The Impact of Federal Reserve Statements and Chairman Sentiment on the Gold and Silver Markets

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Abstract

This study investigates the impact of Federal Reserve monetary policy decisions and communication on global gold and silver markets from May 1999 to June 2012. We argue that the discourse used by central bankers is not only a key driver of financial markets based on empirical evidence, but also, in essence, a device to convey authority and power. Using computer-assisted content analysis, we analyse speech styles of the current and former Federal Reserve Chairmen, Ben Bernanke and Alan Greenspan, to explore their impact on market sentiment. We find that the surprise component of Fed monetary policies significantly influences gold and silver markets. For example, a 1% surprise rate hike increases gold bullion prices by 1.3% and silver bullion prices by 1.5%. We also find significant stylistic differences between the two Fed Chairmen in their policy communications and their impact on market volatility.

Keywords: Market sentiment, Federal Reserve, Monetary policy, Gold and Silver, Content analysis

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1. Introduction

Since the financial crisis in 2007, as the impact of the sub-prime mortgage debt crisis in the United States unfolded, gold and silver have attracted increasing interest from professionals, academics, retail investors and the financial media. Gold and silver have been in a bull market for the major part of this century as increasing concerns over the health of the banking sector and mounting sovereign debt have made them attractive assets. In fact, their more recent price increases have coincided with the most severe financial and economic crisis since the Great Depression in the 1930s.

The Federal Reserve's monetary policy decisions include important information for financial markets and, therefore, their influence on markets has been extensively studied. With the change in policy towards more transparency, the Federal Reserve has sought to improve its policy communication over the last decade. The Federal Open Market Committee (FOMC) first began in May 1999 to issue statements accompanying the federal funds rate target decision on the assessment of future policy changes. Furthermore, the numbers of speeches from chairmen and board members have increased over the last decade and are easily accessible through the Federal Reserve's website. The importance of the central bank´s communication has become ever more important as the Federal funds target rate has reached the zero bound level. Thus communication regarding future policy intentions and the state of the economy through speeches and statements has become an increasingly important policy tool for the Federal Reserve in implementing policy decisions and effecting markets.

With the growing importance of gold and silver in the world of finance, and their lucrative profit potential in recent years, research in the field has been emerging as academics and professionals have sought to explain the role and relationships of gold and silver in financial markets. However, research investigating the relationship between gold and silver and the Federal Reserve´s monetary policy and communication is almost non-existent. Given the growing importance of gold and silver for both investors and central banks, this study investigates how Federal Reserve policies and communication affect the gold and silver markets. In addition, the different speech styles of the Federal Reserve chairmen are analysed in order to gain insight into how sentiment can move financial markets. The study first investigates the impact of unexpected monetary policy and the surprise component of the FOMC statements accompanying the Federal Reserve rate decisions on the gold and silver markets. Then, we analyse the speeches and testimonies by Alan Greenspan and Ben Bernanke using computerised content analysis software in order to investigate how these influence the gold and silver markets.

The study is valuable to market participants as it gives insight into how financial markets behave and what role gold and silver have in the world of finance. Commodity exchanges, central banks and governments that look to attain orderly and efficient markets should have an interest in information that explains how the precious metals respond to monetary policy and central bank communication. For investors, this can help them devise trading strategies and better diversify their portfolios.

The main findings presented in the study are as follows. *Firstly,* unexpected monetary policy has a statistically significant and economically important impact on the gold and silver markets. We find that this relationship is positive, unlike such studies as Bernanke and Kuttner (2005) and Rosa (2011). A hypothesised 1% unexpected interest rate increase is associated with a 1.3% increase in gold bullion and 1.5% increase in silver bullion. This finding is very interesting and gives evidence to claims that gold and silver can be viewed as "safe haven" assets similar to the finding of Baur and Lucey (2010). Gold stocks, however, are affected in the same way as equity markets, namely, a 1% unexpected rate increase is on average associated with a 9.88% decrease in the FTSE gold equities index. The study thus shows that equities of gold producers react differently than the gold bullion and futures markets. The surprise component of the FOMC statements is not found to be statistically significant in most cases, a surprise, given the increasing importance of the statements following the Federal funds zero target rate level in 2008.

Secondly, we illustrate that the tone in Alan Greenspan´s communication to have a statistically significant and economically important effect on the gold and silver markets. The amount of *Certainty* in the tone of Greenspan´s communication is most significant such that, on average, a 1% increase is associated with an increase of 0.03% in silver bullion prices and almost a 0.1% increase in gold equity prices. However, Bernanke´s communication does not have a significant effect on the returns of the gold and silver markets. When the communication between chairmen is compared the results show that Greenspan has significantly more *Activity* and *Realism* whereas Bernanke has more *Optimism* in his tone. Finally the study shows that both chairmen affect the volatility in both the gold and silver markets through their communication tone, though in most cases the size effect is not large. The most important language tone variables are *Certainty, Optimism* and *Realism*. The results show that Federal Reserve chairman sentiment can move the gold and silver markets and the impact is very different between chairmen.

1.1. Gold and silver in financial markets

Gold and silver, have traditionally been used by investors as a store of value, protection against inflation and debasement of currencies issued by governments. The metals have intrinsic value due to being physical assets and carry no counterparty- or default risks. Their unique attributes resulted in them being used as the preferred medium of exchange for centuries as they are easy to store and transport. Gold is durable, divisible and resistant to corrosion and oxidation. Gold and silver were for a very long time accepted universally as payments for goods and services. Gold has been described in various ways from a "barbarous relic" to a "safe haven" asset. The "safe haven" aspect of gold has been studied and the metal is found to protect investors from losses in times of financial crisis and uncertainty (Baur and McDermott, 2010), which is one explanation for the increasing investment demand in recent years (WGC, 2012). They are often called monetary metals due to the link between gold, silver and currencies. For example, the state of Utah recently began accepting gold and silver as legal tender (Utah, 2011).

Gold was until 1971 closely tied to the U.S. dollar and before that to the British sterling in the form of a gold standard. Countries participating in the gold standard fixed the price of their domestic currencies to a specific amount of gold, and maintained the standard by selling and buying to anyone at that price. From 1880 to 1914, the majority of countries were on a gold standard, known as the classical gold standard. The classical gold standard broke down in the beginning of World War I. From 1925 to 1931, the world was briefly on a

Gold Exchange Standard which resulted in financial panic and exchange rates crisis as nations adhering to such strict rules suffered from "sharp declines in inside money stocks" (Bernanke, 1995, p.4). From 1946-1971 there was an attempt to return to a modified gold standard with the Bretton Woods System. Under Bretton Woods, the US dollar was the world reserve currency and was fixed to a price of $35.00 per ounce of gold. President Nixon severed the relationship between gold and the dollar in 1971 when the gold standard was abolished.

During the 1833-1933 period, the gold price was fairly constant at $20 per ounce until the price was fixed at $35 in 1934 (Shafiee and Topal, 2010). The price fix was abandoned in 1967 with trading in silver futures beginning in 1969 and gold futures in 1974. Prices since then have often moved with great volatility. There have been two periods of price jumps in the metals since 1968. The first was in 1977-1981 when the price of gold rose to $800 as high oil prices and inflation were the major factors for the gold price rise (Baur and McDermott, 2010). Silver rose to $49.45 as the Hunt brothers[2] drove up the price of silver by manipulating the market (Christie-David, Chaudhry and Koch, 2000). The second price rise began in 2002 in which gold has increased over fivefold and has risen for eleven consecutive years. In 2008, the gold price rose 6% while most other minerals and other equities fell considerably as the financial crisis unfolded. This shows the different financial characteristics of gold compared to other financial assets (WGC, 2010).

