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The Risk Element in Derivatives Markets: Time-series Evidence on volatility of gold futures and spot price in China[1]

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Abstract

Based on the empirical study of Shanghai Futures Exchange (SHFE) daily gold futures prices and Shanghai Gold Exchange (SGE) daily gold spot prices covering the period 4th January 2011 to 31st July 2014, this paper captures the patterns of price volatility in gold futures in both the time and frequency domains. By using a moving standard deviation of gold futures price and simple time-series analysis techniques, the research findings suggest that the outlook for gold investment environment may be somewhat less favorable particularly because of the difficulty to manage market risk in both the spot and futures markets.

[1] This paper was submitted to the Third International Conference on Futures and Derivative Markets, from 31 October-1 November, 2014, organized by Shanghai Futures Exchange, Shanghai, China.

1 Introduction

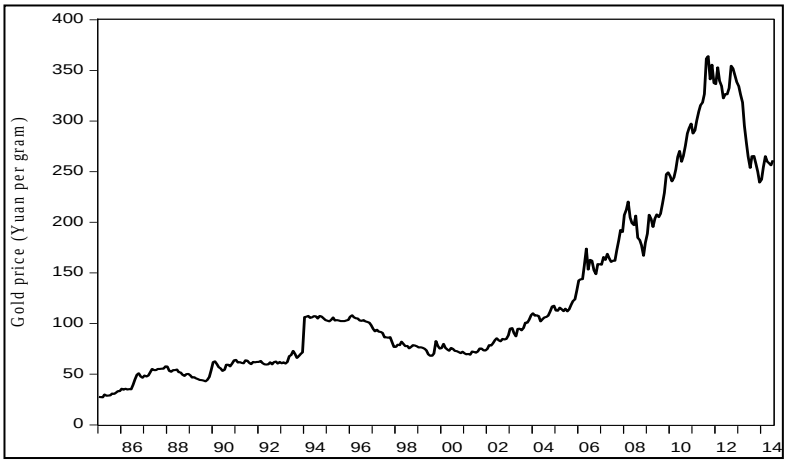
According to the World Gold Council (WGC, 2014), with the investment in gold bars and coins increased from 12 tonnes to 397 tonnes and gold jewellery sales increased from 224 tonnes to 699 tonnes in the past decade, China was both the world's largest jewellery and physical bullion investment market in 2013. Following the State Price Bureau formally abolished gold retail price control in 2001 and the setting up of the Shanghai Gold Exchange (SGE)[2] in 2002, the launching of standardized gold futures contract in Shanghai Futures Exchange (SFE)[3] in response to the growing demand for hedging against fluctuation in gold spot prices has also been a significant contributing factor in the fast growing Chinese gold markets.

As illustrated by Figure 1, the monthly average gold price was 27.5 yuan per gram in January 1985, reached its highest at 363.9 in September 2011, and in July 2014, it was 261.30 yuan per gram. In Table 1, it is also interesting to discover that there are two peaks in the futures gold contract monthly turnover. The first peak was in September 2011 where the 127,173 million yuan turnover in July 2011 increased by 1163% to 1,606,373 million yuan; and then, dropped 66% to 538600 million yuan in October 2011. The second peak is in July 2012 where the 358150 million yuan turnover in June 2012 increased by 418% to 1853357 million yuan; and then, pulled back to 304840 million yuan in August 2012, falling 84%. It reveals that although the gold market provides potentially high returns but is subject to high risk and volatility. Therefore, it is a common practice for the market players to hedge against fluctuation in gold spot prices using gold futures. However, it is interested to know whether the gold futures market perform the function of hedging which helps the economy function by allowing gold mining companies, goldsmiths, high-technology industries, central banks, and financial investors to conduct their businesses with greater certainty over how much they can expect to earn from and pay for commodities. In split of tiny in comparison to the total turnover in derivatives market, gold derivatives are very large in relation to physical gold market, and thus this paper focuses on the gold futures in China by exploring the patterns of price volatility with particular emphasis on both the time and frequency domains.

[2] SGE started operating on 30 October 2002. Private and institutional investors can participate in gold trading via acknowledged members in SGE, which was strictly restricted before 2002. There are four spot gold contracts Eight (Au100g, Ag99.99, Au9995, Au9999, and Pt9995) and three spot deferred contract (mAu(T+D), , Ag(T+D), Au(T+D)) are currently traded in the SGE.

[3] SFE initiated trading standardized gold futures contract on 1 September 2008. Contract series is from January through December, the last trading day is the 15th day of the spot month (If it is a public holiday, the last trading day shall be the 1st business day after the holiday), and the delivery period is the 5 consecutive business days after the last trading day. SFE Gold Contract and Related Regulations, see Operational Manual for Gold Futures Contract Trading (SFE, 2013).

