GOLD RUSH FOR EXPECTATIONS: THE EFFECTS OF FOMC ANNOUNCEMENTS ON GOLD PRICES

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Abstract

I compare the effect of treasury constant maturity rates on gold prices on FOMC and non-FOMC meeting dates to explore potential channels of monetary policy influence on gold prices. The relationships between different treasury rates and gold prices suggest that the price of gold is most heavily influenced by expected inflation. If investors actively use monetary policy to guide their gold investments, the effects of the treasury rates should be amplified right after FOMC meeting dates. Indeed, on FOMC meeting dates, the different treasury rates have an amplified effect of 7% to 9%. In addition, on days right after FOMC meetings, there appears to be a positive relationship between treasury rates and the price of gold. This suggests that investors may initially overreact to FOMC announcements, but the market is able to readjust and mitigate the skewed effects.

Keywords: Gold, FOMC, Treasury constant maturity rate, monetary policy, expected inflation.

Gold as an investment has been critically examined by many researchers. Naively speaking, gold should be an efficiently priced asset: it is a homogeneous commodity that is traded in most major, global markets. Information should be incorporated into the gold price continuously, and unlike shares or bonds, gold is not valued based on performance. However, the price of gold is an elusive subject. Though gold investors, commentators, and researchers have developed speculations about how the price of gold correlates to various macroeconomic factors, these relationships often change depending on different time periods and market conditions.

There are many theories, which will be discussed in later sections, that try undercover driving forces behind gold prices. One of the more popular speculations is the role of real interest rates on the price of gold. Historical trends show a strong negative correlation between the 10-year treasury constant maturity rate and the price of gold. Investors and commodity researchers posit an intuitive reason for this relationship: opportunity cost. When real yields rise, the price of gold should decrease since there is a higher opportunity cost of holding gold. Conversely, when real yields fall, investors should be more willing to put their money in gold, pushing the price of gold up (Johnson, 2014). However, this explanation is not completely satisfactory. Lower yield rates itself does not seem like a comprehensive reason and driver on the price of gold. Moreover, gold is a fundamentally different asset from treasury bills; gold does not pay dividends, and has no true value.

This paper will build on previous research that examined the relationship between real yields and the price of gold. More specifically, this paper aims to uncover the response of investors to changing interest rates and the potential impact monetary policies have on gold investors. It will examine the relationship between changes in gold prices to changes in the real and nominal 10-year, 5-year, and 2-year treasury constant maturity rates. The effect of monetary policy is

investigated through Federal Open Markets Committee (FOMC) meeting announcements by comparing the relationship between maturity rates and gold prices on FOMC and non-FOMC meeting dates. Other factors such as changing market volatility captured with the VIX index, the strength of the US dollar captured by the USD/Euro exchange rate, and the predicted inflation captured by the 10-year breakeven inflation rate are also studied.

While the 5-year and 2-year treasury maturity rates better reflect the effective federal funds rate, the 10-year treasury maturity rate better captures how the market perceives future macroeconomic conditions. The FOMC administers the fed funds rate to fulfill its dual mandate of promoting economic growth while maintaining price stability (Chappelow, 2019). FOMC announcements also provide investors with indicators of future inflationary pressures. While the rates set by the FOMC reflect and respond to the current climate of the market, it incorporates much less of the market reaction to market conditions and information. The 10-year treasury rates will better capture comprehensive investor speculations compared to the 5-year and 2-year rates.

It is thus predicted that there will be a more significant relationship between the 10-year treasury maturity rate constant compared to the 5-year and 2-year rates to reflect the higher incorporation of market information and inflationary expectations. Assuming there is a strong relationship between the change in rates and the price of gold, the effects should be magnified on FOMC meeting dates to reflect the incorporation of new information of inflationary predictions and general market sentiment. An amplified effect on FOMC meeting dates will also suggest that investors actively use monetary policy decisions to inform their investments on gold. It is also predicted that if the price of gold is more respondent to general market climate rather than to real interest rate levels itself, then FOMC meeting dates should not strongly affect the magnitude of correlation between the 5-year and 2-year rates with the price of gold.

Section I provides an overview of the current literature on gold prices. Section II describes the data sources used and the methods of analysis. Section III presents the main results of the effects of different treasury rates and how FOMC meetings dates impact their relationship with gold prices. Section IV discusses the results obtained, and Section V concludes.

I. Background and Literature Review

Gold is unique from other commodities in that its usefulness as an industrial metal is small compared with its investment uses (O'Connor, 2015). The price of gold was fixed up till 1971, and prior to this date, research primarily focused on gold's role as a monetary asset and how its price should be set for macroeconomic policy (Erb and Harvey, 2013).

Since then, four primary theories on drivers of gold pricing have emerged. Investors and speculators often examine gold's relationship (1) with inflation, (2) with currencies, (3) as a safe haven, and (4) with interest rates (Erb and Harvey, 2013). The value of gold and the attractiveness of gold as an investment is heavily debated and there are very divergent opinions. This section will provide an overview of popular contending theories behind owning gold.

Inflation and Gold

Research has shown that gold can be an effective inflation hedge. This relationship occurs because gold acts like money. However, since gold is limited in stock and has a relative inelastic stock in the short run (production through mining is time intensive), it is not possible to increase the supply of gold easily like a fiat currency. Thus, gold's characteristics as a hard currency allows it to maintain its value even when other currencies decrease in purchasing power during times of rising inflation rates (Feldstein, 1980).

Within the United States, there is a historical trend where higher levels of the Consumer Price Index (CPI) have correlated with higher gold prices. Batten et al. (2014) find that though

there is significant time variation of the relationship between gold prices and the CPI, this positive relationship strengthens after 2002. Christie-David et al. (2000) used intraday data to examine the effects of macroeconomic news on the price of gold and found that the United States' CPI releases had a strong effect on gold returns.

