions

	ΔP_t^{GC}	ΔNP_t^{Pr}	ΔNP_t^{Sw}	ΔNP_t^{Mo}	ΔNP_t^{Ot}
ΔNP_t^{Pr}	−0.624 (0.000)				
ΔNP_t^{Sw}	−0.597 (0.000)	0.541 (0.000)			
ΔNP_t^{Mo}	0.638 (0.000)	−0.782 (0.000)	−0.885 (0.000)		
ΔNP_t^{Ot}	0.242 (0.000)	80.248 (0.000)	−0.231 (0.000)	0.030 (0.389)	
ΔNP_t^{No}	0.365 (0.000)	−0.479 (0.000)	−0.347 (0.000)	0.295 (0.000)	0.078 (0.024)

Note: This table reports summary statistics and correlation coefficients of the trading positions and the gold futures prices changes. P_t^{GC} and ΔP_t^{GC} denote prices (Log-transformation) and difference of gold futures; NP_t^i represent the net positions held by type *i* traders on *t*, where *i* = *Pr*, *Sw*, *Mo*, *Ot* and *No*, which refer to producers, swap dealers, money managers, other reportable traders, and non-reportable traders, respectively. $NP_t^i = Long_t^i - Short_t^i$, where $Long_t^i$ ($Short_t^i$) denote the long (short) positions held by type *i* traders on *t*; S.D., Sk, and Ku individually refers to the standard deviation, skewness, and kurtosis of the series; and we use the augmented Dickey-Fuller (ADF) statistics with the Schwarz information criterion to test the null hypothesis that whether an examined series has a unit root, with a corresponding lag of 16 for this test. *** (**) indicates significance at the 1% (5%) level. The number of observations is 632.

$$\widehat{v}_t = \beta_0 + \beta_1' x_t + \beta_2' x_t S_t + \beta_3' x_t S_t^2 + \beta_4' x_t S_t^3 + e_t \tag{4}$$

The statistic is $LM = \frac{T(SSR_0 - SSR)}{SSR_0}$. The linearity test is $H_0 : \beta_2 = \beta_3 = \beta_4 = 0$. If H_0 is accepted, the LM type test suggests that the linearity is between x_t and y_t. If such linearity is rejected, we need to choose between the LSTAR and ESTAR models.

(c) Choose between the LSTAR and ESTAR models. This is done by the following sequence of nested tests:

$$H_0 : \beta_4 = 0, \tag{5}$$

$$H_0 : \beta_3 = 0 | \beta_4 = 0, \tag{6}$$

$$H_0 : \beta_2 = 0 | \beta_3 = \beta_4 = 0 . \tag{7}$$

The rejection of H_0 in (5) implies selecting the LSTAR model. If we accept H_0 in (5) and reject H_0 in (6), we should consider the ESTAR model. If we accept H_0 in (5)-(6) and reject H_0 in (7), we choose the LSTAR model. Finally, the estimation can be performed with maximum likelihood using an optimization procedure.

Table 2 reports the results of the linearity test and shows that the null of linearity is rejected for the regression on the net positions of swap dealers and money managers when the gold futures price serves as the transition variable. The one threshold LSTAR is found to be optimal in these nonlinear models for swap dealers and money managers. Other test statistics in Table 2 suggest a simple linear relationship between the gold futures price and the trading positions of producers/other reportable traders/non-reportable traders. These results indicate that the gold futures price levels determine the trading strategies of swap dealers and money managers; that is, swap dealers and money managers change their trading strategies more dramatically when the gold futures price level varies greatly. We separately describe the linear and nonlinear regression analyses in this section.

4.2. Linear regression model

Wang (2003) finds that the likelihood that investors condition their trading activities on past returns is high because they tend to exhibit positive/negative feedback trading behavior. In addition, Ciner et al. (2013), Hung and Vo (2021), and Drake (2022) find cross-correlations between gold and financial asset market returns. Baur and Lucey (2010) show that holding gold compensates for the losses from investing in stocks. Some previous studies also highlight the diversification benefits of holding stocks and gold in portfolios, indicating the tendency for investors to shift to gold when the stock market performs poorly (Baur and Kuck, 2020; Boako and Alagidede, 2016; Boako et al., 2019). Ciner et al. (2013) find evidence of the role played by gold in serving as a hedge against fluctuations in currency values and a lesser role in reducing the risks in relation to bonds. Chen and Yang (2021) find that the VIX index reflects the level of market uncertainty and affects speculators' risk tolerance and dealers' funding constraints. A higher VIX index level and the funding constraints of financial institutions may alter the changes in traders' positions in gold futures. Hence, the price movements of stocks, bonds, FX futures, the VIX dummy, and TED spread may affect the trading activities of different traders in gold futures.

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Table 2
Linearity tests.