Figure 1 Monthly average spot gold prices: January 1985 to July 2014



Sources: World Gold Council daily gold price being adjusted from price per troy ounce to price per gram using the conversion rate of 1 troy ounce = 31.1034768 grams
<http://www.gold.org/research/gold-price-range-currencies-december-1978-xls-version>

Table 1: Turnover in futures gold contracts in SFE: 2011 and 2012

Month/Year	Turnover *	Month/Year	Turnover
Jan 2011	10383663.15	Jan 2012	35673404.40
Feb 2011	5335153.15	Feb 2012	38331083.57
Mar 2011	9245417.16	Mar 2012	38869129.18
April 2011	11674399.44	April 2012	26656085.76
May 2011	14077984.41	May 2012	41244122.52
June 2011	8958024.17	June 2012	35814967.24
July 2011	12717305.91	July 2012	185335742.83
Aug 2011	116481036.39	Aug 2012	30484059.13
Sept 2011	160637383.34	Sept 2012	36902596.85
Oct 2011	53860014.30	Oct 2012	25530928.79
Nov 2011	51300793.01	Nov 2012	29464058.61
Dec 2011	55089619.01	Dec 2012	31147941.49

* Turnover in 10,000 yuan; turnover include buy and sell
Sources: SHFE Monthly Report, various issues. Available at:
http://www.shfe.com.cn/en/MarketData/dataview.html?paramid=month

Although there is no published systematic research on both the time and frequency domains of price volatility in SFE gold futures, there are a large number of empirical as well as theoretical studies on the gold markets in Chinese communities (Black & Tonks, 2000; Chan, Fung, & Leung, 2004; Liu, 2009; Qi & Wang, 2013; Xin, 2003; Yu, 2003; Zhang, 2012), on the characterization of gold futures (Barone-Adesi, Geman, & Theal, 2010; Domanski & Heath, 2007; Narayan, Narayan, & Zheng, 2010; Poitras, 1990), and on volatility of futures gold prices (Batten & Lucey, 2007; Black & Tonks, 2000; Cai, Cheung, & Wong, 2001; WGC, 2010). The author has therefore incorporated the wisdom of these leading scholars to formulate the research direction of this paper.

2 Dataset and its characteristics

The dataset in this study consists of three time series of gold prices. We chose the closing Au100g price listed in SGE as the spot gold price (SP) and the closing Au price of future contracts for December delivery[4] listed in SFE as future gold price (FP), and chose the observed period from 4th January 2011 to 31st July 2014. In order to get a longer time series of gold prices with a regular frequency to facilitate the analysis without the loss of statistical characteristics of the two above-mentioned time series, we used the World Gold Council's monthly average gold price (WGCP)[5] from January 1985 to July 2014 reported by Word Gold Council.

Table 2 Summary statistics of daily SP, FP and WGCP: 4 January 2011 to 31 July 2014

	SP	FP	WGCP
Mean	307.71	308.64	305.32
Standard Error	1.34	1.36	1.35
Median	319.29	318.10	316.03
Mode	320.00	340.20	315.30
Standard Deviation	38.63	39.14	38.98
Sample Variance	1492.24	1531.98	1519.46
Kurtosis	-1.28	-1.31	-1.31
Skewness	-0.15	-0.14	-0.14
Range	151.77	155.45	154.15
Minimum	241.63	239.80	235.22
Maximum	393.40	395.25	389.36
Count	833	833	833

Notes:
SP=Spot gold prices: Au100g closing price. <http://www.sge.sh/publish/sgeen/statistics/index.htm>
FP=Future gold price: the closing price of future contracts with December as delivery month (from the first trading day to the 15th of December) <http://www.shfe.com.cn/en/MarketData/dataview.html?paramid=kx>
Delete those spot or futures gold prices when there is no corresponding figures in the series.
WGCP= World Gold Council daily gold price being adjusted from price per troy ounce to price per gram using the conversion rate of 1 troy ounce = 31.1034768 grams
<http://www.gold.org/research/gold-price-range-currencies-december-1978-xls-version>

In order to justify that there is no difference among the spot gold price (SP), future gold price (FP), and gold price (WGCP), important summary statistics for the daily values of these time series were summarized in Table 2. Judging from the fact that their means, standard deviation, skewness, and kurtosis, we can say the central tendency, spread, direction and amount of asymmetry, and the degree of peakedness of these three distributions are statistically indistinguishable. Thus, the

[4] Since the last trading day of a gold future contract is the 15th day of the spot month (SFE, 2013), the listed closing future gold prices is from the first trading day to the 15th of December (if it is a public holiday, the Last Trading Day shall be the first business day after the holiday).

[5] World Gold Council daily gold price is denominated in RMB and have been adjusted from price per troy ounce to price per gram using the conversion rate of 1 troy ounce = 31.1034768 grams.

monthly average WGCP can be used as a proxy for the monthly average FP to facilitate a long run analysis because of the non-availability of this series for a long time span. Nevertheless, even though it is easy to prove that the SP and FP series came from the same population, it is worthwhile to take a look at the difference between the observed daily SP and FP. The results are plotted in Figure 2.