1.2. The gold market

Gold has a variety of uses and is for example used within many different industries such as finance, fashion, health, electronics and chemicals. The majority of gold is mined in South Africa, the United States, China and Australia. China is both the largest importer and producer of gold (WGC, 2012). As can be seen from panel A in table 1, the main supply of gold in 2011 came from mining, 63%, with recycled gold accounting for 37%.

[2] The Hunt brothers, Nelson B. Hunt and William H. Hunt, billionaires from Texas, attempted to corner the silver market in the 1980s. From 1970 to 1979 the brothers accumulated large amounts of silver but failed in their attempt to corner the market. Subsequently as their scheme collapsed the price of silver also collapsed from around $50 to $10 in a few trading days.

Table 1: World gold supply and demand

The table displays the gold markets supply and demand from 2008 to 2011 in tonnes. Column 3 depicts each supply/demand category as a percentage of the total supply/demand for the year 2011. Column 4 is the change in supply/demand between 2011 and 2010 depicted in percentages. Data is gathered from the World Gold Council website.

	2011	**% of Supply / Demand**	**%ΔYoY**	**2010**	**2009**	**2008**
Panel A: Supply						
Mine production	2818	63%	3%	2740	2570	2409
Net producer hedging	7	0%	-106%	-108	-254	-352
Total mine supply	*2825*	*63%*	*7%*	*2632*	*2316*	*2057*
Recycled gold	1661	37%	-3%	1719	1668	1316
Total supply	**4486**	**100%**	**3%**	**4351**	**3984**	**3373**
Panel B: Demand						
Jewellery	1973	43%	-2%	2017	1814	2304
Bar and coin investments	1524	33%	26%	1210	786	875
ETFs and similar	162	4%	-56%	368	617	321
Industry	453	10%	-3%	466	410	461
Official sector purchases	456	10%	492%	77	-34	-235
Total Demand	**4568**	**100%**	**10%**	**4138**	**3593**	**3726**

Panel B of table 1 displays the demand side; jewellery was the largest, 43% though it has been decreasing in recent years, opposite to increasing demand from investors. Investors and Exchange Traded Funds (ETFs) accounted for 37% in 2011. Demand from ETFs has increased rapidly since their introduction in 2003; however, their demand has slowed down since the peak in 2009. Shafiee and Topal (2010) argue that a major contributor of the gold price increase since 2002 is the introduction of gold ETFs which have made investing in gold as easy as investing in equities. Official sector purchases (e.g. central banks) accounted for 10% of the demand in 2011, explained by the fact the central banks have become net buyers of gold in 2010 and 2011. Central banks actively take part in the gold market, both buying and selling gold.

Batchelor and Gulley (1995) explain that gold has a peculiar demand and supply feature, as jewellery and central bank reserves can be added to the supply side. Gold as an asset is quite unique because much of the gold that has been mined throughout history is still in existence today and existing gold can be seen as a renewable resource with no degradation in quality. Even though the gold standard no longer exists, central banks continue to be large holders of gold reserves. The International Monetary Fund reports official holdings of reserve assets in March 2011; gold is the third largest accounting for 11% with foreign exchange holdings of the U.S dollar and the Euro the first and second accounting for 52% and 23%, respectively (IMF, 2011).

Table 2: World official gold reserves

The table displays the gold reserve holdings of central banks and the IMF from 2000-2012 in tonnes. All figures are for the end of each year except 2012 (April reserve holdings). Data is gathered from the World Gold Council website.

Ranking	Country / Organization	2012	% of world holdings	2010	2008	2006	2004	2002	2000
1	United States	8,133	26%	8,133	8,133	8,133	8,136	8,149	8,137
2	Germany	3,396	11%	3,401	3,413	3,423	3,433	3,446	3,469
3	IMF	2,814	9%	2,814	3,217	3,217	3,217	3,217	3,217
4	Italy	2,452	8%	2,452	2,452	2,452	2,452	2,452	2,452
5	France	2,435	8%	2,435	2,492	2,720	2,985	3,025	3,025
6	China	1,054	3%	1,054	600	600	600	600	395
7	Switzerland	1,040	3%	1,040	1,040	1,290	1,354	1,917	2,419
8	Russia	896	3%	789	520	401	387	388	384
9	Japan	765	2%	765	765	765	765	765	764
10	Netherlands	613	2%	612	612	641	777	852	912
	Total world holdings	**31,283**		**30,711**	**29,866**	**30,374**	**31,342**	**32,413**	**33,060**

As can be seen from table 2 the United States is the largest holder of gold reserves followed by Germany and the International Monetary Fund. In a study on the gold price from 1994-1997, Cai, Cheung and Wong (2001) examine the 25 largest absolute returns and find that massive central banks gold reserve sales are the main contributors to large drops in the gold price. According to the World Gold Council (WGC, 2012) the level of reserves held by central banks since 1950 have been in the range 30,000-36,000 tonnes per year and the total amount of gold mined in history is approximately 160,000.

1.3. The silver market

Silver is used in many industries such as fashion, sterling ware, photographic, finance, electrical and high-tech industries. Most silver is produced in Mexico, Peru, China and Australia. Panel A of Table 3 displays the supply side of silver. The majority, 73% in 2011, came from mine production while recycled silver accounted for nearly a quarter of the supply. Total supply decreased 3% between 2011 and 2010 due to a dramatic decrease in government sales and less producer hedging. An increase in recycled silver by 12% on a yearly basis stemmed these decreases.

Table 3: World silver supply and demand

The table displays the silver markets supply and demand from 2008-2011 in millions of ounces. Column 3 depicts each supply/demand category as a percentage of the total supply/demand for the year 2011. Column 4 is the change in supply/demand between 2011 and 2010 depicted in percentages. Data is gathered from the Silver Institute website.

	2011	% of Supply / Demand	%ΔYoY	2010	2009	2008
Panel A: Supply						
Mine production	762	73%	1%	751	716	684
Net producer hedging	11	1%	-79%	50	-17	-9
Total mine supply	*772*	*74%*	*-4%*	*802*	*699*	*675*
Net government sales	12	1%	-74%	44	16	31
Recycled silver	257	25%	12%	229	200	201
Total supply	**1041**	**100%**	**-3%**	**1075**	**914**	**907**
Panel B: Demand						
Jewellery	160	15%	-5%	167	160	159
Implied Net Investment	164	16%	-11%	185	132	31
Photagraphy	66	6%	-8%	72	79	101
Industry	487	47%	-3%	500	405	493
Silverware, Coins & Medals	164	16%	9%	151	138	123
Total Demand	**1041**	**100%**	**-3%**	**1075**	**914**	**907**

From panel B in table 3 it can be seen that industrial demand was the largest accounting for around 47% in 2011. Due to this strong demand from industries silver is more prone to effects from the business cycle as opposed to gold, which has the majority of demand coming from jewellery (Silver Institute, 2012). There is increasing demand from investors and in 2009 and 2010 the market saw huge increases which offset an increase in supply. Investment demand for silver accounted for 16% in 2011. Physical silver bar investments grew 67% in 2011. Photography, which used to be a major part of the demand for silver, decreased nearly 8% in 2011, a trend that has been evident for the past decade (Silver Institute, 2012).