Regression	LM statistic (*p*-value)	Suggested model
ΔNP_t^{Pr}	2.97 (0.39)	Linear
ΔNP_t^{Sw}	28.79 (0.00)	LSTAR (1)
ΔNP_t^{Mo}	26.16 (0.00)	LSTAR (1)
ΔNP_t^{Ot}	7.08 (0.13)	Linear
ΔNP_t^{No}	5.62 (0.22)	Linear

Note: This table reports the results of the following linearity tests for the models.
$\Delta \text{NP}_t^i = \alpha_0 + \alpha_1 \Delta P_{t-1}^{GC} + \alpha_2 \Delta P_{t-1}^{SP} + \alpha_3 \Delta P_{t-1}^{TN} + \alpha_4 \Delta P_{t-1}^{USD} + \alpha_5 \Delta TS_{t-1} + \alpha_6 \Delta \text{NP}_{t-1}^i + \alpha_7 D_{t-1}^{VIX} + [\beta_0 + \beta_1 \Delta P_{t-1}^{GC} + \beta_2 \Delta P_{t-1}^{SP} + \beta_3 \Delta P_{t-1}^{TN} + \beta_4 \Delta P_{t-1}^{USD} + \beta_5 \Delta TS_{t-1} + \beta_6 \Delta \text{NP}_{t-1}^i] F(\gamma, c, S_t) + u_t$.
Where NP_t^i refers to the net positions held by type i traders on t, where $i = Pr, Sw, Mo, Ot$ and No, which refer to producers, swap dealers, money managers, other reportable traders, and non-reportable traders, respectively. $F(\cdot)$ is a normalized function and bounded in the interval [0, 1]; we use the gold futures price (P_t^{GC}) as the threshold variable, so S_t is assigned to P_t^{GC}; γ determines the slope of the transitions; c determines the location of transition, with its value being expressed at the log-transformation level; ΔP_{t-1}^{GC}, ΔP_{t-1}^{SP}, ΔP_{t-1}^{TN}, and ΔP_{t-1}^{USD} are the changes in gold, S&P 500 index, U.S. 10-year Treasury note, and U.S. dollar index futures prices on the previous week. D_{t-1}^{VIX} represents VIX volatility dummy variable and it equals to one when VIX index levels are above the 23.81 threshold determined by Chen and Yang (2021) and otherwise zero on the previous week. ΔTS_{t-1} represnts the TED spread on the previous week.

Here, we consider factors including the gold futures, stock futures, interest rate futures, FX futures markets, the VIX dummy, and TED spread and examine how they influence the trading positions of different traders using the following linear model:

$$\Delta \text{NP}_t^i = \alpha_0 + \alpha_1 \Delta P_{t-1}^{GC} + \alpha_2 \Delta P_{t-1}^{SP} + \alpha_3 \Delta P_{t-1}^{TN} + \alpha_4 \Delta P_{t-1}^{USD} + \alpha_5 \Delta TS_{t-1} + \alpha_6 \Delta \text{NP}_{t-1}^i + \alpha_7 D_{t-1}^{VIX} + u_t, \tag{8}$$

where ΔNP_t^i represents the change in the net positions held by type i traders at time t. ΔP_{t-1}^{GC}, ΔP_{t-1}^{SP}, ΔP_{t-1}^{TN}, and ΔP_{t-1}^{USD} are the changes in gold, S&P 500 index, U.S. 10-year Treasury note, and U.S. dollar index futures prices compared to the previous week.[6] We consider the VIX dummy variable (D_{t-1}^{VIX}) to capture the equity volatility regimes effect and it equals one when VIX index levels are above the 23.81 threshold determined by Chen and Yang (2021), and zero otherwise. ΔTS_{t-1} represents the TED spread (i.e., the spread between the interest rate on U.S. interbank loans and the three-month T-bill rate) to proxy the funding constraints of financial institutions (Karnaukh et al., 2015) in the regression analyses.[7]

The estimation results of Equation (3) are reported in Table 3, and Model (3) in Table (3) shows that the estimated coefficients for the gold futures price changes are significantly positive for the net long positions of individual traders. Individuals tend to take more long positions in gold futures when previous gold prices rise, which is consistent with the findings of Chen and Yang (2021) and De Long et al. (1990). They may be viewed as noise traders and follow the positive-feedback strategies of rational speculators. Rational speculators' early buying triggers positive-feedback trading and turns to go short at the peak of the gold futures prices. However, individuals keep on engaging in positive-feedback trading.

In addition, the trading behavior of producers and other reportable traders has no relevance with regard to changes in gold futures prices. Their current trading positions are found to be significantly correlated with previous trading positions. For producers, the significantly positive correlation between intertemporal trading activities may imply the existence of persistent hedging demand in gold futures. Other reportable traders are often viewed as small speculators and their significantly negative intertemporal trading may indicate short-term changes in speculative trading positions in gold futures. We provide possible explanations for the empirical results of producers' and other reportable traders' position changes and suggest that future studies could further investigate the possible reasons for their trading behavior in gold futures in order to enhance our understanding.