Figure 2 Daily spot and futures gold prices: 4 Jan 2011 to 31 July 2014

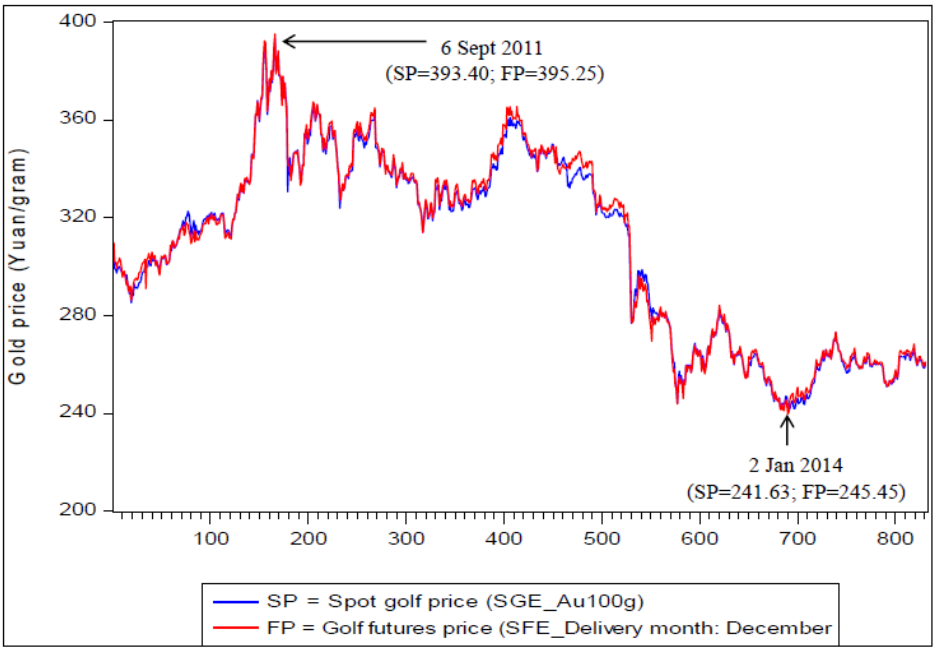
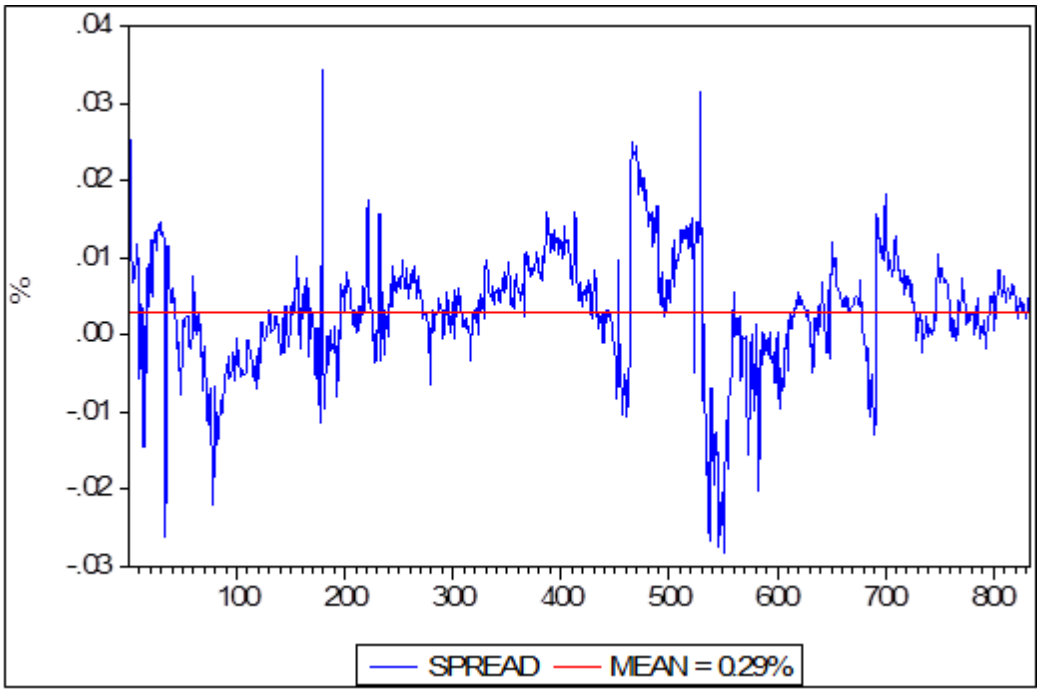


Figure 3 Daily spot and futures gold price spreads of futures gold price on SFE and the spot god price on SGE as percentage to the spot price: 4 Jan 2011 to 31 July 2014



However, the two curves SP and FP in Figure 2 are very close to each other, it is very difficult to identify the spreads between these two series. To solve this problem, we can first calculate their differences expressed in terms of per cent, and then depict the price evolution for the spreads of futures gold price on SFE and the spot gold price on SGE. It is interesting to note that the mean of spreads was 0.29%, which means on average the futures gold price was 0.29% higher that the spot gold price; and thus, it is unwise to borrow money to buy gold futures contracts.

