Models of Gold Options Market and Evidence in Favor of Financialized Gold and Against Disasterization

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Questions

Dual role of gold as a financialized commodity and/or safe-haven commodity

The role of gold:

- Is it an investment commodity? ***Gold is Financialized***
- Is it a safe-haven commodity? ***Disasterization of gold***

Is there a model that can account for the role of gold as investment commodity and/or safe-haven commodity?

Unique Data Set

Data set composed of

- futures of all maturities
- monthly and weekly options
  - weekly options can help account for short term risk (jumps)
- silver and copper monthly futures options and futures

Extant literature yet to utilize gold weekly options

Gold Options Can Help Answer the Role of Gold as Financialized Commodity

Is gold an investment commodity? ***Financialized***

- Gold futures average return is positive over past 30 years (3% annualized)
- Gold futures' curve is 98% in contango
- World Gold Council: allocating a small portion of a portfolio to gold reduces risk without hindering the upside

Hypothesis on Financialized Gold:

The average excess returns of gold OTM put options are negative, and become more negative at lower OTM strikes.

Gold Options Can Help Answer the Role of Gold as Safe-Haven Commodity

Is gold a safe-haven commodity? ***Disasterization***

- Gold tends to rise during poor economic conditions, monetary misconduct, and disasters (e.g. Bernstein 2012)
- Gold has low correlation with equities (e.g. Erb and Harvey 2013)

Hypothesis on Disasterization of Gold:

The average excess returns of OTM gold call options is negative, and becomes more negative at higher OTM strikes.

OTM Gold Put Options Favor Financialized Gold

$$r^{\text{put}}_{\{t \to t+\hbar\}}[k] = \frac{\max(K - F(t+\hbar, T), 0)}{\text{put}[t; K]} - R^{\text{rf}}_{\{t \to t+\hbar\}}, \quad \text{for } \hbar = \frac{30}{365} \text{ or } \hbar = \frac{1}{52}$$

Panel A: Monthly put options, January 12, 1990, to October 27, 2020 (369 cycles)

	AVG. (%)	Stationary Bootstrap 90% CI ⌊Lower	Upper⌋	NW[p]	Bootstrap CI	Bootstrap CI	Bootstrap CI
Monthly: 5% OTM put (delta is -10)	**-65***	⌊-81	-45⌋	(0.000)			
Monthly: 3% OTM put (delta is -20)	**-40***	⌊-57	-22⌋	(0.000)			
Monthly: 1% OTM put (delta is -38)	**-19***	⌊-32	-4⌋	(0.016)			
Monthly: 5% OTM *minus* 1% OTM					⌊-58, -34⌋*		
Monthly: 5% OTM *minus* 3% OTM						⌊-30, -18⌋*	
Monthly: 3% OTM *minus* 1% OTM							⌊-32, -11⌋*

Panel B: Weekly put options, January 22, 2016, to October 23, 2020 (248 cycles)

	AVG. (%)	Lower	Upper	NW[p]	Bootstrap CI	Bootstrap CI	Bootstrap CI
Weekly: 3% OTM put (delta is -7)	**-50***	⌊-83	-15⌋	(0.011)			
Weekly: 2% OTM put (delta is -16)	**-15**	⌊-39	11⌋	(0.443)			
Weekly: 1% OTM put (delta is -31)	**-11**	⌊-29	8⌋	(0.416)			
Weekly: 3% OTM *minus* 1% OTM					⌊-72, -6⌋*		
Weekly: 3% OTM *minus* 2% OTM						⌊-59, -11⌋*	
Weekly: 2% OTM *minus* 1% OTM							⌊-21, 11⌋

OTM Gold Call Options Do Not Support Disasterization Hypothesis

$$r^{\text{call}}_{\{t\to t+\hbar\}}[k] \;=\; \frac{\max(F(t+\hbar,T)-K,0)}{\text{call}[t;K]} - R^{\text{rf}}_{\{t\to t+\hbar\}} \qquad \text{for} \qquad \hbar = \frac{30}{365} \;\; \text{or} \;\; \hbar = \frac{1}{52},$$

	AVG. (%)	Stationary Bootstrap 90% CI ⌊Lower	Upper⌋	NW[p]	Bootstrap CI	Bootstrap CI	Bootstrap CI
Panel A: Monthly call options, January 12, 1990, to October 27, 2020 (369 cycles)							
Monthly: 1% OTM call (delta is 38)	**4**	⌊-16	24⌋	(0.702)			
Monthly: 3% OTM call (delta is 22)	**10**	⌊-20	41⌋	(0.643)			
Monthly: 5% OTM call (delta is 10)	**12**	⌊-34	65⌋	(0.750)			
Monthly: 5% OTM *minus* 1% OTM					⌊-29, 50⌋		
Monthly: 5% OTM *minus* 3% OTM						⌊-21, 29⌋	
Monthly: 3% OTM *minus* 1% OTM							⌊-9, 21⌋
Panel B: Weekly call options, January 22, 2016, to October 23, 2020 (248 cycles)							
Weekly: 1% OTM call (delta is 32)	**24**	⌊-4	54⌋	(0.223)			
Weekly: 2% OTM call (delta is 17)	**7**	⌊-36	53⌋	(0.798)			
Weekly: 3% OTM call (delta is 7)	**-45**	⌊-89	5⌋	(0.036)			
Weekly: 3% OTM *minus* 1% OTM					⌊-109, -30⌋*		
Weekly: 3% OTM *minus* 2% OTM						⌊-93, -16⌋*	
Weekly: 2% OTM *minus* 1% OTM							⌊-40, 5⌋