[6] In all regressions, we follow Newey and West (1987) to adjust for the heteroskedasticity and autocorrelation in the regression errors by using Newey–West robust heteroskedasticity and autocorrelation consistent standard errors.

[7] We also use the VIX index as a transition variable in the LSTAR analyses and find that VIX index high-low regimes affect the changes in traders' positions. Hence, we consider the VIX dummy variable in the regression analyses and adopt 23.81 as the VIX index threshold, according to the work of Chen and Yang (2021). We thank an anonymous referee for pointing out the importance of considering the impact of the VIX volatility regime on traders' positions in gold futures. However, we still use the gold futures price threshold, because the gold futures price threshold exists with the consideration of the volatility regime dummy variable. As gold is a traditional safe-haven asset, gold futures prices may partly reflect the VIX index level (i.e., market uncertainty) and affect trader positions. In addition, based on the argument of De Long et al. (1990) and Röthig and Chiarella (2007), rational speculators may also change their behavior with different asset price regimes. By combining these effects, we finally consider the use of the gold futures price threshold in this study.

Table 3
Linear model of net positions and futures returns.

Variables	Model (1)			Model (2)			Model (3)		
	$\Delta NP_t^{\ Pr}$			$\Delta NP_t^{\ Ot}$			$\Delta NP_t^{\ No}$		
	Coef.		S.D.	Coef.		S.D.	Coef.		S.D.
α_0	0.01		0.04	0.01		0.02	−0.01		0.01
α_1	−2.62		2.18	−0.02		0.89	4.95	***	0.68
α_2	1.17		1.83	0.54		0.86	−0.75		0.63
α_3	1.06		5.44	1.70		2.59	−5.17	***	1.91
α_4	3.62		4.17	0.85		1.98	2.70	*	1.46
α_5	−0.09		0.34	−0.01		0.16	0.04		0.11
α_6	0.10	**	0.04	−0.05	*	0.03	−0.23	***	0.04
α_7	0.07		0.10	0.01		0.04	−0.01		0.02
Adj. R^2	0.06			0.02			0.09		

Note: This table reports the estimation of the linear model for the change in the net positions held by type *i* traders at time *t* (divided by 10,000), ΔNP_t^i, which represents where $i = Pr$, Ot, or No, respectively denoting producers, other reportable traders, and non-reportable traders.
$\Delta \mathrm{NP}_t^i = \alpha_0 + \alpha_1 \Delta P_{t-1}^{GC} + \alpha_2 \Delta P_{t-1}^{SP} + \alpha_3 \Delta P_{t-1}^{TN} + \alpha_4 \Delta P_{t-1}^{USD} + + \alpha_5 \Delta TS_{t-1} + \alpha_6 \Delta \mathrm{NP}_{t-1}^i + \alpha_7 D_{t-1}^{VIX} + u_t$.
Where ΔP_{t-1}^{GC}, ΔP_{t-1}^{SP}, ΔP_{t-1}^{TN}, and ΔP_{t-1}^{USD} are the changes in gold, S&P 500 index, U.S. 10-year Treasury note, and U.S. dollar index futures prices on the previous week. The changes are calculated as the log difference in the price. D_{t-1}^{VIX} represents VIX volatility dummy variable and it equals to one when VIX index levels are above the 23.81 threshold determined by Chen and Yang (2021) and otherwise zero on the previous week. ΔTS_{t-1} represnts the TED spread on the previous week. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. We follow Newey and West (1987)'s way to adjust for the presence of heteroskedasticity and autocorrelation in the regression errors by employing the Newey–West robust heteroskedasticity, autocorrelation-consistent standard errors.

4.3. Logistic smooth transition autoregressive (LSTAR) model

In this section, we examine whether there exist nonlinear responses in terms of traders' trading activities in relation to price changes under different gold price regimes. Under the LSTAR framework, we can consider the trading activities of different traders in the two regimes associated with small and large values of the transition variables (i.e., the gold futures price) relative to the threshold value.[8] Hence, we model the nonlinear relationships between the trading positions of swap dealers/money managers and gold futures using the following LSTAR (1) model:

$$\begin{aligned}\Delta \mathrm{NP}_t^i = {} & \alpha_0 + \alpha_1 \Delta P_{t-1}^{GC} + \alpha_2 \Delta P_{t-1}^{SP} + \alpha_3 \Delta P_{t-1}^{TN} + \alpha_4 \Delta P_{t-1}^{USD} + \alpha_5 \Delta TS_{t-1} + \alpha_6 \Delta \mathrm{NP}_{t-1}^i + \alpha_7 D_{t-1}^{VIX} + \left[\beta_0 + \beta_1 \Delta P_{t-1}^{GC} + \beta_2 \Delta P_{t-1}^{SP} + \beta_3 \Delta P_{t-1}^{TN}\right. \\ & \left. + \beta_4 \Delta P_{t-1}^{USD} + \beta_5 \Delta TS_{t-1} + \beta_6 \Delta \mathrm{NP}_{t-1}^i\right] F(\gamma, c, S_t) + u_t,\end{aligned} \tag{9}$$