3 Volatility in the Time Domain

This section is designed to capture the pattern of future gold price volatility over the observed time span. We look at the long run, and then the short run price movement behaviors based on the a series of moving standard deviation (SD) calculate from monthly average spot gold price (WGCP) as a proxy for the monthly average FP. The calculating formula for a series of moving standard deviation (Brennan, 1982; Koray & Lastrapes, 1989) is expressed as:

$$MA_t = \left[\frac{1}{m} \times \sum_{i=1}^{m} \left(P_{t-i+1} - \overline{P}_{(t-m) \text{ to } t} \right)^2 \right]^{\frac{1}{2}}$$

Where: m is the order of the moving SD.

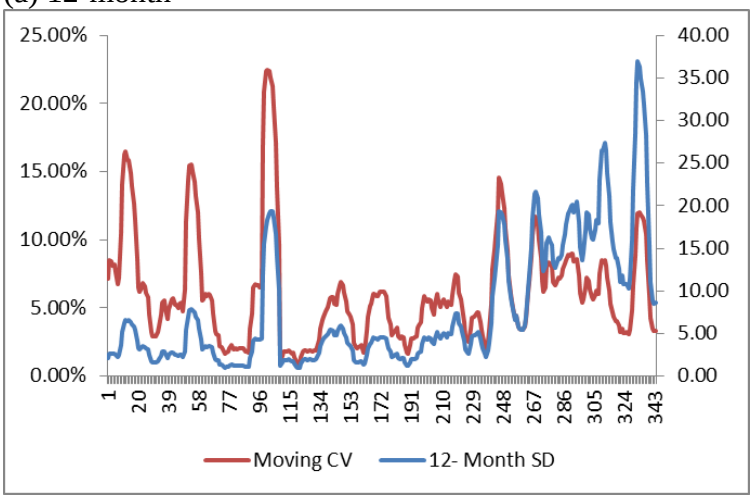
3.1 Long run

Taking into consideration of the trend effect on the gold price over a long time span, in addition to the 12-month, 6-month and 3-month moving SD for the monthly average WGCP, we calculated the moving coefficient of variation (CV)[6] by the same order of the moving average. This is done merely for the sake of comparison. Figure 4 shows the time movement of SD and CV in the period from January 1985 to July 2014. We discover that, in panels (a) to (c), the amplitude of SDs were lower than those of their corresponding CVs in the earlier part of the time span, but the in the later part, the situation is the situation is reversed. This observation revealing the periodic mean gold price for the 344 data points from 1985 to 2014 were rising over time.

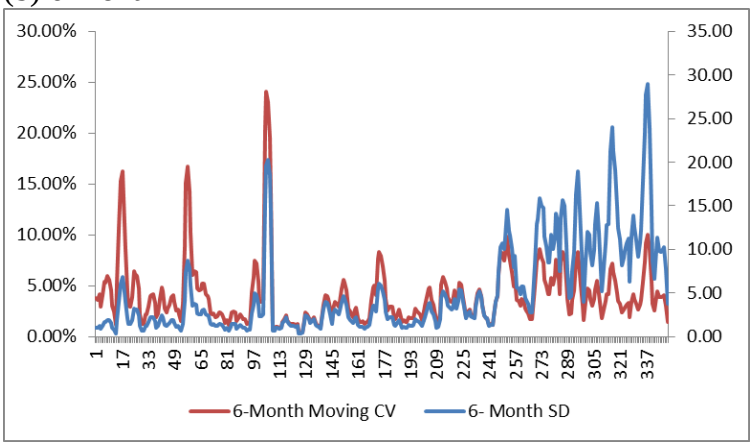
[6] The CV is obtained by expressing the standard deviation as a percentage of the estimate mean to which it refers, that is CV=(SD/Mean)×100%.