Researchers have also assessed the effectiveness of gold as an inflation hedge by examining the fluctuations of real gold prices. Bekaert and Wang (2010) suggest that if gold were a perfect hedge against short-term inflation, the real price of gold would be constant and not have significant variability. However, they found that the real price of gold is volatile (almost as volatile as its nominal price), suggesting that gold is a poor short-term inflation hedge. Erb and Harvey (2013) looked at monthly observations and found that real gold returns has significant variation, and the variation in inflation rates were much lower. On the contrary, most studies focusing on 10-year inflation rates and 10-year gold returns have found that gold serves as a good hedge against long-run inflation during longer time periods (O'Connor, 2015).

Currency and Gold

Many investors posit that the USD is one of the primary drivers of gold price (Erb and Harvey, 2013). Since gold is traded primarily in dollars, a weaker dollar makes gold cheaper in other countries, increases their demand, and ultimately drives up the price of gold. Tulley and Lucey (2007) show that the trade-weighted value of the USD is the most significant factor in explaining gold prices with a power GARCH model. However, other researcher such as Pukthuanthong (2011) and O'Connor (2012) show that the relationship may simply be statistical and not casual.

Gold speculators suggest that gold can potentially serve as a foreign exchange currency hedge, or as a hedge against one's own currency. As a foreign exchange hedge, the return on gold

should offset the expected decline of one's own currency. Reboredo (2013) showed that gold acts as a somewhat effective dollar hedge with 8 currency pairs. However, there is a theoretical problem with this hypothesis. If the price of gold in a given country is driven by the country's inflation rate, and if the exchange rate between countries is driven by the difference in their inflation rates, one of the countries must have an inflation rate of zero in order for gold be an effective hedge (O'Connor, 2015).

Gold may also serve as hedge against one's own currency. When currency debasement occurs, holding gold allows investors to maintain a constant store of value. If the debasement occurs as a result of inflation, gold essentially serves as an inflation hedge. Since gold has a negative relationship with the USD, when the dollar loses value, investors may exchange their dollars for gold, raising the price of gold on average (O'Connor, 2015).

Capie, Mills, and Wood (2005) examined gold as a currency risk hedge against Yen/USD and Sterling/USD exchange rates, and showed that its ability to act as a hedge varies with time and is based on unpredictable political and economic events. Erb and Harvey (2012) looked at 23 developed and emerging countries, and found that the real price of gold rises and falls at the same time across the countries. This evidence of global co-movements is inconsistent with the idea that gold can act as a currency hedge. If the real price of gold moves together across currencies, it is unlikely that currency movements can explain why the real price of gold fluctuates.

Safe Haven

Investing in gold as protection during times of stress is closely tied with gold's speculated behaviour as an inflation and currency hedge. Baur and Lucey (2010) define a safe haven in terms of its "ability to protect wealth from financial crashes." If gold were to serve as an effective safe haven, it should remain relatively stable and accessible during times of stress. Times of stress may

include periods of losses in financial markets or when other asset markets falter (Baur and Lucey, 2010). It is speculated that though gold may not provide short-term inflation hedge, it may provide protection during hyperinflationary periods. Likewise, though gold may not be an effective hedge for currencies generally, it may be effective during times of significant currency debasement (which may occur during hyperinflationary times). Moreover, in relation to interest rates, the negative relationship may be driven by the fear of potential negative future macroeconomic events (O'Connor, 2015).

Sanderson (2015), and others have found that gold is very attractive to investors during extreme periods of stress. Papers such as Bernholz (2006), McGuire (2010), and Hanke and Krus (2012) show that historically real gold prices rose during each instance of hyperinflation. Baur and Lucey (2010) studied the relationship between US, UK, and German stocks, bonds, and gold returns, and found that gold is a hedge and safe haven for stocks but not bonds. Bohen and Qadan (2010) studied gold and market constructed measures of risk and found that during times of financial crisis, gold leads the VIX, making it a better safe haven asset. However, Lucey and Li (2014) found that there are significant periods where gold did not act as a safe haven or hedge for US stocks and bonds. Moreover, with the introduction of more speculative investment vehicles for gold, gold's ability to act as a safe haven is further put into question (Erb and Harvey, 2012).

Interest Rates and Gold

As previously mentioned, another theory behind the ownership of gold is the competing assets argument, where speculators posit that the price of gold is a result of real interest rates (Elfenbein, 2010). Commentators and researchers such as DeLong (2011), Krugman (2011), and Elfenbein (2012) have investigated links between the price of gold and interest rates from the perspective of Gibson's paradox. Looking at the historical relationship between the real price of

gold in USD and the real yield of a 10-year Treasury Inflation-Protected Security, there is strong negative correlation. Gold speculators view interests rates as the opportunity cost of holding gold. As DeLong (2011) states, "gold is expensive to hold in a portfolio when real interest rates are high, and cheap to hold when interest rates are low." Gold prices appear heavily influenced by the level of 10-year US real yields (Johnson, 2014).

Baur (2011) showed that while there is a positive relationship between gold price and short-term interest rates, there is a negative relationship between long-term interest rates and gold prices. These results show that the opportunity cost of holding gold in the short run is insignificant and dominated by other effects such as inflation expectation. Other researchers also note the unpredictability of gold fluctuations recognizing that the real gold returns are often low after high real gold prices and the relationship with interest rates is weak. This paper will explore and test gold's relationship with interest rates, but highlight the significance of correlations between varying factors on the price of gold.

II. Method and Data

The data in this paper was sourced from the Federal Reserve Bank of St. Louis (FRED). The data includes the London Gold Fixing Price at 10:30 AM and 3:00 PM GMT which translates to 6:30 AM and 11 AM respectively in EST. The London Gold Fixing is designed to fix a price for settling contracts between members of the London bullion market, but the price is also used as an informal benchmark for pricing the majority of gold products and derivatives on world markets.