wher $F(\gamma, c, S_t) = \left(1 + exp\left\{\frac{-\gamma}{\hat{\sigma}_{S_t}}(S_t - c)\right\}\right)^{-1}$. *F* (.) is a normalized function of bounded variation inside the interval [0, 1]; St is the threshold variable and is assigned to the gold futures prices (P_t^{GC}); γ denotes the smoothness parameter and determines the slope of the transition function; c governs where the transition occurs and is expressed at the log-transformation level; and the factors are the same as in Equation (3). In Equation (4), there are two regimes: in Regime 1, F (.) = 0 if I(St < c), and the parameters (α + βF (γ, c, St)) become α; in Regime 2, F (.) = 1 if I(St > c), and the parameters (α + βF (γ, c, St)) become α + β. In the model, the two regimes are related, with small or large values of the transition variable St relative to the threshold value (c). C determines when the regime changes. Other factors are the same as those in Equation (8).

The LSTAR Model (1) in Table 4 shows the high and low gold price regimes: the one in which the gold futures prices lie above 7.22 (i.e., 1366.4 before log-transformation) is the high gold price regime, and the other one in which they lie below 7.22 is the low gold price regime. This threshold point determined by the LSTAR model is close to the mean value of the gold prices. In addition, α_1 carries a significantly negative sign ($\alpha_1 = -13.11$) in the low price regime (i.e., when gold futures prices are below 7.22), meaning that ΔP_{t-1}^{GC} has a negative impact on $\Delta \mathrm{NP}_t^{Sw}$ in the low price regime. This result suggests that swap dealers will engage in negative feedback trading during the lower gold price period, reflecting their hedging demand or commitment to meet the needs of clients. However, when the gold futures price rises above 7.22, ΔP_{t-1}^{GC} has less of a negative impact on $\Delta \mathrm{NP}_t^{Sw}$ ($\alpha_1 + \beta_1 = -13.11 + 10.06$). This result indicates that swap dealers may reduce the intensity of their negative feedback trading during the higher gold price period.

With regard to money managers, Model (2) of Table 4 points to opposite results to those for swap dealers. ΔP_{t-1}^{GC} in the low price regime has a significantly positive impact on $\Delta \mathrm{NP}_t^{Mo}$ ($\alpha_1 = 9.49$). However, the result indicates that money managers will switch their positive feedback trading to negative feedback trading during a high price period ($\alpha_1 + \beta_1 = 9.49 - 10.09$). That is, money managers

[8] Please refer to Teräsvirta (1994, 1998)for detailed discussions regarding the specification and estimation techniques for the LSTAR model. The Lagrange multiplier (LM)-type tests and the F-test proposed by Teräsvirta (1994, 1998) point out that one threshold is optimal between the variables.

Table 4
LSTAR model of net positions and futures returns.

Variables	Model (1)			Model (2)		
	ΔNP_t^{Sw}			ΔNP_t^{Mo}		
	Coef.		S.D.	Coef.		S.D.
α_0	−0.04		0.05	0.09		0.15
α_1	−13.11	***	2.79	9.49	**	4.01
α_2	1.34		2.83	−0.73		6.08
α_3	−12.25		8.68	1.54		16.19
α_4	1.34		5.51	−17.17		17.99
α_5	0.04		0.07	0.17		0.10
α_6	0.29		0.27	0.15	**	0.06
α_7	0.11		0.10	−0.01		0.00
β_0	0.02		0.05	−0.10		0.17
β_1	10.06	*	5.37	−10.09	**	5.03
β_2	−3.40		5.92	0.75		7.35
β_3	51.96	***	15.54	−7.53		20.84
β_4	−11.90		10.27	14.56		19.96
β_5	−0.73		1.54	−0.01		0.01
β_6	−0.17	*	0.09	−0.21	**	0.09
c	7.22	**	3.01	7.21	**	3.18
Adj. R^2	0.13			0.16		