1.4. The contemporary debate on gold and silver

With gold and silver attracting more attention in recent years, their role in financial markets is being debated by both professional and academics. Recent advocates of a return to some form of the gold standard are former World Bank president Robert Zoellick (Zoellick, 2011), and former Federal Reserve president Alan Greenspan (Othman, 2009). Hillier, Draper and Faff (2006) find evidence that investment portfolios containing gold, silver and platinum perform significantly better than portfolios consisting only of equities. They argue precious metals can help diversify investment portfolios and that they exhibit hedging capabilities against economic and political risks and stock market volatility.

Legendary investor Warren Buffet has, however, openly stated his disliking of investing in gold. Buffet states in a Berkshire Hathaway annual shareholder letter, that gold is favoured by investors around the world who are fearful of almost all other assets, "*gold, however, has two significant shortcomings, being neither of much use nor procreative*" (Berkshire Hathaway, 2011, p.18).

Interestingly, the current and former Federal Reserve chairmen, Ben Bernanke and Alan Greenspan, have very different opinions on the role and merit of gold. Alan Greenspan writes in an essay "Gold and Economic Freedom" explaining that gold has a significant advantage over other mediums of exchange due to it being relatively scarce and having both artistic and functional uses. He states that: "*under the gold standard, a free banking system stands as a protector of an economy's stability and balanced growth"* (Greenspan, 1967, p.97). And he further states that:

"*In the absence of the gold standard, there is no way to protect savings from confiscation through inflation. There is no safe store of value"* (Greenspan, 1967, p.100).

Greenspan also commented before congress in 1994 that people switch from currency to gold to hedge expected inflation and that gold has been a good indicator of future expected inflation and as a store of value (The Wall Street Journal, 1994 cited in Mahdavi and Zhou, 1997, p.476).

However, current Federal Reserve chairmen, Ben Bernanke, in a paper on the macroeconomics of the Great Depression, finds evidence that countries leaving the gold standard recovered more quickly from the Great Depression (Bernanke, 1995). In a recent lecture Bernanke defends the decision of the U.S. to leave the gold standard and notes that it harmed the global economy during the Great Depression. He further explains that a country on a gold standard will see more short term volatility, though prices over the long run remain stable. As the money supply is subject to the supply of gold, countries on a gold standard cannot react to changes in the economy as central banks will not be able to stabilize the economy by adjusting the money supply (Bernanke, 2012).

With this difference of opinion it is interesting to investigate whether the gold and silver markets react differently to the speeches and policy changes from each chairman.

The remainder of this study is structured as follows. The next section, section 2, will give a description of the relevant literature on gold, silver and the Federal Reserve policy and communication. Section 3 will describe the research methodology and data applied in the study. In section 4, the results are presented from the empirical tests and section 5 concludes the study.

2. Literature Review

Federal Reserve policy changes and the relationship with financial assets is an important topic which has been extensively researched in recent years. The response of asset prices, from the perspective of policy makers, is a vital component in analysing the effects of monetary policy on the economy (Rosa, 2011). Gold has been an important financial asset for centuries as a store of value and in times of financial and political uncertainty (Baur and Lucey, 2010). The effects of monetary policy on commodity prices, especially gold and silver, given their close tie to money and presence of central banks in the gold market is an important subject. However, research on the effects of unexpected monetary policy change on

gold and silver is scarce. This section first explores the growing research in the last decade into what affects gold and silver prices. Then the extensive research on the impact Federal Reserve monetary policy changes have on financial markets is explored. Lastly an account is made of the recent research investigating the effects of Federal Reserve communication such as speeches and testimonies, which has become important information for market participants as well as a key tool for the central bank in managing the markets expectations.

2.1 What influences Gold and Silver prices?

2.1.1 Commodities

The similar price movements of commodities such as precious metals and oil have attracted interest from researchers who document strong positive correlation between them. Sari, Hammoudeh and Ewing (2007) examine the gold, silver, oil and copper futures markets and find that copper is almost independent of the other commodities with gold and silver strongly linked together with the two precious metals helping to explain the volatility in oil price forecast errors. Shafiee and Topal (2010) use spot gold and spot Crude oil prices over the 1968-2008 period and find that oil and gold are positively correlated by 85% and that the ratio of one ounce of gold to one barrel of crude oil has been fairly stable. Using the spot gold price and Brent crude-oil spot price over the period 2000-2008, Zhang and Wei (2010) examine the interactions between the gold and oil markets and find a significant cointegration relationship and a unilateral linear Granger causality relationship where the rising price of oil in the 21st century has triggered the rising price in gold. This relationship is, however, not evident in the opposite direction contrary to the Sari, Hammoudeh and Ewing (2007) study. Sari, Hammoudeh and Soytas (2010) find results that indicate gold and silver affect each other. The results show that gold explains approximately 16% of the variation in silver returns and silver explains almost 23% of the variation in the gold price.

Gold and platinum prices were positively correlated over the 1985-2006 period but there was a correlation shift to negative and back in 1996-2001. Kearney and Lombra (2009) investigate the reasons for the correlation change and find evidence that actions of gold producers in the derivatives market significantly affect gold prices. The decline in gold prices in the 1990s is associated with large increases in forward sales and they argue that the price rise in recent years is associated with declining forward sales of producers, in other words producers have been dehedging their production.

2.1.2 Exchange rates

The negative relationship between commodities, especially gold, and the U.S. dollar is well documented in academic papers. The theoretical and empirical relationship between gold and exchange rates is studied by Sjaastad and Scacciavillani (1996) and further by Sjaastad (2008). Both studies use the law of one price, where the spot price of gold in a depreciating currency rises and falls in an appreciating currency, to assess the relationship. They argue that in terms of exchange rates, during the 1980s the gold market was dominated by European currencies but since the 1990s the U.S dollar has become dominant. Capie, Mills and Wood (2005) use an exponential GARCH model to investigate the relationship between the London gold price fix and the yen/dollar and pound/dollar exchange rates and find evidence that gold has served as a hedge against the dollar from 1971-2004. Tully and Lucey (2007) use an asymmetric power GARCH (APGARCH) model to assess the effects of macroeconomic variables on monthly cash and futures gold prices over the period 1984-2003. They confirm that the dollar is one of the main variables that influence gold prices.

Pukthuanthong and Roll (2011) use gold bullion prices from 1971-2009 denominated in dollars, yens, euros and pounds and argue that the relationship described in Sjaastad and Scacciavillani (1996), Capie, Mills and Wood (2005) and Sjaastad (2008) is inaccurate. They explain that it is intuitively puzzling that a higher gold price results in the dollar depreciating against other currencies because it implies that the gold price is connected to appreciations of other currencies. They argue prior studies fail to consider that a rising price of gold in a currency is related to depreciation of that currency, not just the dollar but every currency of the world. They find significant evidence that the dollar price of gold is associated with dollar depreciation and the same is true for the euro, pound and yen.

Hammoudeh, Sari and Ewing (2009) find that exchange rates have an influence on gold, silver and oil futures volatility and that gold is affected by exchange rates both short term and long term whereas silver is only affected short term. Sari, Hammoudeh and Soytas (2010) investigate the relationship between oil, precious metals and the U.S./Euro exchange rate and find evidence that precious metals and exchange rates are connected over short periods of time (up to 2 days). However, in the long term, there is no relationship between the commodity returns and the exchange rates.