The percentage change of the price of gold at a daily, weekly, and monthly frequency were examined. The changes of 10-year, 5-year, and 2-year treasury constant maturity rates at both a nominal level and inflation-indexed level at daily, weekly, and monthly frequency levels were used. The Federal Open Market Committee (FOMC) meeting dates were manually sourced from

Federal Reserve website from 1990 to the present. The United States officially ended its adherence to the gold standard in 1973, and the relationship between interest rates and gold prices strengthened during the second half of the 1980s. Thus, 1990 was chosen as the starting time for the data. Since there are (during most years) 8 FOMC meetings per year, this provided a sufficient total of 232 meeting date data points. The change of the volatility index (VIX) was used as a measurement for changes in market volatility, and the strength of the dollar was measured with the change in exchange rates between the USD and the Euro. The 10-year breakeven inflation rate was used to measure the market expectation for inflation.

To examine the relationship between the real and nominal 10-year, 5-year, and 2-year treasury constant maturity rates with the price of gold, I regress the changes of the treasury rates on the percent change of the price of gold. This is done at a daily, weekly, and monthly frequency to isolate the noise of daily trading data. The effect of market volatility and changes in the strength of the dollar are captured through changes in the VIX and changes in US to Euro exchange rate. The market predicted inflation is captured by the 10-year breakeven inflation rate.

$$(1)\quad \Delta P_a = \alpha + \beta_1\, \Delta ten_a + \beta_2\, \Delta five_a + \beta_3\, \Delta two_a + \mu_1\, vix + \mu_2\, exch + \mu_3 bchg + \epsilon_a$$

In the above regression, ΔP_a is the percentage change in gold prices calculated as $\frac{p_t - p_{t-1}}{p_{t-1}}$. The variables $\Delta ten_a, \Delta five_a$, and Δtwo_a are the changes in the 10-year, 5-year, and 2-year treasury constant maturity rates, where $a \in$ daily, weekly, and monthly frequencies of regressions. *Vix* is the change in VIX, *exch* is the change in exchange rate between the USD and the Euro, and *bchg* is the change in the 10-year breakeven inflation rate.

To isolate the impact of investor response to monetary policy, the same regression is run with the addition of an indicator variable for FOMC meeting dates. Since FOMC announcements

are made at 2PM EST which is after the afternoon Gold Fixing time in GMT, the change of the price of gold is examined for the following day.

$$(2)\ \Delta P_a = \alpha + \beta_1 \Delta ten_a + \beta_2 \Delta five_a + \beta_3 \Delta two_a + \delta\, fomc + \gamma_1\, fomc * \Delta ten\_a + \gamma_2\, fomc * \Delta five_a + \gamma_3\, fomc * \Delta two_a + \mu_1\, vix + \mu_2\, exch + \mu_3 bchg + \epsilon_a$$

Here, *fomc* is an indicator variable that equals 1 on FOMC meeting dates, and 0 on all other days. Since time is an important factor in isolating the effects of the FOMC announcements, the correlation between treasury rate changes and gold prices are also examined on the days right before FOMC meetings, the days right after FOMC meetings, and during a two day average after FOMC meetings. Likewise to regression (2), indicator variables were used for the different dates examined.

III. Results

Treasury Constant Maturity Rate Effects

The following results show the varying relationships between different term treasury rates and the price of gold. Table 1a shows the regression results of real 10-year, 5-year, and 2-year treasury constant maturity rates on the percent changes of afternoon gold price fixings at various time frequencies. The morning fixed price changes produce similar results. Of the regression variables, the change in real 10-year rates and the change in nominal 2-year rates appear the most significant, and we see that their coefficient magnitude is almost double that of the 5-year rate effect. The impact of the rates appear to be captured mostly by the 10-year and 2-year rates. The changing inflation expectation also has a significant effect on the price of gold. Removing the 10-year breakeven inflation variable does not dilute the magnitude and significance of 10-year rate, but significantly reduces the relationship of the 2-year rate. The changing VIX and the changing exchange rates appear to have little significance on the changing gold price. Running the same

regression with nominal maturity rates yield insignificant results. Regressing each term rate individually on the daily percentage change of gold prices, the magnitude of impact remains at around negative 2.5 % for both the 10-year and 2-year rate when inflation expectation is controlled. The results (displayed in table 1b) suggest that on average, an increase in the change of real 10-year rates or nominal 2-year rates by 1% will lower the percentage change in gold prices by 2.5%.

	(1) rtnpm	(2) week_pmrtn	(3) month_pmrtn
real10yr_chg	-0.0203		
	(-1.69)		
real5yr_chg	0.00460		
	(0.35)		
nom2yr_chg	-0.0127		
	(-1.37)		
vix_chg	0.00000427	0.000110	0.00364
	(0.02)	(0.16)	(1.60)
ex_chg	-0.0120	0.0950	0.155
	(-0.39)	(0.71)	(0.38)
bchg	0.0226*	0.0754*	0.137
	(2.34)	(2.08)	(1.23)
week_real1~g		-0.0639*	
		(-2.14)	
week_real5~g		0.00544	
		(0.18)	
week_nom2y~g		-0.000438	
		(-0.03)	
mo~l10yr_chg			-0.0772
			(-1.75)
mon~l5yr_chg			0.00784
			(0.22)
month_nom2~g			-0.00717
			(-0.31)
_cons	0.000115	0.000726	0.00535
	(0.62)	(0.92)	(1.65)
N	3620	689	116

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 1a: regression results of different real constant maturity rates on the percent changes of the afternoon gold price fixings at various time frequencies.

	(1) rtnpm	(2) rtnpm	(3) rtnpm
real10yr_chg	-0.0242***		
	(-4.49)		
bchg	0.0136	0.0161	0.0309***
	(1.70)	(1.90)	(3.69)
real5yr_chg		-0.0126	
		(-1.24)	
nom2yr_chg			-0.0249***
			(-4.60)
_cons	0.000114	0.000124	0.000128
	(0.63)	(0.68)	(0.71)
N	3758	3758	3758

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 1b: individual regression of different real constant maturity rates on the daily percent changes of the afternoon gold price fixings.