Note: We focus on the nonlinear effect of gold prices on trading behavior of swap dealers and money managers by using the LSTAR model. This table reports the estimation of this model for ΔNP_t^i (divided by 10,000), which represents the change in the net positions held by type i traders at time t, where $i = Sw$ or Mo, respectively denoting swap dealers in Model (1) and money managers in Model (2).
$\Delta NP_t^i = \alpha_0 + \alpha_1 \Delta P_{t-1}^{GC} + \alpha_2 \Delta P_{t-1}^{SP} + \alpha_3 \Delta P_{t-1}^{TN} + \alpha_4 \Delta P_{t-1}^{USD} + \alpha_5 \Delta TS_{t-1} + \alpha_6 \Delta NP_{t-1}^i + \alpha_7 D_{t-1}^{VIX} + [\beta_0 + \beta_1 \Delta P_{t-1}^{GC} + \beta_2 \Delta P_{t-1}^{SP} + \beta_3 \Delta P_{t-1}^{TN} + \beta_4 \Delta P_{t-1}^{USD} + \beta_5 \Delta TS_{t-1}$ - $+\beta_6 \Delta NP_{t-1}^i] F(\gamma, c, S_t) + u_t$.
Where $F(\gamma, c, S_t) = \left(1 + exp\left\{\frac{-\gamma}{\widehat{\sigma}_{S_t}}(S_t - c)\right\}\right)^{-1}$. $F(.)$ is a normalized function and bounded in the interval of [0, 1]; S_t is the threshold variable and assigned to the gold futures prices (P_t^{GC}); γ governs the smoothness of the transitions; c determines the location of the transition, with its value being expressed at the log-transformation level; ΔP_{t-1}^{GC}, ΔP_{t-1}^{SP}, ΔP_{t-1}^{TN}, and ΔP_{t-1}^{USD} are the changes in gold, S&P 500 index, U.S. 10-year Treasury note, and U.S. dollar index futures prices on the previous week. D_{t-1}^{VIX} represents VIX volatility dummy variable and it equals to one when VIX index levels are above the 23.81 threshold determined by Chen and Yang (2021) and otherwise zero on the previous week. ΔTS_{t-1} represnts the TED spread on the previous week.***, **, and * individually represent significance at the 1%, 5%, and 10% levels. We employ the Newey–West robust heteroskedasticity, autocorrelation-consistent standard errors to adjust for the presence of heteroscedasticity.

will change their positive feedback trading strategies during a high gold price period. Hence, a higher gold price level may affect the hedging activities in which swap dealers engage as well as the premium that money managers require for bearing the trading risks when they engage in transactions with swap dealers or other market participants.

5. Trader positions spillover analysis

To further understand the trading intertemporal interactions among these different types of traders, especially across low and high gold price regimes, in this section we first use the spillover measure of Diebold and Yilmaz (2012 and 2014) to examine the trading spillovers among these traders. Then, we adopt the rolling-window estimation to capture the time variation in trading spillovers and to explore the determinants of the directional spillovers transmitted from swap dealers and money managers to others.

5.1. Diebold and Yilmaz spillover measure

According to Diebold and Yilmaz (2012 and 2014), we first employ the VAR model for net positions (ΔNP_t^i).[9] We compute the extent of the spillover transmissions among all net positions using H-step-ahead forecast error variance decompositions based on the VAR, $\varphi_{ij}^g(H)$, for H = 1, 2, …

$$\varphi_{ij}^g(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} \left(e_i' A_h \sum e_j\right)^2}{\sum_{h=0}^{H-1} \left(e_i' A_h \sum A_h' e_i\right)}, \tag{10}$$

[9] Please refer to the studies by Diebold and Yilmaz (2012 and 2014) for a detailed explanation of this method.

where σ_{jj} is the standard deviation of the error term for the jth equation. For the error vector ε, Σ is the variance matrix of ε. E_i is the selection vector, and it has one as the ith element and zero otherwise. Finally, $\varphi_{ij}^{g}(H)$ can be normalized, as in equation (11):

$$\widetilde{\varphi}_{ij}^{g}(H) = \frac{\varphi_{ij}^{g}(H)}{\sum_{j=1}^{N} \varphi_{ij}^{g}(H)}. \tag{11}$$

We can learn more about the directions of the spillover transmission—that is, a directional spillover based on net position i "from" other net positions as $DS_{i.}$ in equation (12) and a directional spillover based on net position i "to" other net positions as $DS_{.i}$ in equation (13):

$$DS_{i.}^{g}(H) = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{N} \widetilde{\varphi}_{ij}^{g}(H)}{\sum_{i,j=1}^{N} \widetilde{\varphi}_{ij}^{g}(H)} \bullet 100 = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{N} \widetilde{\varphi}_{ij}^{g}(H)}{N} \bullet 100, \tag{12}$$

$$DS_{.i}^{g}(H) = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{N} \widetilde{\varphi}_{ji}^{g}(H)}{\sum_{i,j=1}^{N} \widetilde{\varphi}_{ji}^{g}(H)} \bullet 100 = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{N} \widetilde{\varphi}_{ji}^{g}(H)}{N} \bullet 100. \tag{13}$$

We can obtain the net directional spillover for the net position of type i (NS^{i}), as $NS^{i}(H) = DS_{.i}^{g}(H) - DS_{i.}^{g}(H)$. A positive net directional spillover indicates that the trading position of type i is a transmitter and a receiver of a negative value.