2.1.3 Inflation

There is an open debate in the literature on whether inflation has an effect on gold prices and if gold is in fact a store of value and protector against inflation. Sjaastad and Scacciavillani (1996) find significant evidence that a one percentage point increase in world inflation leads to a 0.78 percent increase in the spot price of gold. However, a later study by Sjaastad (2008) finds that inflation is actually significantly negatively related to spot gold prices. He argues that a spike in world inflation in the early 1980s might have influenced the earlier study and concludes gold is no longer a protector against inflation. It is worth noting that Sjaastad (2008) uses a sample period, 1991-2004, which is a period of relative low and stable inflation compared to the sample period in the Sjaastad and Scacciavillani (1996) study, which has periods of high inflation.

Mahdavi and Zhou (1997) investigate whether gold has predictive power regarding future inflation over the period 1970-1994 using the London closing spot gold price. They find no evidence of a cointegration relationship between the gold price and the consumer price index and argue that gold is not a good indicator of inflation and further state that the role of gold as a hedge against inflation has diminished. However, Tully and Lucey (2007) use the APGARCH model and find that neither inflation nor interest rates have any statistically significant relationship with either gold futures or spot prices. Shafiee and Topal (2010) find a negative 9% correlation between gold and cumulative inflation and conclude there is no positive significant relationship between the gold price and inflation.

Blose (2010) tests if changes in expected inflation affect the spot gold price. He finds evidence that surprises in the CPI do not affect the spot gold price and argues that the spot gold price is not related to future expectations on inflation. Gold futures spot prices are however affected by change in inflation expectations consistent with the result from Christie-David, Chaudhry and Koch (2000) and Cai, Cheung and Wong (2001) that CPI news releases affect gold futures prices.

2.1.4 Macroeconomic news

Several studies investigate the response of gold and silver to macroeconomic news releases. Christie-David, Chaudhry and Koch (2000) and Cai, Cheung and Wong (2001) both use intra-day futures data, Batten et al. (2010) use monthly observations and Roache and

Rossi (2010) use daily frequencies. Christie-David, Chaudhry and Koch (2000) examine whether monthly macroeconomic news releases, over the period 1992-1995, affect gold and silver futures prices. They use the reaction of interest rate futures, treasury and municipal bonds, as a basis for comparison. The findings show that the releases significantly affect the interest rate futures whereas the effects on the gold and silver markets are more modest. Gold and silver both respond strongly to the issue of Capacity Utilization and the unemployment rate. Gold responds significantly to the CPI and gross domestic product (GDP) but silver only to the CPI. Interestingly silver exhibits a higher variance than gold or interest rate futures, even though most of the announcements have an insignificant effect on silver. The authors explain that speculative trading in the silver market seems plausible given the high volatility of the metal.

Cai, Cheung and Wong (2001) find evidence similar to Christie-David, Chaudhry and Koch (2000). They examine the intra-day return volatility and ARCH effects, using high frequency gold price data from 1994-1997 and find that the unemployment rate, GDP and CPI significantly influence the gold futures market. Batten et al. (2010) examine monthly price volatilities from 1986-2006 for four precious metals; gold, silver, platinum and palladium to try and find their macroeconomic determinants. The results show that gold volatility is affected by monetary factors but silver is however not affected by such factors. They state that this result for gold is "*consistent with the argument that gold can be regarded as surrogate money*", with inflation, interest rate and exchange rates important variables for the gold market (Batten et al., 2010, p.69). They argue that the results show precious metals cannot be considered a single asset class and that silver cannot be seen as a substitute for gold in investors' portfolios (Batten et al., 2010). Roache and Rossi (2010) use a GARCH model and daily futures price data from 1997-2009 to assess the impact of macroeconomic news on a broad range of commodities and find that during the period commodities in general have been insensitive to such news releases. Gold and silver are significantly affected by the U.S dollar index, however, they are not affected by the FOMC interest rate decision or the CPI release, contrary to the Christie-David, Chaudhry and Koch (2000) and Cai, Cheung and Wong (2001) findings. For a summary of the factors influencing gold and silver see table 4 below.

Table 4: Gold and silver influence factors

The table displays the summary of findings on gold and silver in the literature review section of the study. Yes with a "+" shows a positive influence. Yes with a "-" shows a negative influence. If no sign appears after the Yes then the sign of the influence could not be determined. N/A stands for not available.

Influence factor	Authors (date)	Influence gold	Influence silver
Commodities			
Oil	Sari, Hammoudeh and Ewing (2007)	Yes +	Yes +
	Shafiee and Topal (2010)	Yes +	N/A
	Zhang and Wei (2010)	Yes +	N/A
	Cai, Cheung and Wong (2001)	Yes +	N/A
Platinum	Kearney and Lombra (2009)	Yes +	-
Gold	Sari, Hammoudeh and Soytas (2010)	N/A	Yes +
Silver	Sari, Hammoudeh and Soytas (2010)	Yes +	N/A
Producer hedging	Kearney and Lombra (2009)	Yes -	N/A
Exchange rates			
U.S. dollar	Sjaastad and Scacciavillani (1996)	Yes -	N/A
	Sjaastad (2008)	Yes -	N/A
	Capie, Mills and Wood (2005)	Yes -	N/A
	Tully and Lucey (2007)	Yes -	N/A
	Hammoudeh, Sari and Ewing (2009)	Yes - (long term)	No (long term)
	Hammoudeh, Sari and Ewing (2009)	Yes - (short term)	Yes - (short term)
	Roache and Rossi (2010)	Yes -	Yes -
	Sari, Hammoudeh and Soytas (2010)	Yes - (short term)	Yes - (short term)
U.S. dollar, Yen, Euro and Pound	Pukthuanthong and Roll (2011)	Yes -	N/A
Inflation			
Inflation hedge	Sjaastad and Scacciavillani (1996)	Yes +	N/A
	Sjaastad (2008)	No	N/A
	Mahdavi and Zhou (1997)	No	N/A
	Tully and Lucey (2007)	No	N/A
	Shafiee and Topal (2010)	No	N/A
Macroeconomic news			
CPI release	Christie-David, Chaudhry and Koch (2000)	Yes	Yes
	Roache and Rossi (2010)	No	Yes +
	Cai, Cheung and Wong (2001)	Yes +	N/A
	Blose (2010)	No	N/A
PPI	Christie-David, Chaudhry and Koch (2000)	Yes	No
	Roache and Rossi (2010)	No	No
	Cai, Cheung and Wong (2001)	No	N/A
Unemployment rate	Christie-David, Chaudhry and Koch (2000)	Yes	Yes
	Cai, Cheung and Wong (2001)	Yes +	N/A
GDP release	Christie-David, Chaudhry and Koch (2000)	Yes	No
	Cai, Cheung and Wong (2001)	Yes +	N/A
	Roache and Rossi (2010)	No	No
Other factors			
Safe haven	Baur and McDermott (2010)	Yes	N/A
	Baur and Lucey (2010)	Yes	Yes
Monetary factors	Batten et al. (2010)	Yes	No

2.1.5 Safe haven asset

Gold and silver are sometimes called "safe haven assets" by investors and the financial media. The "safe haven" description of gold is quite common but has rarely been tested in academic studies. Capie, Mills and Wood (2005) find gold to be a hedge against the dollar; they however note that the hedge varies over time and seems to be dependent on unpredictable political and economic events giving indications to gold being a "safe haven" asset. In a recent study, Baur and Lucy (2010) examine the role of gold in financial markets as a hedge and test the hypothesis that gold is a "safe haven" asset against stocks and bonds. Gold has low/negative correlation with most other assets indicating it might act as a natural hedge, and is also positively skewed suggesting the possibility of a "safe haven". Baur and Lucy (2010) use daily spot gold prices from 1995-2005 and find that gold is a "safe haven" asset for stocks and bonds, however, it is an average hedge against equities and is not a hedge against bonds. Baur and McDermott (2010) extend the research to stocks in emerging and developed countries. They find, using daily, weekly and monthly gold return observations over a 30 year period (1979-2009), that investors react to short lived extreme shocks to financial markets. Increasing uncertainty in financial markets leads investors to purchase gold, however, in the most extreme levels of negative market shock, gold co-moves with other assets and does not act as a "safe haven". They argue gold is a "panic buy" after negative market shocks. The evidence suggests gold is a strong "safe haven" asset in most developed countries, however, in emerging markets gold is at best a weak "safe haven" asset.