	(1) rtnpm	(2) week_pmrtn	(3) month_pmrtn	(4) rtnpm	(5) week_pmrtn	(6) month_pmrtn
real10yr_chg	-0.0242***			-0.0257***		
	(-4.49)			(-4.79)		
bchg	0.0136	0.0646	0.0962			
	(1.70)	(1.74)	(0.99)			
week_real1~g		-0.0562***			-0.0572***	
		(-4.08)			(-4.16)	
mo~l10yr_chg			-0.0859***			-0.100***
			(-5.06)			(-6.82)
_cons	0.000114	0.000998	0.00502	0.000117	0.00121	0.00506*
	(0.63)	(1.40)	(1.56)	(0.64)	(1.76)	(2.03)
N	3758	797	121	3758	850	194

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 1c: individual regression of the 10-year rate at different time frequencies with and without controlling for expected inflation.

Using longer time frequencies, the effects of the 5-year and 2-year rates are much smaller in magnitude and significance. At the weekly and monthly level, the real 10-year rate captures most of the impact on gold prices. The changing VIX and changing exchange rates still appear to have little impact on the price of gold. However, the inflation breakeven rate remains significant (though less so in the monthly regressions). Regressing the weekly and monthly 10-year rate individually on the average weekly and monthly gold prices, amplifies the magnitude of the negative correlation. At a weekly frequency, the magnitude increases to a negative 5.7% decrease

in the percentage change of gold prices, and at a monthly frequency, the magnitude increase to negative 10%. Likewise to the daily results, nominal weekly and monthly treasury rates have much weaker correlations and significance.

Impact of FOMC Meeting Dates

The following results show the isolated impacts of treasury rates on FOMC meeting dates. For robustness checks, the impact of random and non-FOMC meeting dates were used. The dates just before and after FOMC meetings dates were examined.

Table 2 shows the results of FOMC meeting effects on the relationship between the treasury rates and the price of gold. The interaction between the FOMC date and the 2-year and 5-year rates appear to have to the most relevant impact in this regression. The meeting dates seem to amplify the 5-year rate changes on gold prices most significantly, and appear to reverse the negative relationship of the 2-year rate with the price of gold. The inflation expectations remains significant.

	(1)	(2)	(3)	(4)
	rtnam	rtnam	rtnam	rtnam
real10yr_chg	-0.00306	-0.00444		
	(-0.34)	(-0.86)		
real5yr_chg	0.00351		-0.00154	
	(0.52)		(-0.31)	
nom2yr_chg	-0.00774			-0.00763
	(-0.92)			(-1.33)
fomcdate	-0.000312	-0.0000852	-0.000419	0.000302
	(-0.31)	(-0.08)	(-0.40)	(0.28)
tenxfomc	-0.0334	-0.0654***		
	(-0.97)	(-3.65)		
fivexfomc	-0.0439		-0.0611***	
	(-1.44)		(-3.85)	
twoxfomc	0.0309			-0.0198
	(1.50)			(-1.24)
bchg	0.0261**	0.0225**	0.0229**	0.0292***
	(3.02)	(2.72)	(2.71)	(3.31)
_cons	0.000139	0.000138	0.000139	0.000139
	(0.74)	(0.73)	(0.74)	(0.74)
N	3789	3789	3789	3789

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 2: regression results of FOMC meeting effects on of the price of gold.

Regressing each treasury rate change on the gold prices individually, we see that FOMC meeting dates significantly magnifies the negative relationship of the 10-year rate. The negative relationship is captured in large by the interaction term for all rates, though the effect of the FOMC meeting dates on the 2-year rate has a less significant impact. Figures 1a and 1b show this visually by comparing the correlation of 10-year rates on FOMC meetings dates with morning fixed price changes and afternoon fixed prices changes. Figure 1c and 1d show the correlation between 10-year rates and fixed price changes on aggregate dates and on a random sample of dates respectively. The same effect is also shown graphically for the 5-year and 2-year rates which can be found in the appendix.

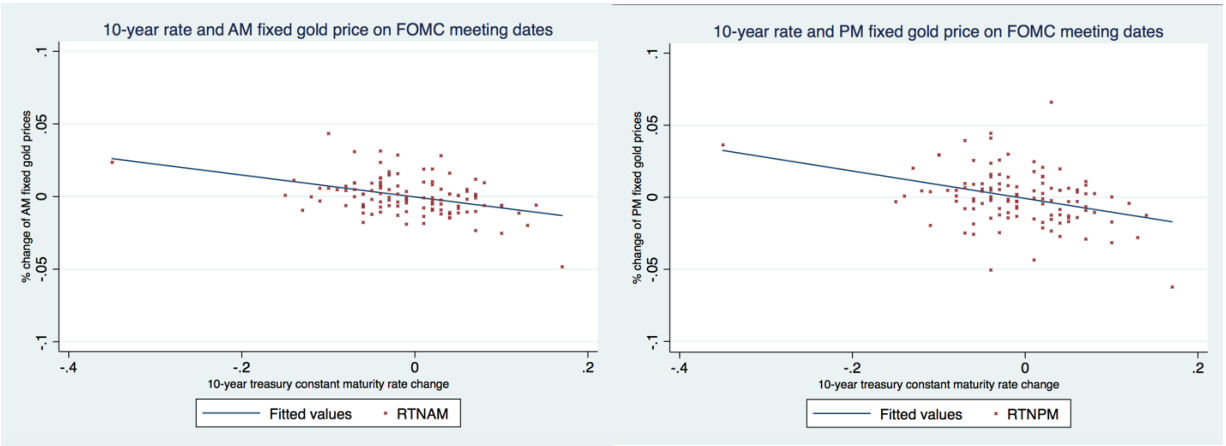

Figure 1a and 1b: strong negative correlation of 10-year rates on FOMC meetings dates with morning fixed price changes and afternoon fixed prices changes.