The static trading spillover of the Diebold and Yilmaz measure is presented in Table 5. The "net directional spillover to others (NET)" row shows that (1) trading positions held by producers (net trading spillover = 60.0%–54.4% = 5.6%), those held by swap dealers (net trading spillover = 58.6%–55.7% = 2.9%), and those held by money managers (net trading spillover = 69.7%–59.6% = 10.1%) serve as the major trading transmitters to others, with the largest *NS* of 10.1% being recorded for money managers. These results are consistent with the findings of Ji et al. (2019), supporting the view that money managers play a trading transmitter (spillover) role in relation to other traders in the futures market. Ordu-Akkaya et al. (2019) also support the view that money manager positions significantly spill volatility over to the others in the crude oil and gold futures markets.

(2) Trading positions held by other reportable traders and non-reportable traders serve as the major recipients from other traders (net trading spillover = 8.1%–12.8% = −4.7% for other reportable traders and net trading spillover = 19.3%–33.3% = −14.0% for non-reportable traders). It is not surprising that the former individual traders are followers in gold futures, compared to the institutional traders. Pertaining to other reportable traders, they represent small speculators and generate little interaction with producers, swap dealers, money managers, and non-reportable traders.
(3) The net directional spillover from swap dealers (money managers) to money managers (swap dealers) is 31.4% (34.9%) which is larger than the other net directional spillovers, supporting the view that the trading activities of swap dealers and money managers strongly interact with each other in the gold futures.

To sum up, this table shows that the average value of total trading spillovers is 43.1%. Our results also indicate that swap dealers and money managers tend to trade spillovers with individual traders and small speculators in the gold futures market.

In this study, we also use the volatility impulse response functions (VIRF) connectedness approach of Gabauer (2020) and the TVP-VAR connectedness approach of Antonakakis and Gabauer (2017) to investigate the trading positions connectedness in gold futures.[10] These two approaches have the advantage of not needing to arbitrarily set the rolling window-size. In the VIRF and TVP-VAR connectedness analyses, we find that the results remain consistent with those obtained in the VAR-based model. These analyses check the robustness of previous findings.

5.2. Determinants of the dynamic trading spillover

To further explore the dynamic trading spillover with gold futures price shocks, we adopt the Diebold and Yilmaz spillover analysis for the five types of traders' positions by using rolling-window estimations where the width of the rolling window is 200 days and the

[10] We thank an anonymous reviewer for suggesting that the use of the VIRF and TVP-VAR connectedness models to reduce the problem of the rolling window size is chosen arbitrarily. These connectedness results are not reported in this study due to space constraints but are available upon request.

Table 5
Trading positions spillover analysis.

	ΔNP_t^{Pr}	ΔNP_t^{Sw}	ΔNP_t^{Mo}	ΔNP_t^{Ot}	ΔNP_t^{No}	**FROM**
ΔNP_t^{Pr}	45.6	13.3	27.8	3.1	10.1	54.4
ΔNP_t^{Sw}	13.1	44.3	34.9	2.8	4.8	55.7
ΔNP_t^{Mo}	24.9	31.4	40.4	0.2	3.1	59.6
ΔNP_t^{Ot}	6.0	5.3	0.2	87.2	1.2	12.8
ΔNP_t^{No}	15.9	8.6	6.8	2.0	66.7	33.3
TO	60.0	58.6	69.7	8.1	19.3	43.1
NET	5.6	2.9	10.1	−4.7	−14	

Note: This table reports spillovers of net trading positions of each trader by using the 10-day-ahead forecast error variance decomposition of the VAR. The *ij*-th entry of the upper-left 5 × 5 net positions submatrix gives the *ij*-th pairwise directional spillover (i.e., the percentage of 10-day-ahead forecast error variance of net positions *i* in response of shocks arising from net positions *j*). The rightmost (**FROM**) column gives total directional spillover (from) (i.e., summation of row [from all others to *i*]). The bottom (**TO**) row gives total directional spillover (i.e., summation of column [to all others from *j*]). The bottommost (**NET**) row gives the difference in total directional spillover (which is calculated as **TO** minus **FROM**). The bottom-right element is total spillover index (%).

predictive horizon for the variance decomposition is still 10 days. In addition, we also investigate the determinants of the trading spillover in this section.

The trading behavior of money managers and swap dealers will change when the gold futures price rises above the threshold level (i.e., 1366.4 before log-transformation) as determined by the LSTAR model. These changes in the trading activities of money managers and swap dealers may affect the trading spillover and trading transmission mechanism of different types of traders. We first compare the total spillover (*TS*) and the net directional spillovers (*NS*) of different traders in the high and low gold futures price periods.