Figure 4 Time plot of moving SD and CV : January 1985 to July 2014

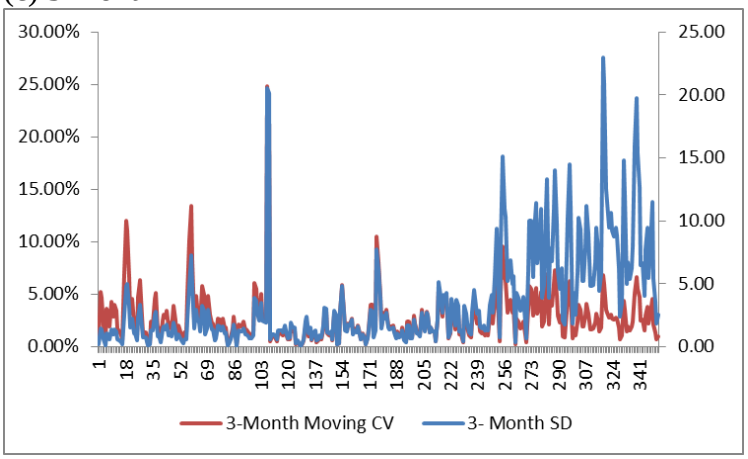
(a) 12-month



(b) 6-month



(c) 3-month

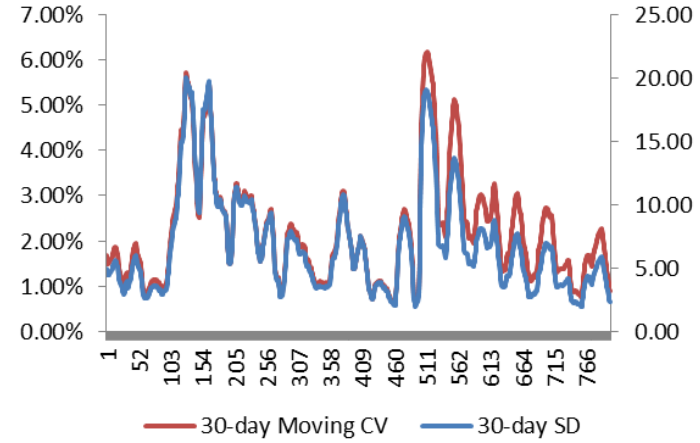


3.2 Short run

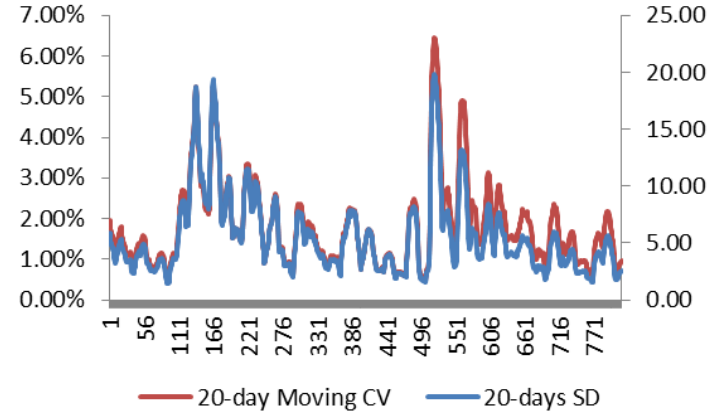
Over a short time span as presented in Figure 3, it shows the time movement of SD and CV in the period from 4 January 2011 to 31 July 2014 for the daily gold future price (FP). We discover that, in panels (a) to (c), the amplitude of SDs were higher than those of their corresponding CVs in the earlier part of the time span, but the in the later part, the situation is the situation is reversed. This observation revealing the periodic mean gold price for the 804 data points from 4 January 2011 to 31 July 2014 were declining over time.

Figure 5 Time plot of moving SD and CV: 4 January 2011 to 31 July 2014

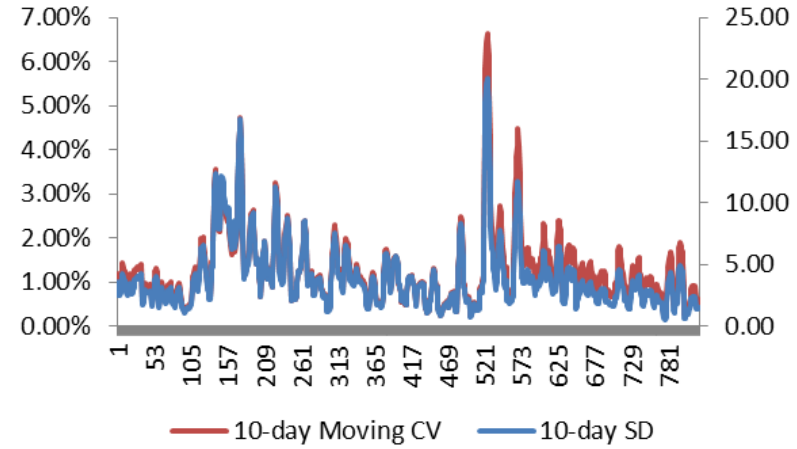
(a) 30-day



(b) 20-day



(c) 10-day



4 Volatility in the Frequency Domain

To examine the gold future price volatility in the frequency domain, we use the method of non-parametric Value-at-Risk[7] (Jorion, 2007) but look at the moving SD instead of the returns of investment in the gold futures market. Based on the moving SD series derived in the previous section, we created a probability distribution of the moving SD in groups for different orders of the moving average from which we can capture the pattern of volatility in the time movement of gold futures prices.