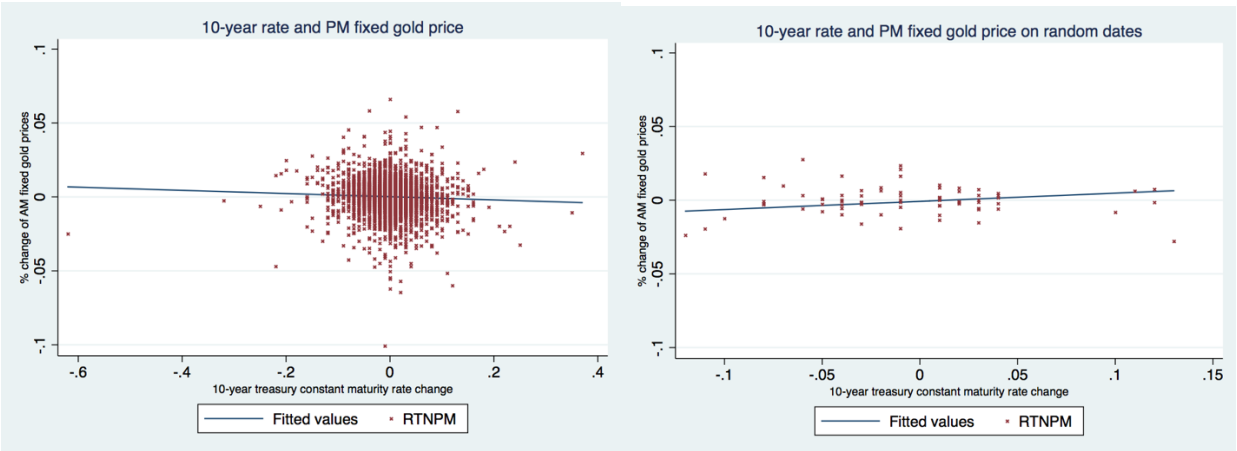

Figure 1c and 1d: weaker correlation between general 10-year rates and PM fixed price changes on all sample dates and on a random sample of dates.

Table 3 shows the results of regressing on days right after the FOMC meeting. On post FOMC meeting dates, there appears to be a significant positive correlation between the 10-year rate and the gold price. The magnitude of the interaction term is positive, statistically significant, and larger than the negative effect of the 10-year rate change. The magnitude of the coefficient is almost of the same magnitude as the negative amplified effect of the 10-year rate on the FOMC meeting dates. The post FOMC meeting 5-year interest rates also appear to have a positive relationship with the change in gold prices, though less statistically significant. The relationships are shown visually in figures 2a and 2b. There is no noticeable trending effect of the nominal 2-year rates on post FOMC meeting dates on the price of gold.

	(1) rtnam	(2) rtnam	(3) rtnam
real10yr_chg	-0.0109*		
	(-2.16)		
postfomc	-0.000313	-0.000511	-0.000319
	(-0.20)	(-0.33)	(-0.18)
tenxpost	0.0742*		
	(1.97)		
bchg	0.0232**	0.0241**	0.0294***
	(2.79)	(2.82)	(3.33)
real5yr_chg		-0.00569	
		(-0.98)	
fivexpost		0.0689	
		(1.78)	
nom2yr_chg			-0.0102
			(-1.89)
twoxpost			0.0583
			(1.02)
_cons	0.000168	0.000170	0.000173
	(0.91)	(0.92)	(0.94)
N	3789	3789	3789

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 3: regression results of effects on days right after the FOMC meeting.

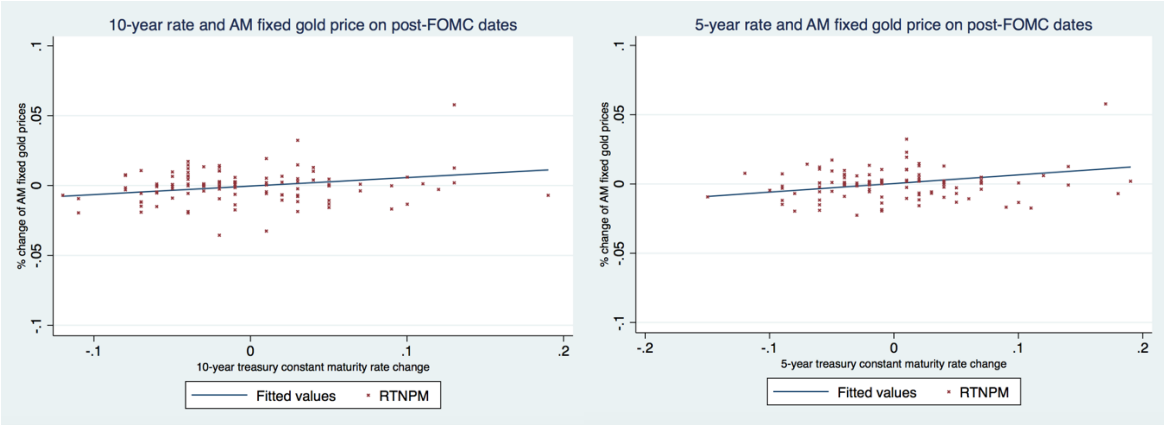

Figure 2a and 2b: post FOMC meeting 10-year and 5-year interest rates appear to have positive relationship with the change in gold prices.

Table 4 shows the results of regressing on dates right before the FOMC meeting. There appears to be no statistically significant relationship between any of the treasury rates on pre FOMC dates and the price of gold.