In Table 6, we report the average values of the dynamic total spillover and net directional spillover measures as well as the t-statistics as we test the null hypothesis that the mean differences for these spillover measures in the high and low gold price regimes are equal to 0. Table 6 shows that the total spillover among producers, swap dealers, money managers and non-reportable traders decreases significantly when gold futures prices rise above the threshold level. In addition, all *NS* measures change significantly in the two gold price regimes and also during the low gold price period, with the average value of *NS* for money managers (swap dealers) being 12.61 (6.69). The average value of *NS* for money managers (swap dealers) declines to 11.89 (5.18) during the high gold price period. These results support the view that the trading spillover transmitter role of money managers and swap dealers becomes less strong during the high gold price period. However, money managers and swap dealers still dominate in terms of their trading spillover transmission role during the high gold price period.

Fig. 2 plots the time-varying net directional spillover transmissions of money managers and swap dealers. We find that money managers decrease spillover transmissions (i.e., the green line) when the gold futures prices lie above the horizontal dashed line. On March 23, 2020, the U.S. Fed. Announced that it would use its full range of tools to support households, businesses, and the U.S. economy overall against the coronavirus pandemic (QE4). We find that, after March 23, 2020, net directional spillover transmissions of money managers and swap dealers become closer and gold futures prices rise.

The LSTAR model points out that swap dealers turn their trading behavior from greater negative feedback trading during the low price period to lower negative feedback trading during the high price period, whereas money managers in times of low prices engage in positive feedback trading but adopt negative feedback trading when prices are high. It is insightful to further explore the determinants of the dynamic trading spillovers of money managers and swap dealers. Here, we focus on the major trading transmitters including swap dealers and money managers and use the rolling-window estimation for NS^i, identifying the determinants of NS^i as follows:

$$\mathrm{NS}_t^i = \alpha_0 + \alpha_1 D_t^{GC} + \alpha_2 \Delta P_t^{SP} + \alpha_3 \Delta P_t^{TN} + \alpha_4 \Delta P_t^{USD} + \alpha_5 \Delta TS_t + \alpha_6 D_t^{VIX} + u_t, \quad (14)$$

where NS_t^i represents the net directional spillover of type *i*, where $i = Sw$ or Mo. D_t^{GC} is a dummy equal to one if gold futures prices are higher than 1366.4 (the threshold derived by the LSTAR model) and zero otherwise. Other factors are the same as before.

The results of Equation (14) are reported in Table 7. The results show that the transmitter role of swap dealers and money managers in trading positions decreases. In particular, the net spillovers of swap dealers decline more than those of money managers when gold futures prices rise above 1366.4. Other factors have an insignificant impact on dynamic trading spillovers. These results confirm that swap dealers and money managers may change their trading strategies when gold futures prices rise above the threshold level—i.e., swap dealers reduce their negative feedback strength during the high price period, whereas money managers turn to negative feedback trading. Hence, the trading transmitter role of swap dealers and money managers becomes less strong when gold futures prices rise above the threshold value.

6. Conclusions

In this study, we investigate the determinants of trading positions held by different types of traders in the gold futures market and adopt the DCOT report to separate traders into five categories: “producers,” “swap dealers,” “money manager traders,” “other reportable traders,” and “individual traders.” Our results indicate that when the gold futures price falls below the 1366.4 threshold endogenously determined by the LSTAR model, money managers adopt positive feedback trading strategies while swap dealers engage

Table 6
Comparison of net spillover in trader positions during high- and low-gold price regimes.

	TS_t	NS_t^{Pr}	NS_t^{Sw}	NS_t^{Mo}	NS_t^{Ot}	NS_t^{No}
Low price regime	53.40	2.12	6.69	12.61	−9.45	−11.97
High price regime	47.22	4.70	5.18	11.89	−8.95	−12.82
t-test	13.91***	−6.78***	2.53**	2.10**	−1.50	1.59

Note: This table shows the average values in weekly total spillover and net spillover for different trader positions in the sample. The t-statistics test the null hypotheses that the mean differences of net (total) spillover measures in the high- and low-gold price regimes are equal to 0. The gold futures prices lie above 7.22 (i.e., 1366.4 before log-transformation) is the high gold price regime and the other one that lies below 7.22 is the low gold price regime. *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

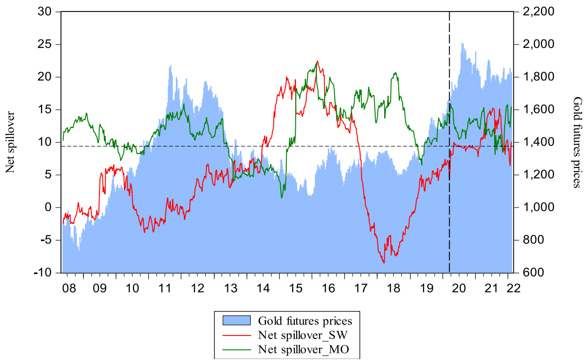

Fig. 2. Gold futures prices and net directional spillovers of different traders. Note: This figure shows the time-varying net spillover held by swap dealers (Sw) and money managers (Mo) in gold futures. The vertical dashed line indicates on March 23, 2020. U.S. Fed announced that it would use its full range of tools to support households, businesses, and the U.S. economy overall against the coronavirus pandemic on March 23, 2020 (QE4). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 7
Net spillover in trader positions and high-low gold futures price levels.