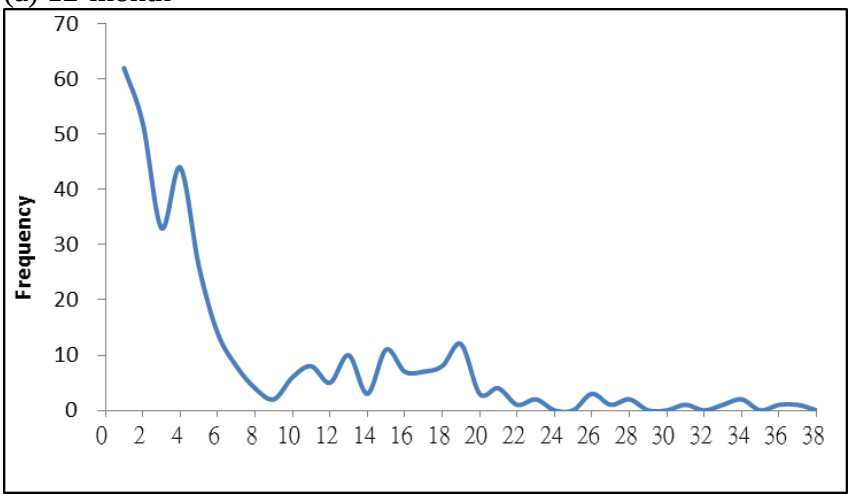
4.1 Long run

As we can see from panels (a) to (c) in Figure 6, the frequency distributions of moving SD from January 1985 to July 2014 were significantly skewed to the right side and thus have long right tails, and that the lower the order of the moving SD, the more smoothly of the frequency curve. Table 3 lists the frequency and probability distributions of these three time series which have a goodness of fit to the Chi Square distribution with df=1 indicating there was about 27%, 15%, 6% chance to have a moving SD of more than 10 yuan for the 12-month, 6-month, and 3 month order of moving SD, respectively.

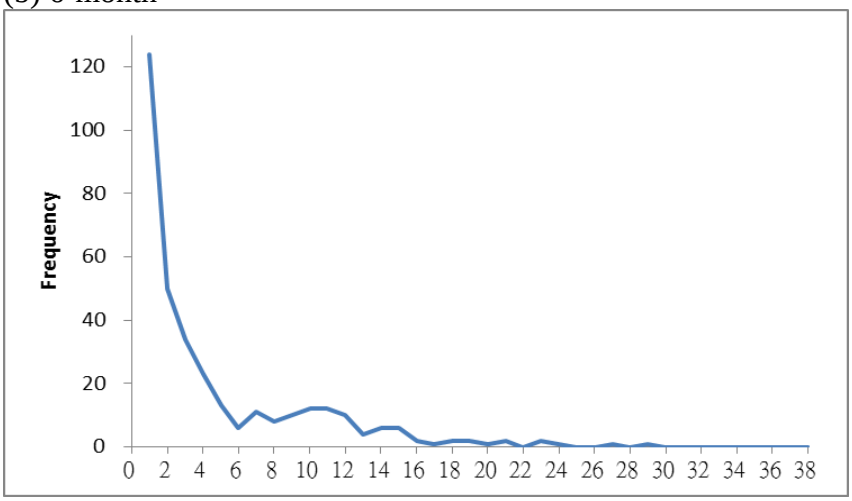
[7] VaR measures the maximum loss in the market value of a portfolio with a given confidence level.