	(1) rtnam	(2) rtnam	(3) rtnam
real10yr_chg	-0.00880		
	(-1.64)		
prefomc	0.000501	0.000490	0.000474
	(0.52)	(0.51)	(0.50)
tenxprefomc	0.00740		
	(0.50)		
bchg	0.0234**	0.0242**	0.0288**
	(2.80)	(2.82)	(3.23)
real5yr_chg		-0.00378	
		(-0.67)	
fivexprefomc		-0.00251	
		(-0.20)	
nom2yr_chg			-0.00778
			(-1.32)
twoxprefomc			-0.00866
			(-0.48)
_cons	0.000132	0.000135	0.000136
	(0.70)	(0.71)	(0.72)
N	3789	3789	3789

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 4: regression results of effects on dates right before the FOMC meeting.

For robustness checks, I ran regressions on randomly selected dates between FOMC meetings since January 1990. The results show that the treasury rate effects on random dates are not statistically significant. Looking at all dates except FOMC meeting dates, the magnitude of the interaction term is smaller than the 10-year rate relationship with the gold price. The visuals for these results can be found in the appendix.

IV. Discussion and Future Work

As gold speculators and commentators often note, there appears to be a strong negative relationship between the real interest rates and the price of gold (Johnson, 2014). This relationship is hypothesized to be the result of the opportunity costs of holding onto gold with varying interest rates and inflation expectations. Though these relationships hold true, the casual relationship of interest rates on the gold price is hard to prove. Isolating a causal impact is difficult amidst the many factors that influence the volatility and fluctuation of the price of gold.

The results support the theory that long-term interest rates are negatively correlated with the price of gold (Baur, 2011). Without controlling for inflation expectation, there is a very weak negative relationship between gold prices and the nominal 2-year rates (which is highly correlated with the fed funds rate and short-term interest rates). Without controls, at a weekly and monthly frequency level, the relationship for the shorter maturity rates are insignificant. However, once inflation expectation is controlled for with the 10-year breakeven rate, the magnitude of impact and significance of the nominal 2-year rate rises drastically. These result help extend past findings that suggest the opportunity costs of holding gold in the short run are insignificant (Baur, 2011). The importance of the inflation expectation variable suggests that the insignificance of opportunity cost is due to an overshadowed effect of inflation expectations on short-term interests. Without controlling for inflation expectation, most of the relationships between the treasury rates is

captured by the 10-year rate which further demonstrates the significance of investor inflation expectation. The stronger relationship between 10-year rates and the price of gold is also consistent with the hypothesis that inflation expectations play a significant role in gold pricing, and also suggests that investors still perceive gold to be an inflation hedge. At different time frequency regressions (daily, weekly, and monthly), the same results are produced at higher statistical significance levels. This captures the strong relationship of interest rates and inflation on the price of gold with less trading noise.

Examining the effect of FOMC meeting dates, the results demonstrate a significant impact of monetary announcements on investors' reaction to gold. The meeting times significantly amplify the magnitude of the negative relationship of treasury rates and gold prices. This suggests that investors actively use FOMC meeting decisions to guide gold trades. This result parallels past research that have found a strong effect of CPI announcements on gold returns (Christie-David et al., 2000).

Since fund rate changes are good indicators of expected inflationary pressures, these results further support the hypothesis that expected inflation plays a prominent role in gold investing behaviour. The significance of the 10-year inflation breakeven term in all regressions highlight the importance of market expectations of inflation. As the graphs in the previous section show, while the negative relationship between different rates are hard to visually distinguish in the aggregate data, the relationship is significantly amplified on FOMC meeting dates. Even after controlling for expected inflation, the 10-year rates have a high negative correlation with price of gold. This suggests that the 10-year rates captures other market factors beyond inflation that play a role in the valuation of gold. However, the fact that the negative relationship between gold prices and treasury rates are amplified on FOMC meeting dates suggests that these negative correlations may

also be due to an overreaction of investors to projected macroeconomic trends. Regressing the effect of individual rates on FOMC meeting dates, the results also show that FOMC meeting dates have large amplification effects on all term rates. Especially since the 5-year rate effect did not have a significant relationship with the price of gold, its sudden significance on FOMC meeting dates suggests that there is something inherent about the FOMC announcements that drive gold investment behaviours.

Comparing morning and afternoon fixed gold prices, the negative fit relationship is much stronger in the morning compared to the afternoon. The morning gold fixing price has a smaller time lag after the FOMC meeting announcements. Since the announcements are released 2PM EST, this maps to 7PM GMT which is after the afternoon gold fixing time. Thus, the fixed prices the next morning are the closest observed market response to the effects of the FOMC meetings. There would be a greater amount of time for the market to react and readjust in the afternoon fixed prices. The stronger negative fit of morning fixed prices is further evidence that gold investors are actively responding to the FOMC announcements. The lowered magnitude of the effect throughout a single day suggests that this initial investor reaction may be an overreaction. This time-diffusion effect of FOMC announcements and reaction of investors reflected in the price of gold should be furthered explored in the future.

Interestingly, the effect of rate changes on gold prices the day after FOMC meetings appears to be significantly positive. Though this could be noise in the daily trading data, it may also be evidence that investors did initially overreacted to FOMC meeting announcements, but the market readjusted for the overreaction by mitigating the negative impact the following day. Investor overreaction to announcements, and the gold markets' ability to adjust to these overreactions are other topics to be further explored.

To ensure that the amplified effect of interest rates are due to FOMC meetings announcement, the same regressions were run on randomly selected and spaced out dates. The results through these random date regressions show that the interaction term of treasury rates and non-FOMC meeting dates have no significant impact on the price of gold. This proves that FOMC meeting announcements are significant, and that these announcements will determine the expected magnitude of the relationship between treasury rates and the price of gold. Controlling for market volatility through the VIX, strength of the dollar through the Euro exchange, and inflation expectation throughout the 10-year inflation breakeven rate, the results suggest that general volatility and the strength of the dollar appear to have little impact on the price of gold. This shows that investors do not consider market and currency volatility as driving factors for investing in gold, and that in general, investors do not actively use gold as a safe haven or currency hedge. However, the expected inflation levels have a significant positive relationship with the price of gold. This suggests that the valuation of gold is most dependent on inflation expectation and that gold's relationship with longer-term interest rates is due to built in inflation expectations.