Variables	Model (1)			Model (2)		
	NS_t^{Sw}			NS_t^{Mo}		
	Coef.		S.D.	Coef.		S.D.
α_0	6.69	***	0.50	12.61	***	0.28
α_1	−1.55	***	0.59	−0.69	**	0.33
α_2	16.32		12.43	−6.73		20.91
α_3	9.94		37.35	−1.95		40.87
α_4	12.98		28.18	−23.83		15.77
α_5	−0.45		2.73	−0.18		1.55
α_6	−2.42	***	0.62	−0.42		0.35
Adj. R^2	0.02			0.02		

Note: We conduct the determinant analysis for net trading position spillovers of swap dealers and money managers during the high price period. This table reports the estimation of the model for NS_t^i which represents the net spillover positions held by type *i* traders at time *t*, where $i = Sw$ or Mo, respectively denoting swap dealers in Model (1) and money managers in Model (2).
$NS_t^i = \alpha_0 + \alpha_1 D_t^{GC} + \alpha_2 \Delta P_t^{SP} + \alpha_3 \Delta P_t^{TN} + \alpha_4 \Delta P_t^{USD} + \alpha_5 \Delta TS_t + \alpha_6 D_t^{VIX} + u_t$.
Where D_t^{GC} is a dummy equal to unity if gold futures prices are larger than the threshold value of 1366.2 and zero otherwise. ΔP_{t-1}^{GC}, ΔP_{t-1}^{SP}, ΔP_{t-1}^{TN}, and ΔP_{t-1}^{USD} are the changes in gold, S&P 500 index, U.S. 10-year Treasury note, and U.S. dollar index futures prices. D_{t-1}^{VIX} represents VIX volatility dummy variable and it equals to one when VIX index levels are above the 23.81 threshold determined by Chen and Yang (2021) and otherwise zero on the previous week. ΔTS_{t-1} represnts the TED spread on the previous week. ***, **, and * indicate levels of significance at the 1%, 5%, and 10%, respectively. We employ the Newey–West robust heteroskedasticity, autocorrelation-consistent standard errors to adjust the presence of heteroscedasticity.

in negative feedback trading. When the futures price rises above the threshold level, money managers turn to negative feedback trading, whereas swap dealers reduce the intensity of their negative feedback.

In addition, according to the spillover measure of Diebold and Yilmaz (2012 and 2014), money managers and swap dealers play the trading transmitter role in relation to small speculators and individual traders, and their trading transmitter role declines during the high gold price period. When the gold futures price rises above the threshold level, it may affect the hedging activities of swap dealers and the risk tolerance of money managers to trade, finally influencing the whole trading dynamics for gold futures.

Given these findings, our study provides relevant policy implications. First, measuring the extent to which traders in gold markets are connected to each other and the total connection is important for researchers, corporations, and investors. For example, investors are able to develop trading strategies in the gold futures market through analyzing and monitoring these trading spillover transmissions. Secondly, many previous studies have discussed why traders trade and how investors react in the equity, FX, and commodity futures markets. However, little is known about the investors' behavior in the gold futures market, especially in response to different gold price levels. To understand why traders trade and when their trading behavior changes is also important for policymakers to monitor the market and to regulate it, such as setting position limit rules for some speculators in gold futures. Finally, due to gold being a traditional safe-haven asset, higher gold futures prices may reflect heightened equity market risk and play a unique role in the global economy. We find that the gold threshold level alters the trading behavior of swap dealers and money managers in gold futures and in turn may also affect the trading behavior of these institutional investors in the equity or FX markets We therefore suggest that these issues could be discussed in future work.

Financial disclosure

Yu-Lun Chen (Corresponding Author) acknowledges financial support from the Ministry of Science and Technology, Taiwan (R.O. C.) (MOST 109-2410-H-033 -002 -MY2).

CRediT authorship contribution statement

Yu-Lun Chen: Conceptualization, Data curation, Formal analysis, Investigation, Funding acquisition, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Wan-Shin Mo:** Conceptualization, Formal analysis, Resources, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. CME gold futures- contract specifications

1. Contract Unit	100 troy ounces
2. Price Quotation	U.S. dollars and cents per troy ounce
3. Settlement Method	Deliverable
4. Termination of Trading	Trading terminates at 12:30 p.m. CT on the third last business day of the contract month
5. Trading Hours	CME Globex:
	Sunday - Friday 6:00 p.m. - 5:00 p.m. (5:00 p.m. - 4:00 p.m./CT) with a 60-min break each day beginning at 5:00 p.m. (4:00 p.m. CT)
6. Price Limit or Circuit	Dynamic circuit breakers
7. Position Limits	Initial Spot-Month Limit: 6000

Source: https://www.cmegroup.com/.

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