Figure 6 Frequency distributions of moving SD: January 1985 to July 2014

(a) 12-month



(b) 6-month



(c) 3-month

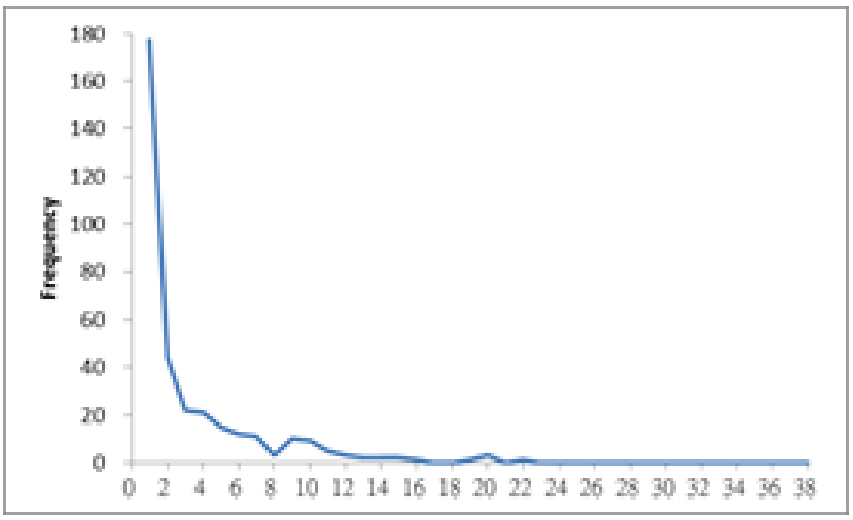


Table 3 Frequency distribution of 12-month, 6 month, and 3-month moving SD

	12-month moving SD		6-month moving SD		3-month moving SD	
Class X_i	f	$Pr(X>X_i)$	f	Pr(X>Xi)	f	Pr(X>Xi)
1	62	81.98%	124	63.95%	177	48.55%
2	52	66.86%	50	49.42%	44	35.76%
3	33	57.27%	34	39.53%	22	29.36%
4	44	44.48%	23	32.85%	21	23.26%
5	26	36.92%	13	29.07%	15	18.90%
6	14	32.85%	6	27.33%	12	15.41%
7	8	30.52%	11	24.13%	11	12.21%
8	4	29.36%	8	21.80%	3	11.34%
9	2	28.78%	10	18.90%	10	8.43%
10	6	27.03%	12	15.41%	9	5.81%
11	8	24.71%	12	11.92%	5	4.36%
12	5	23.26%	10	9.01%	3	3.49%
13	10	20.35%	4	7.85%	2	2.91%
14	3	19.48%	6	6.10%	2	2.33%
15	11	16.28%	6	4.36%	2	1.74%
16	7	14.24%	2	3.78%	1	1.45%
17	7	12.21%	1	3.49%	0	1.45%
18	8	9.88%	2	2.91%	0	1.45%
19	12	6.40%	2	2.33%	1	1.16%
20	3	5.52%	1	2.03%	3	0.29%
21	4	4.36%	2	1.45%	0	0.29%
22	1	4.07%	0	1.45%	1	0.00%
23	2	3.49%	2	0.87%	0	0.00%
24	0	3.49%	1	0.58%	0	0.00%
25	0	3.49%	0	0.58%	0	0.00%
26	3	2.62%	0	0.58%	0	0.00%
27	1	2.33%	1	0.29%	0	0.00%
28	2	1.74%	0	0.29%	0	0.00%
29	0	1.74%	1	0.00%	0	0.00%

30	0	1.74%	0	0.00%	0	0.00%
31	1	1.45%	0	0.00%	0	0.00%
32	0	1.45%	0	0.00%	0	0.00%
33	1	1.16%	0	0.00%	0	0.00%
34	2	0.58%	0	0.00%	0	0.00%
35	0	0.58%	0	0.00%	0	0.00%
36	1	0.29%	0	0.00%	0	0.00%
37	1	0.00%	0	0.00%	0	0.00%
38	0	0.00%	0	0.00%	0	0.00%
Total	344	n.a.	344	n.a.	344	n.a.

4.2 Short run

As we can see from panels (a) to (c) in Figure 7, the frequency distributions of moving SD from 4 January 2011 to 31 July 2014 were significantly skewed to the right side and thus have long right tails, and that all the three distributions were similar. They have a goodness of fit to the Chi Square distribution with df=4 indicating there was about 18%, 11%, 4% chance to have a moving SD of more than 10 yuan for the 30-day, 20-day, and 10-day order of moving SD, respectively.

Figure 7 Frequency distributions of moving SD: 4 January 2011 to 31July 2014

(a) 30-day (b) 20-day (c) 10-day

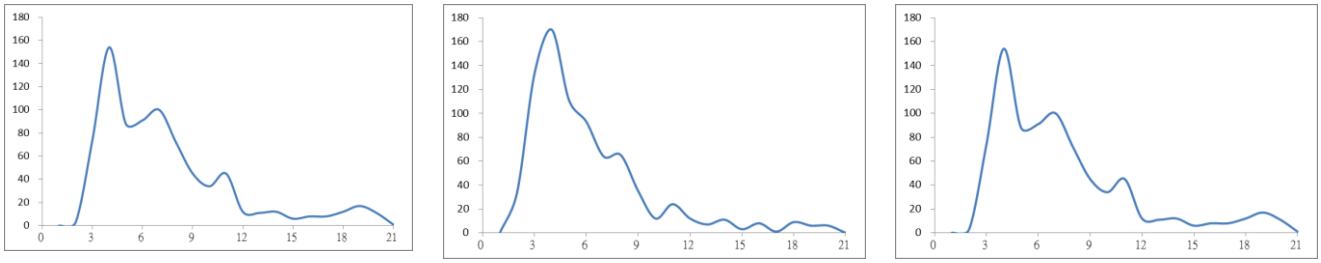


Table 4 Frequency distribution of 30-day, 20-day, and 10-day moving SD

	30-day moving SD		20-day moving SD		10-day moving SD	
Class X_i	f	$Pr(X>X_i)$	f	Pr(X>Xi)	f	Pr(X>Xi)
1	0	100.00%	0	100.00%	15	98.13%
2	3	99.63%	34	95.77%	151	79.35%
3	74	90.42%	133	79.23%	182	56.72%
4	154	71.27%	170	58.08%	181	34.20%
5	88	60.32%	111	44.28%	110	20.52%
6	91	49.00%	93	32.71%	41	15.42%
7	100	36.57%	64	24.75%	37	10.82%