V. Conclusion

The effects of 10-year, 5-year, and 2-year treasury constant maturity rates on the price of gold on non-FOMC meeting dates and FOMC meeting dates are compared. FOMC meeting dates are shown to amplify the negative relationship between the treasury rates and the price of gold. Controlling for market volatility and exchange rates suggest that the price of gold is not dependent nor significantly related to these factors. However inflation expectation captured through the 10-year inflation breakeven rate has a strong positive relationship with the price of gold.

This evidence supports the hypothesis that the price of gold is not driven by real interest rates, but is influenced heavily by interest rates through its relation to expected inflation and

general macroeconomic conditions. The significant amplified impact on FOMC meeting dates suggest that investors of gold actively use monetary policy to make gold investment decisions. The resulting effects of FOMC meetings also suggests that investors are sensitive and reactionary to the treasury rates. The results further suggest that the amplified responses to the treasury rates may be due to investor overreactions. Most of the relationship between shorter interest rates captured through the 5-year and 2-year rates are found only on FOMC meeting dates, and are insignificant otherwise. Moreover, on days right after FOMC meetings, there appears to be a positive relationship between treasury rates and the price of gold further. This suggests that though investors may have initially overreacted to FOMC meeting announcements, the gold market readjusts to mitigate the initial skewed effects.

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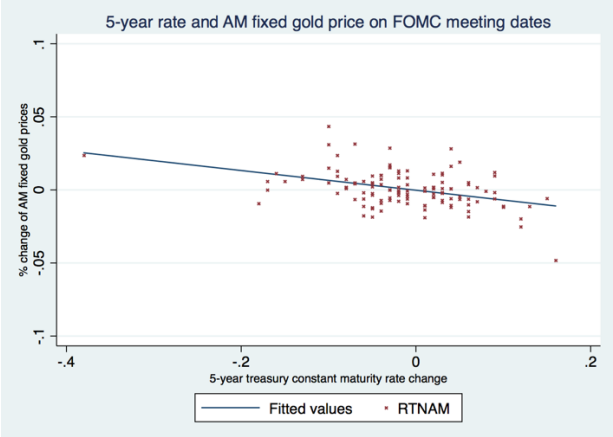
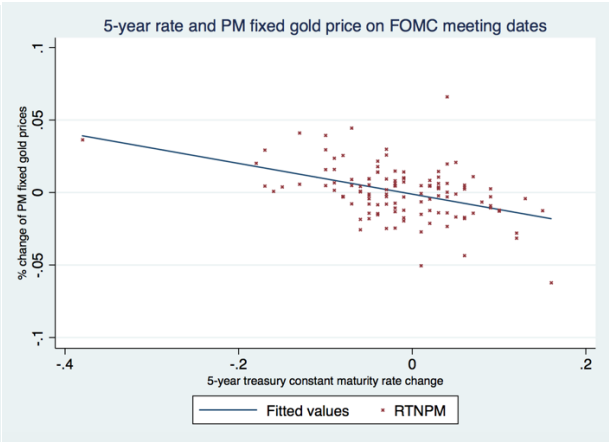
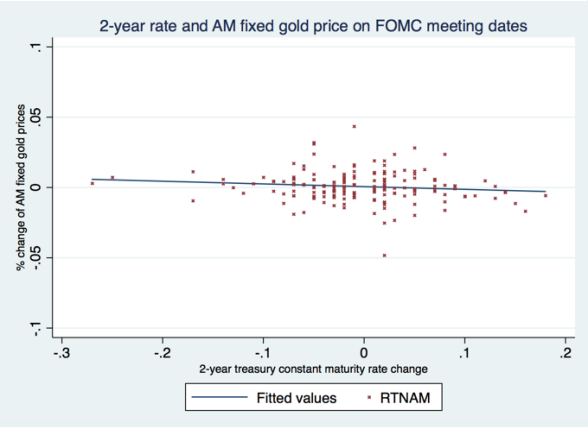
Appendix

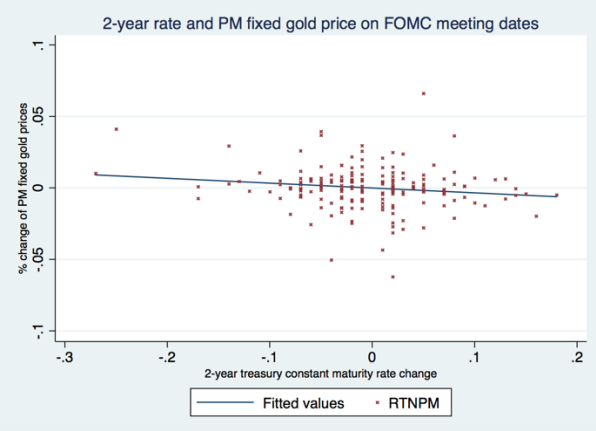
5-year treasury constant maturity rates and the price of gold (AM vs. PM)