2.2 Federal Reserve monetary policy changes

2.2.1 Daily data

"The most direct and immediate effects of monetary policy actions, such as changes in the Federal funds rate, are on the financial markets; by affecting asset prices and returns, policymakers try to modify economic behavior in ways that will help to achieve their ultimate objectives" (Bernanke and Kuttner, 2005, pp.1221).

The existing literature has in recent years extensively investigated the influence of Federal Reserve monetary policy decisions on asset prices and term structure both by using daily and intraday data. Among important studies that use daily data are Kuttner (2001), Ehrmann and Fratzscher (2004), Rigobon and Sack (2004), Bernanke and Kuttner (2005) and Jansen and Tsai (2010). Kuttner (2001) uses Federal funds futures rates to distinguish between the response of the term structure to expected and unexpected policy actions over the sample period 1989-2000. He finds that the interest rates response to unanticipated changes is large and highly significant. However, the response to anticipated changes is minimal (Kuttner, 2001).

Ehrmann and Fratzscher (2004, p.722) use a survey-based measure from a Reuters poll the day before FOMC meetings to examine the effects of the "*surprise component of monetary policy decisions on equity returns*". Using a sample of 79 FOMC meetings from 1994-2003 they find evidence that capital intensive cyclical industry sectors react "*two to three times stronger to U.S. monetary policy than non-cyclical industries*" (Ehrmann and Fratzscher, 2004, p.734). Furthermore individual stocks that are; financially constrained, have a small size or a poor credit rating are affected significantly more than other stocks. They argue much of the variation in individual stock responses to monetary policy can be explained by heterogeneous financial constraints. Rigobon and Sack (2004) examine the effects of monetary policy shocks on stock market indexes and long term interest rates over a

similar period as Ehrmann and Fratzscher (2004) from 1994-2001 using a heteroskedasticity-based estimator rather than an event study. They find that an increase in short-term rates results in a decline of stock market indexes. They demonstrate that the response of asset prices can be identified based on an increase in variance of policy shocks on the days of FOMC meetings. They also find that the response from an event study estimate such as Kuttner (2001) has some modest bias compared to the heteroskedasticity-based results though the difference between the methods is not statistically different.

Bernanke and Kuttner (2005) analyse how equity prices react to unanticipated changes in daily and monthly Federal funds futures in the period 1989-2002. They use an event study, while keeping in mind that event-study results are slightly biased (understate the true response to monetary policy) as is argued by Rigobon and Sack (2004)[3]. Using the method formulated by Kuttner (2001) they find similar evidence as Rigobon and Sack (2004) that on average an unanticipated 25 basis point cut in rates results in a 1% increase in broad stock market indices. Bernanke and Kuttner (2005) warn that a possible reason for caution when interpreting the results of daily instead of intraday data is that other news might affect the stock returns. The rate changes might not be independent from other news or events happening over the day of the announcements. The results are however very significant and similar to research that uses intraday data (Bernanke and Kuttner, 2005).

Jansen and Tsai (2010) build on the existing literature on effects of monetary policy surprises on stock returns and evaluate asymmetries in the response between bull and bear markets from 1994-2005. They use an event study and the Kuttner (2001) method to measure monetary policy surprises and find evidence that the effect of a surprise monetary policy change in a bear market is associated with a large statistically significantly negative stock market return. The surprise policy action has in most industries a significantly greater effect in bear markets compared to bull markets (Jansen and Tsai, 2010).

2.2.2 Intraday data [4]

Among important studies that use intraday data to assess the markets response to Federal Reserve monetary policy are Wongswan (2009), Chuliá, Martens and Dijk (2010) and Birru and Figlewski (2010). The use of intraday data can be used as a solution to endogeneity and joint-response issues possibly affecting research using daily data. The intraday data examines the reaction to FOMC´s announcement over a short time frame, "*thus distinguishing the impact of the policy change from the effects of news arriving earlier or later in the day*" (Bernanke and Kuttner, 2005, p.1230). Wongswan (2009) investigates the effect of U.S. monetary surprises on 15 foreign equity indexes from 1998-2004. He uses a two factor model using the method from Kuttner (2001) to find the target rate surprise and a path surprise component, which is often related to the accompanying target rate statement. The study has similar results as most research into the effects that the target rate surprise has a significant effect on foreign equity indexes with an unanticipated rate cut associated with a stock increase from 0.5% to 2.5%.

[3] The event study based estimators are biased as they require a strong assumption regarding heteroskedasticity due to problems with endogeneity, omitted variable bias and joint response issues. The bias understates the true response of financial markets to monetary policy due to these issues. One solution to the bias is to use intraday data instead of daily data thus minimising endogeneity problems.

[4] Both intraday data and daily data are commonly used in the literature. Emphasise in recent years has been on intraday data as access to high frequency data has improved.

Chuliá, Martens and Dijk (2010) examine asymmetric effects of positive and negative monetary policy surprises, on a five minute window around the announcements, on stock returns, volatilities and correlations between 1997 and 2006. They use, as many papers have, the Kuttner (2001) measure of surprise in monetary policy and find evidence that a surprise increase is associated with a significant decline in stock returns. They find that positive surprises have stronger effects on stocks than negative surprises which is a marked difference from the Bernanke and Kuttner (2005) study, which finds little evidence of such asymmetry. Chuliá, Martens and Dijk (2010) find further interesting asymmetrical evidence as news regarding positive rate changes has more effects than the magnitude of the surprise whereas for negative surprises the magnitude was more important.

Birru and Figlewski (2010) use the same methodology as Kuttner (2001) in assessing the surprise policy decision. They investigate the effect the surprise has on stocks using real time high frequency option prices to extract the markets risk neutral probability density function for future stock prices. They discover, contrary to the efficient market hypothesis, the market´s adjustment to the news continues well beyond the initial information release. They confirm that the announcement is important and moves stock prices substantially as markets are more than five times more uncertain on announcement days with uncertainty going down after the announcement. They find evidence of information leakage before the announcement and volatility is higher implying stocks are adjusting to new information.

In one of the few papers investigating commodities, Anzuini, Lombardi and Pagano (2012) study the effects of U.S. monetary policy surprise on commodity prices in general using monthly data from 1970-2008. They use a Vector autoregression system (VAR)[5], not only investigating the co-movements between commodities and interest rates, but instead identifying a monetary policy shock in a VAR system and assessing the effect of each policy shock on the commodity prices. The results show a significant effect of monetary policy surprise on commodities where a 100 basis point expansionary policy shock drives up commodity prices by 4-7%. They assess the robustness of the result using the methodology by Kuttner (2001) using data from 1989-2008 and arrive at similar results.