8	72	27.61%	65	16.67%	25	7.71%
9	45	22.01%	35	12.31%	17	5.60%
10	34	17.79%	12	10.82%	11	4.23%
11	45	12.19%	24	7.84%	10	2.99%
12	12	10.70%	12	6.34%	6	2.24%
13	11	9.33%	7	5.47%	5	1.62%
14	12	7.84%	11	4.10%	2	1.37%
15	6	7.09%	3	3.73%	2	1.12%
16	8	6.09%	8	2.74%	3	0.75%
17	8	5.10%	1	2.61%	1	0.62%
18	12	3.61%	9	1.49%	1	0.50%
19	17	1.49%	6	0.75%	1	0.37%
20	11	0.12%	6	0.00%	2	0.12%
21	1	0.00%	0	0.00%	1	0.00%
Total	804	n.a.	804	n.a.	804	n.a.

5 Conclusion

Our main findings are as follows. First, the small mean spread of SFE futures gold price and the SGE spot gold price (0.29%) did not provide a strong incentive for financial investors to do "interest rate-gold price spread" arbitrage activity. Second, the spot and futures gold price volatility in the long run was larger in the short run implying that financial investors in the gold futures market tend to keep their contracts (no matter in the put or call position) in a short period rather than hold to maturity. The last and the most importance finding is that the empirical distribution of gold price volatility by using a moving standard deviation of gold prices follows a Chi Square distribution, with df=1 for a long time span from January 1985 to July 2014, but changed to a little bit flattened distribution with df=4 for a long time span. Based on these findings, although gold prices will most probably remain at attractive and affordable levels during the next few years, the outlook for gold investment environment may be somewhat less favorable particularly because of the difficulty to manage market risk in both the spot and futures markets.

References

Barone-Adesi, G., Geman, H., & Theal, J. (2010). On the lease rate, convenience yield and speculative effects in the gold futures market. *Swiss Finance Institute Research Paper*(09-07).

Batten, J. A., & Lucey, B. (2007). Volatility in the Gold Futures Market. *HKUST Business School Research Paper*, (No. 07-25). Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=996235

Black, J., & Tonks, I. (2000). Time series volatility of commodity futures prices. *Journal of Futures Markets, 20*(2), 127-144.

Brennan, J. P. (1982). The representation of risk in econometric models of supply: Some observations. *Australian Journal of Agricultural and Resource Economics, 26*(2), 151-156.

Cai, J., Cheung, Y. L., & Wong, M. (2001). What moves the gold market? *Journal of Futures Markets, 21*(3), 257-278.

Chan, K. C., Fung, H.-G., & Leung, W. K. (2004). Daily volatility behavior in Chinese futures markets. *Journal of International Financial Markets, Institutions and Money, 14*(5), 491-505.

Domanski, D., & Heath, A. (2007). Financial investors and commodity markets. *BIS Quarterly Review, 3*(1), 53-67.

Jorion, P. (2007). *Value at risk: the new benchmark for managing financial risk* (Vol. 2): McGraw-Hill New York.

Koray, F., & Lastrapes, W. D. (1989). Real exchange rate volatility and US bilateral trade: a VAR approach. *The Review of Economics and Statistics*, 708-712.

Liu, C. (2009). *Price forecast for gold futures based on GA-BP neural network.* Paper presented at the Management and Service Science, 2009. MASS'09. International Conference on.

Narayan, P. K., Narayan, S., & Zheng, X. (2010). Gold and oil futures markets: Are markets efficient? *Applied energy, 87*(10), 3299-3303.

Poitras, G. (1990). The distribution of gold futures spreads. *Journal of Futures Markets, 10*(6), 643-659.

Qi, M., & Wang, W. (2013). The Monthly Effects in Chinese Gold Market. *International Journal of Economics and Finance, 5*(10), p141.

SFE. (2013). Operational Manual for Gold Futures Contract Trading. Retrieved from http://www.shfe.com.cn/en/products/Gold/manual/507.html

WGC. (2010). Gold: hedging against tail risk Retrieved 15 August 2014, from Word Gold Council http://www.gold.org/download/file/2984/WOR5963_Gold_Hedging_against_tail_risk.pdf

WGC. (2014). China's gold market: progress and prospects Retrieved 15 August 2014, from World Gold Council http://www.gold.org/supply-and-demand/china-report

Xin, Y. (2003). *Price behaviour in China's commodity futures markets.* The Hong Kong Polytechnic University.

Yu, X. (2003). *Price behavior in China's commodity futures markets.* PhD Thesis, The Hong Kong Polytechnic University, Hong Kong.

Zhang, D. (2012). Price discovery in gold markets: China and the US.

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