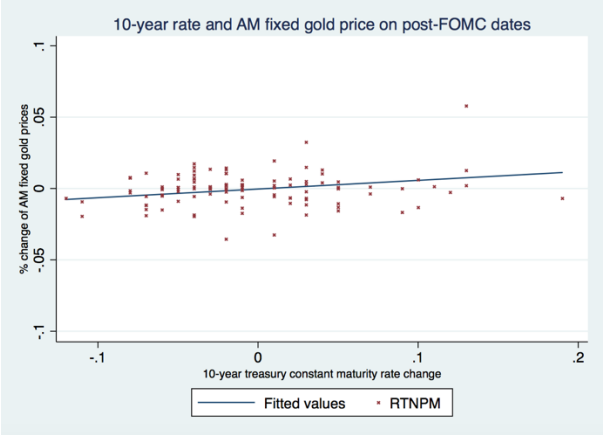


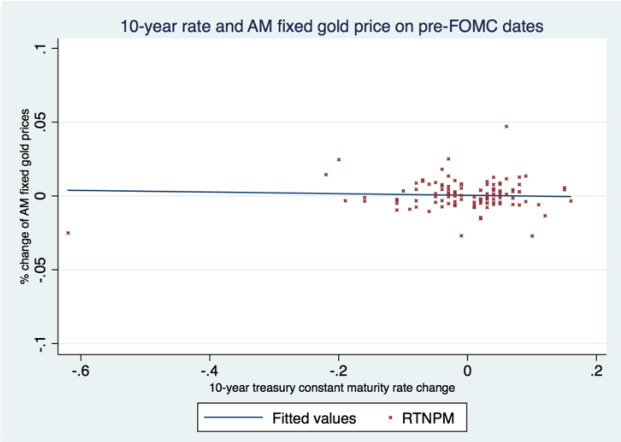
2-year treasury constant maturity rates and the price of gold (AM vs. PM)



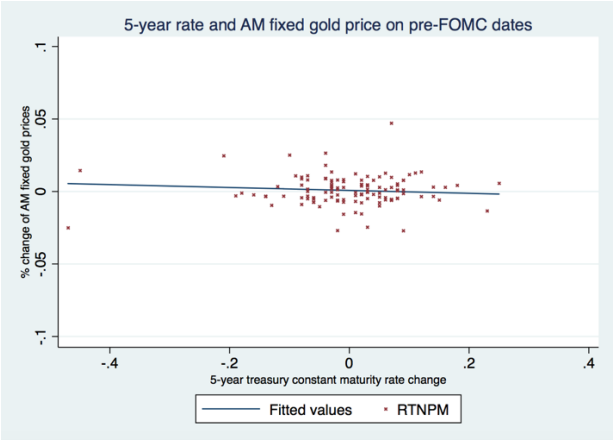


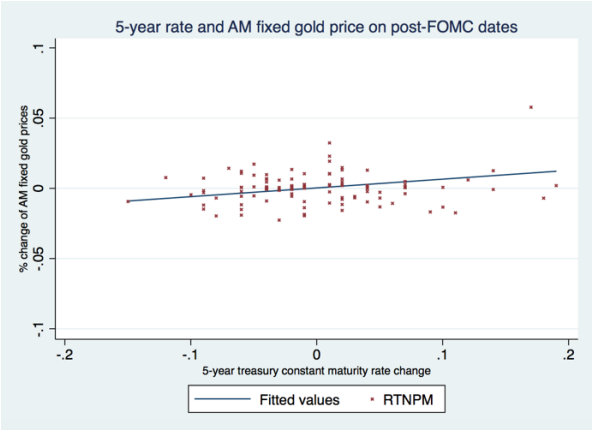
10-year treasury constant maturity rates and the price of gold (pre / post FOMC meeting)



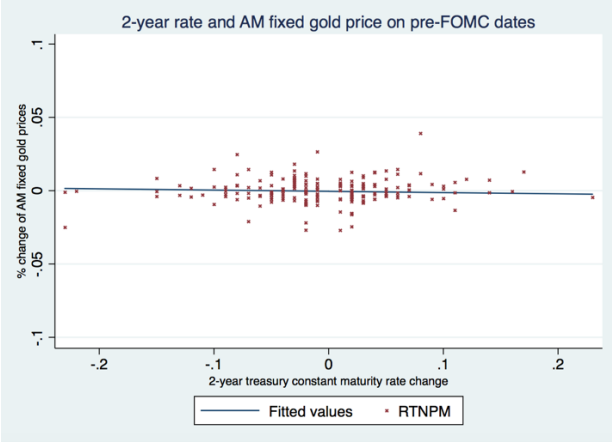


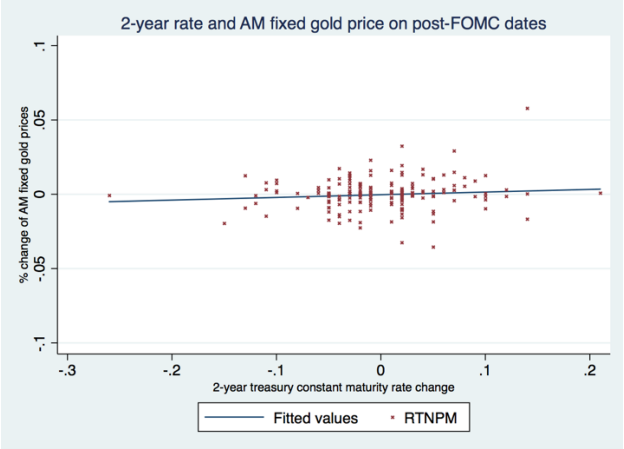
5-year treasury constant maturity rates and the price of gold (pre / post FOMC meeting)





2-year treasury constant maturity rates and the price of gold (pre / post FOMC meeting)





Random date regression effects

	(1) rtnam	(2) rtnam	(3) rtnam
real10yr_chg	-0.00959		
	(-1.89)		
randate2	-0.000898	-0.00115	-0.00145
	(-0.74)	(-0.90)	(-1.03)
tenxranfomc	0.0645		
	(1.37)		
bchg	0.0231**	0.0244**	0.0295***
	(2.76)	(2.85)	(3.34)
real5yr_chg		-0.00456	
		(-0.82)	
fivexranfomc		0.0457	
		(1.10)	
nom2yr_chg			-0.00903
			(-1.60)
twoxranfomc			0.0337
			(1.15)
_cons	0.000178	0.000180	0.000182
	(0.95)	(0.97)	(0.97)
N	3789	3789	3789

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001