2.3 Federal Reserve communication

Empirical research on the influence of written statements and verbal communication from the Federal Reserve on financial markets has been scarce though notably growing in recent years. Ehrmann and Fratzscher (2007) use daily data and content analysis to analyse all speeches, interviews and testimony from the 19 members of the FOMC as well as members from the European Central Bank (ECB) and Bank of England. The FOMC data is gathered from 1999 to 2004 and is distinguished into two categories, monetary policy and economic outlook. The results show that the communication of central banks is statistically and economically significant and that they are important drivers of financial markets. Furthermore, asset prices react strongest to members of the FOMC with U.S. markets reacting significantly more to statements from the Federal Reserve chairman, Alan Greenspan, than other members of the FOMC. Results for European markets show similar results for the president of the ECB and Bank of England. This result emphasises the influence Federal Reserve chairmen have on financial markets through communication.

Rosa (2011) uses a high frequency event-study and confirms that Federal Reserve´s monetary policy decisions and statements accompanying the decisions have effects on U.S.

[5] Vector autoregression (VAR) is a statistical model that is used to find linear interdependencies among multiple time series. VAR systems are generalized autoregression models where all variables are treated symmetrically with their own explanation equation.

stocks and volatility indexes. He uses the same method as Kuttner (2001) to assess policy shocks and then divides the FOMC statements into Positive (hawkish), Negative (dovish) and Neutral using content analysis and a numeric scoring system (described in more detail in section 3.3.1). Interestingly the statements accompanying the policy decision have a greater significant effect on stock prices than the unanticipated target rate changes. The results thus show the importance and effect that written words and phrases from the Federal Reserve have on financial markets. Rosa (2011) argues in line with Ehrmann and Fratzscher (2007) that a key driver of stock returns is the central bank´s communication about its future policy intentions. Lucca and Trebbi (2009) use a new method involving an automated scoring technique, instead of the content analysis classification used by Ehrmann and Fratzscher (2007) and Rosa (2011), to analyse the content of FOMC policy statements from 1999-2008 and their effect on Treasury yields. Using intraday data and the Dow Jones Factiva and Google applications to code the statements into numeric variables, they find evidence that shorter term yields react more to the policy decision itself whereas longer-dated Treasury yields react more to the communication in the FOMC statements. Furthermore when using daily data and VAR models they find the same result as Rosa (2011); that FOMC communication is a more important factor than the policy decisions themselves.

Hayo, Kutan and Neuenkirch (2008) and Hayo, Kutan and Neuenkirch (2011) use a GARCH model and further improve the research by Ehrmann and Fratzscher (2007) by directly analysing all speeches from 1998-2009 delivered by members of the FOMC. They categorise positive and negative communication in separate variables allowing for asymmetric reactions to good and bad news. Hayo, Kutan and Neuenkirch (2008) have similar findings as Ehrmann and Fratzscher (2007), when investigating the effects on stock market index returns, Treasury bills and notes. The chairman of the Federal Reserve has more influence than other members of the FOMC and the communication has significant effects on the market. Furthermore the reaction to the Federal Reserve communication is significantly more during the financial crisis from 2007-2009. When investigating the effect on commodity price volatility, Hayo, Kutan and Neuenkirch (2011) find that the communication has significant effects on price volatility, with expected rate changes decreasing volatility and unexpected rate changes increasing volatility. These results give weight to the importance of further research into the effects of communication from the Federal Reserve such as speeches, especially from the chairmen, and how they affect different markets.

To conclude, the existing literature has found evidence that the recent price increases of gold and silver in the 21st century can be attributed to rising oil prices, decreasing forward sales by gold and silver producers in the derivatives market, depreciation of the U.S dollar and other world currencies and increasing demand from investors looking for a “safe haven” asset. There is debate whether gold and silver are protectors against rising inflation and that the rising precious metals prices serve as indicators of rising future inflation. There is also an open debate if the gold and silver markets react to macroeconomic news such as the CPI and GDP releases.

The existing literature is almost unanimous in its findings that Federal Reserve´s monetary policies are important drivers of financial markets and unexpected changes to policy decisions have significant effects on markets. Furthermore there is evidence that the statements accompanying the rate decisions are more important than the decisions themselves. The speeches of FOMC members have also been found to have significant effects on financial markets with the communication of Federal Reserve chairmen having significantly more effect than from other FOMC members. The post announcement statements that accompany monetary policy decisions have however been found to be more

important than the communication such as speeches, interviews and testimonies from the Federal Reserve.

The lack of research into the relationship between gold, silver and the Federal Reserve monetary policy and communication is peculiar as gold and silver are important assets within the field of finance. None, which the author knows of, have attempted to investigate the response of the gold and silver markets, to the communication from Federal Reserve chairmen and if the market reacts differently to different chairmen. There is therefore a gap in the research on the effects of Federal Reserve policies on the gold and silver market. This study will attempt to shed light on this relationship which has seemingly been neglected by researchers.

3. Research methodology and data

3.1 Data

The sample is from 18th May 1999 – 31st May 2012. The date 18th May 1999 is the day the FOMC began to issue balance of risk statements accompanying the rate decisions and is therefore chosen as the sample starting point. Daily observations are used. The unscheduled FOMC meeting on the 17th of September 2001 is excluded from the data set as it was the first day markets began trading after the terrorist attacks on 11th September 2001. The unscheduled meetings on 10th August 2007 and 11th March 2008 are excluded as there was no rate decision and no balance of risk assessment. Since the beginning of the financial crisis, which began in December 2007 according to the National Bureau of Economic Research (NBER), the monetary policy adapted by the Federal Reserve has changed. There is now a zero Federal funds target rate and the accompanying statements to the FOMC meetings contain information regarding new policy methods such as quantitative easing and other measures taken by the Federal Reserve during the crisis period. These measures are beyond the scope of this study and thus we compute the effect of Federal Reserve monetary policy decisions and statements over two different periods; 1) the period prior to the financial crisis: May 1999 to December 2007 and 2) the period containing the financial crisis: May 1999 to June 2012.

All speeches and testimonies from the Federal Reserve chairmen are used over the sample period except for the instances when two or more communications are classified on the same day, which happens on ten occasions where seven speeches from Greenspan (15th October 1999, 20th June 2000, 22nd April 2002, 25th September 2002, 19th November 2002, 11th March 2005 and 2nd December 2005) and two speeches (13th April 2010 and 19th November 2010) and one testimony (30th September 2010) from Bernanke are excluded. News reports from media sources such as Reuters and Bloomberg are examined to determine which communication is more important to markets. Communication taking place after the closing of markets is classified as taking place on the next working day.

GoldB: Gold bullion spot price from Handy & Harman[6]. The price is based on U.S. dollars per Troy Oz; SilverB: Silver bullion spot price from Handy & Harman. The price is based on U.S. dollars per Troy OZ.

[6]Handy and Harman was founded in 1867 as a precious metals company. Today they are a precious metals fabricator and refiner. They began issuing daily gold and silver prices for American producers and today the prices are accepted worldwide as a guide to valuing gold and silver. This is the price Handy & Harman can buy gold and silver.

GoldF: The gold futures data is the one month forward contract attained from the continuous futures series from Datastream with switchovers at the first day of a new month. The futures contracts are the daily CMX-Gold-100-Oz; SilverF: The silver futures data is the one month forward contract attained from the continuous futures series from Datastream with switchovers at the first day of a new month. The futures contracts are the daily CMX-Silver-5000-Oz.