Summary

Our analysis indicates that:

1. negative gold OTM put option risk premiums favor financialized gold
2. positive gold OTM call option risk premiums do not support the disasterization hypothesis

Next:

1. modelling gold with spanned, unspanned, idiosyncratic, and jump risks
2. focus on accounting for the dual role of gold as investment commodity and/or safe-haven commodity

Structure of Our Model

- Heath, Jarrow, and Morton (1992) (HJM) framework to model the gold futures & option prices:
  - model the evolution of instantaneous forward cost of carry of different deliveries to accounts for the entire futures curve of gold rather than the spot gold (gold is 98% in contango)
- Modelling of pricing kernel to derive risk premiums
- Kalman Filtering to estimate the parameters

Analytical or Semi-Analytical Solutions

- Gold VIX
- Integrated Variance
- Option Prices
- Option Risk Premiums

Goals of Our Model

1. Good fit to the the observations

   (judged by low Root-Mean-Square of $100 \times \log \frac{\text{model value}}{\text{actual data}}$)

2. Reproduce the observed risk premiums

3. Identify the importance of each risk components in gold market:

   3.1 a model with spanned and unspanned risks (**GSV**)

   3.2 a model with spanned, unspanned, and idiosyncratic risks (**GSVI**)

   3.3 a model with spanned, unspanned, and jump risks (**GSVJ**)

Models Fitting Errors across Three Models

GSVI performs the best

	Estimated Parameters (#)	Panel A: Root-Mean-Squared Error (%) Futures prices	Option prices	Volatilities	Panel B: Average Error (%) Futures prices	Option prices	Volatilities
GSV	13	0.165	29.39	19.63	0.04	5.68	10.25
GSVI	18	0.162	28.89	18.28	0.03	-1.26	7.27
GSVJ	18	0.163	29.44	19.36	0.04	5.50	9.99
Diebold-Mariano:							
$RMSE_t^{GSVI} - RMSE_t^{GSV}$			-0.50	-1.35			
(NW[p])			(0.066)	(0.000)			
$RMSE_t^{GSVJ} - RMSE_t^{GSVI}$			0.55	1.08			
(NW[p])			(0.054)	(0.000)			
$RMSE_t^{GSVJ} - RMSE_t^{GSV}$			0.05	-0.27			
(NW[p])			(0.540)	(0.000)			

GSVI Performs the Best in Fitting to Gold VIX

		AVG.	SD	Stationary Bootstrap Lower	Stationary Bootstrap Upper	Percentile 5th	25th	50th	75th	95th
	Actual $\mathrm{VIX}^{\text{gold}}(t)$ (%)	16.3	6.8	⌊14.2	18.5⌋	7.9	11.6	15.5	19.3	27.5
GSV	Model $\mathrm{VIX}^{\text{gold}}(t)$ (%)	17.0	5.6	⌊15.4	18.7⌋	11.4	13.3	15.5	18.7	28.1
GSVI	Model $\mathrm{VIX}^{\text{gold}}(t)$ (%)	16.4	5.6	⌊14.8	18.1⌋	10.8	12.6	15.0	18.3	27.3
GSVJ	Model $\mathrm{VIX}^{\text{gold}}(t)$ (%)	17.0	5.7	⌊15.4	18.7⌋	11.3	13.2	15.4	18.6	28.0
GSV	Model *minus* Actual	0.6	3.4	⌊0.0	1.3⌋	-4.5	-1.2	0.8	2.3	5.0
GSVI	Model *minus* Actual	0.1	3.2	⌊-0.5	0.7⌋	-4.6	-1.6	0.3	1.7	4.4
GSVJ	Model *minus* Actual	0.6	3.5	⌊0.0	1.3⌋	-4.8	-1.2	0.9	2.4	5.1

Gold is a Financialized Commodity

	Option Risk Premiums (Average, monthly)						$\mathbb{rp}^{\text{futures}}_{\{t\rightarrow t+\hbar\}}$ (annualized, %)	$\mathbb{rp}^{\text{volatility}}_{\{t\rightarrow t+\hbar\}}$ (%)
	OTM puts			OTM calls				
	5%	3%	1%	1%	3%	5%		
Actual data	**-65**	**-40**	**-19**	**4**	**10**	**12**	**3.00**	**-15.7**
90% BI	⌊-78, -49⌋	⌊-54, -25⌋	⌊-31, -6⌋	⌊-14, 25⌋	⌊-22, 47⌋	⌊-43, 78⌋	⌊-1.6, 7.5⌋	⌊-20.5, -11.2⌋
GSV	-35	-27	-19	-5	-9	-15	3.21	-8.8
GSVI	-34	-26	-18	-5	-9	-14	2.60	-8.7
GSVJ	-35	-26	-19	-5	-9	-15	3.18	-8.8

Estimated Models Imply the Dominance of Unspanned Risks

- most of nonidiosyncratic risk is unspanned risk

- jumps size (in risk-neutral measure) is average -1.2% with intensity of 9.3 times a year

  but adding jumps has a small effect on model performance

Conclusion

1. Empirically, the OTM risk premiums of gold options
   - support that the gold is a financialized commodity
   - do not support that the gold is a safe-haven commodity
2. Theoretically, we propose models of gold that
   - model the evolution of instantaneous cost carry of gold
   - include spanned, unspanned, idiosyncratic, and jump risks
3. Estimations of models indicate that
   - models can reproduce observations and risk-premiums
   - idiosyncratic risk is important in gold markets
   - nonidiosyncratic risk is predominantly unspanned risk
   - adding jumps has a small effect on model performance