HUI: A gold stock index which consists of 15 of the largest gold producer companies in the world. It is listed on the AMEX stock exchange under the symbol HUI. It is a widely watched gold index, founded in 1996; FTSE: The FTSE gold mines index contains all gold mining companies that have a sustainable gold production of a minimum of 300,000 ounces a year and have at least 51% of their revenue coming from mining gold. The index began trading 31st December 1992. No index was available for silver equities.

GLD: The largest gold fund is the New York SPDR Gold Trust ETF, which accounts for over 80% of exchange traded gold products. It began trading 18th November 2004. The trust holds physical gold bullion.

SLV: The largest silver fund is the iShares Silver Trust ETF and it began trading 28th April 2006. The trust holds physical silver bullion.

Federal funds futures are contracts traded on the Chicago Board of Trade. They are called "30 Day Federal Funds Futures" with the implied futures rate calculated as 100 minus the contract price. The futures data is collected from Datastream. The FOMC policy decisions and statements and Federal Reserve chairmen speeches and testimonies are gathered from the Federal Reserve database available at: http://www.federalreserve.gov/newsevents/default.htm

PMI: The purchasing manager index is constructed by the Institute for Supply Management and is a survey of around 400 purchasing managers in the manufacturing sector regarding the sentiment towards their industry. The index is published the first day of each month and covers the previous month´s data. Available at: http://www.ism.ws/ismreport/content.cfm?itemnumber=10752;

CPI: The median inflation expectation is a survey done by the University of Michigan and displays the 12 months future inflation expectation. Data is gathered from the St. Louis Fed AIRFRED database.

3.2. Methodology

The daily logarithmic returns are calculated as follows:

$$\ln(r_t) = \ln\left(\frac{P_t}{P_{t-1}}\right) \quad (1)$$

Where P_t is the closing price on the day of an FOMC meeting or a communication event by a Federal Reserve chairman and P_{t-1} is the closing price on the day before such an event.

Table 5 details the summary statistics for the data in the period prior to the financial crisis, May 1999 to December 2007. Statistics for the second period are available in Appendix B. The gold stock indexes, FTSE and HUI, show the most volatility. Also notable is that silver is more volatile than gold. It can be observed that the gold and silver market variables do not show signs of fifth order autocorrelation according to the Ljung-Box statistic

and 4 out of 6 gold and silver series are normally distributed according to the Jarque-Bera test at the 5% statistical significance level.

Table 5: Summary statistics for period prior to financial crisis

The table displays descriptive statistics. Observations are on days of FOMC meetings, May 1999-December 2007 excluding the 17th September 2001, 10th August 2007 and 11th March 2008 meetings. The daily logarithmic returns are calculated from closing price data, obtained from Datastream. All return statistics are expressed in percentage terms. Std. Dev. depicts standard deviation. Max. and Min. depict Maximum and Minimum. Kurt. And Skew stand for Kurtosis and Skewness. J-B depicts the Jarque-Bera test p-value. The J-B tests for normality in the return data. L-B(5) shows the Ljung-Box test p-value for the null hypothesis of no 5th order autocorrelation. Obs. stands for observations. Fed is the actual Federal funds target rate change. UMP is the unexpected monetary policy change. Index is a variable constructed by the author from the FOMC statements. FOMCST is the surprise component of the FOMC statements. For other data variables see section 3.1.

Variable	Mean	Std. Dev.	Max.	Min.	Kurt.	Skew.	JB	L-B	Obs.
Fed	0.00	0.24	0.50	-0.50	3.0	-0.8	0.03	0.00	72
UMP	-0.02	0.12	0.15	-0.88	39.5	-5.5	0.00	0.43	72
Index	0.17	0.79	1.00	-1.00	1.7	-0.3	0.04	0.00	72
FOMCST	0.02	0.39	1.00	-0.96	4.1	-0.3	0.09	0.33	72
GoldB	0.08	0.93	4.00	-2.64	7.1	0.4	0.00	0.61	72
GoldF	0.13	0.79	2.49	-1.60	3.5	0.5	0.17	0.40	72
SilverB	0.14	1.47	5.48	-6.93	10.8	-1.0	0.00	0.13	72
SilverF	0.06	1.08	2.62	-3.40	3.8	-0.4	0.12	0.85	72
FTSE	0.20	2.25	5.78	-4.55	2.7	0.2	0.66	0.80	72
HUI	0.29	2.20	7.50	-3.83	3.6	0.6	0.09	0.82	72

Measuring effects of monetary policy on asset prices can be difficult as the market is generally forward looking; already incorporating expected policy changes into asset prices. Thus the unexpected changes need to be isolated from the expected. The focus on unexpected changes helps with issues such as endogeneity and simultaneity and allows for a more clear reaction to Federal Reserve monetary policy (Bernanke and Kuttner, 2005). Using the same methodology as Kuttner (2001), the unexpected changes in the Federal funds rate are extracted from the spot-month Federal funds futures contracts. For a FOMC meeting taking place on day *t* of month *m* the unexpected rate change is derived from the change in the Federal futures contract price relative to the price on the day prior to the event. The change in the futures rate must be scaled, due to the contract´s settlement price being based on the monthly average Federal funds rate, by the number of days in the relevant month that are affected by the change. The Federal funds futures prices are a convenient way to identify unexpected target rate changes as they "*embody expectations of the effective Federal funds rate, averaged over the settlement month*" (Bernanke and Kuttner, 2005, p.1223-1224). The unexpected changes are calculated as follows:

$$UMP_t = \frac{D}{D-t}(f^0_{m,t} - f^0_{m,t-1}) \quad (2)$$

Where UMP_t is the unexpected monetary policy change at day t of month m, D is the number of days in month m and $f^0_{m,t}$ is the m month´s futures rate. As the scaling factor in Eq. (2) becomes very large at the end of the month, the day t target rate error can become large. Thus if the policy decision takes place in the last 3 days of the month, the 1-month futures rate change is used. Additionally if the rate change takes place in the first day of the month, the futures rate from the last day of the previous month, $f^0_{m-1,D}$, is used as opposed to $f^0_{m,t-1}$.

The unexpected change can be in the opposite direction to the change itself (for example if a rate hike is higher than expected). The market can also react if there is a lack of a change, if the market was expecting a change. As this is an event-study analysis the timing of the announcement is important. As of February 1994 the Federal Reserve began announcing the monetary policy decision on the same day as the decision was made. The decisions are usually announced around 2:15 p.m. Eastern time before the close of the futures market. Thus the rate changes are assigned to the dates of announcements eliminating almost any timing uncertainty.

Just as with the unexpected monetary policy decisions the markets should incorporate into prices the expectation of the statements before each FOMC meeting. Therefore market expectations for the future FOMC statements need to be computed in order to extract the unexpected changes in the FOMC statements. To compute the surprise statement component the methodology from Rosa (2011) is used. The methodology is in three parts.

First, by using content analysis the FOMC statements are analysed for the tone regarding future policy decisions and coded into a wording *Index* variable (-1, 0, 1). The variable takes the value of 1 for positive statements that imply a stronger economic outlook or a possible policy "tightening"; the value of -1 for negative statements that imply a weaker economic outlook or a possible policy easing and 0 for statements that are neutral to the future policy. This method has the disadvantage of being the authors own judgement of the statement tone regarding future policy intentions. To avoid the possibility of a bias or a wrong coding in the analysis, Ragnar Már Skúlason independently analysed a random sample of 12 statements of the 110 meetings that took place during the sample period. The coding of the statements from the author and Skúlason were identical for all the statements. Furthermore in an independent analysis Rosa (2011) coded the FOMC statements and all but two meetings had the same coding as in this study. This result is reassuring and minimizes the possibility of a wrong FOMC statement coding in the study. The results of the index variable coding can be seen in Appendix C. An example of a full FOMC statement and its coding can be seen in Appendix D. The key wording and sentences used to code the statements can be seen in Appendix E.

A forecast regression is used to compute the probability of each statement taking on the three values in the *Index* variable. The probability of each *Index* value is then used to compute the markets expectation for the FOMC statement announcement. As the dependant variable in the forecast regression can only take on three values (-1, 0, +1), the chosen method is an ordered response probit model. The model is a generalization of a probability model and allows for more than two outcomes. The model uses the same method as a binary model as the observed response of the dependant variable is computed by using a latent variable, which is dependent on a set of linear explanatory variables. The actual response (the forecasted tone of the FOMC statement) depends on where the latent variable is with regards to threshold coefficients in Eq. (4). The higher the value on the right hand side in Eq. (3) the more likely the statements should contain a tone of policy tightening. The forecast regression is the following:

$$Index_t^* = Index_{t-1} + PMI_{t-1} + CPI_{t-1} + Slope_{t-1} + \varepsilon_t \quad (3)$$

$$\begin{aligned} Index_t &= -1 \quad if \quad Index_t^* \leq \lambda_1 \\ Index_t &= 0 \quad if \ \lambda_1 < Index_t^* \leq \lambda_2 \\ Index_t &= 1 \quad if \quad Index_t^* > \lambda_2 \end{aligned} \quad (4)$$

where $Index_t^*$ is the optimum wording index variable, $Index_{t-1}$is the previous index value, PMI_{t-1} is the purchasing managers index survey, $CPI_{t-1}$is the median inflation expectation for the next 12 month and $Slope_{t-1}$ is the short term yield curve computed as the difference between 3month ahead Federal fund futures rate and the current months Federal funds futures rate. $Index_t$ is the latent variable and λ_1 and λ_2 are the threshold coefficients. All the explanatory variables are known to markets the day before each FOMC meeting.

The forecast regression method assumes firstly, that the Federal Reserve's assessment of the future policy decisions and economic outlook shows some persistence; hence the prior FOMC statement value is included. Secondly, macroeconomic factors can predict the FOMC statements future policy intentions. The FOMC statements frequently reference inflation and growth in the economy as reasons for the Federal Reserve´s future policy outlook. Thus the forward looking PMI index survey and the CPI index survey are used as macroeconomic indicators. Finally the slope of the term structure of the Federal Funds Futures rates is likely to contain the markets expectations regarding future monetary policy changes. For example if the slope is negative (the three month forward rate is lower than the current rate) the market expects the central bank to cut rates in the next three months. To compute the markets expectations for the future statement the formula is as follows:

$$E_{t-1}[Index_t] = \sum_{i=-1}^{1} \Pr(Index_t = i) * i \quad (5)$$

where $E_{t-1}[Index_t]$ is the conditional market expectation given the information available the day before each announcement. The probability of each index value $\Pr(Index_t = i)$ (1, 0,-1) is computed in the ordered response probit model.

The final part is to compute the surprise component of the FOMC statement. It is calculated as the actual FOMC announcement, which is coded in the variable $Index_t$, minus the expected announcement, $E_{t-1}[Index_t]$:

$$FOMCST_t = Index_t - E_{t-1}[Index_t] \quad (6)$$

To measure the Federal Reserve chairmen communications (speeches and testimonies) the computerized content analysis Diction software 6.0 is used. The Diction software is designed to analyse, for example, public speeches and is based on the assumption that higher frequencies of words in a given text imply that the word is more meaningful and more important than infrequent words. Diction uses searches of over 10,000 words and 31 dictionaries to analyse each communication.

There are understandably both advantages and disadvantages to using such computerized content analysis. The main disadvantage is that words are taken out of context. The main

advantage is that computerized content analysis is completely impartial and reliable in analysing the chairmen´s communication. It can also detect language characteristics that are missed by humane analysis.

All speeches and testimonies are analysed by Diction which has five master language variables and this study investigates them all to assess the style and sentiment in the Federal Reserve chairmen communication. The five master language variables are *Certainty, Activity, Optimism, Realism* and *Commonality*. The variable *Certainty* is chosen as uncertainty is an important part of financial markets. The chairman´s *Optimism* was deemed an important variable as markets can interpret the language of the chairman for hints regarding the future outlook of financial markets. *Activity* and *Realism* give important reference to the way the chairman describes the time horizon for policy actions and describes the conditions of the economy. *Commonality* was included in the study as the fifth master variable. Diction computes the master variables by standardizing scores for each language characteristics that constitute each master variable. For the purpose of this study we take the logarithm of each master variable in order to have the log-log functional regression form for easier interpretation. For further information on how Diction computes each variable and the meaning of each variable see Appendix F.

An example of a communication from Alan Greenspan is the speech before the Conference on Bank Structure and Competition, 6th May 2004. The Diction score is: *Activity* 51.66, *Certainty* 34.37, *Optimism* 47.3, *Realism* 47.1 and *Commonality* 50.04. The *Certainty* score is the lowest for Greenspan´s communication and the gold and silver markets fell considerably, between 1% and 5%, on the day of the speech. Part of Greenspan´s speech is as follows:

> "*Nonetheless, a paradigm encompassing globalization and innovation, far more than in earlier decades, appears to explain the events of the past ten years better than other conceptual constructs. If this is indeed the case, because there are limits to how far globalization and the speed of innovation can proceed, the current apparent rapid pace of structural shift cannot continue indefinitely. A couple of weeks ago, I indicated in testimony to the Congress that the outlook for the next year or two has materially brightened. But the outlook for the latter part of this decade remains opaque because it is uncertain whether this transitional paradigm, if that is what it is, is already far advanced and about to slow, or whether it remains in an early, still vibrant stage of evolution*." (Greenspan, 2004, p.4).

An example of a communication from Ben Bernanke is the testimony before the Committee on the Budget, 3rd March 2009. The Diction score is: *Activity* 46.19, *Certainty* 41.98, *Optimism* 44.35, *Realism* 37.42 and *Commonality* 52.32. The *Optimism* score is the third lowest in all of Bernanke´s communication and both the gold and silver bullion and futures markets fell 3% on the day of the testimony. Part of Bernanke´s testimony is as follows:

> "*The recent near-term indicators show little sign of improvement. Businesses shed 600,000 jobs in January, about the same pace of job loss as in November and December, and the unemployment rate jumped to 7.6 percent. Moreover, the number of claims for unemployment insurance has moved higher since mid-January, suggesting that labor market conditions may have worsened further in recent weeks. In reaction to the deteriorating job market, the sizable losses of equity and housing wealth, and the tightening of credit conditions, households have continued to rein in their spending.*

Home sales and new construction have continued to decline despite lower mortgage rates, reflecting the uncertain economic environment and the expectation of many potential buyers that home prices have further to fall." (Bernanke, 2009, p.2.).

The ordinary least squares regression method is used to estimate the effect of monetary policy surprises on the gold and silver markets. The following ordinary least squares regression is computed for each gold and silver variable:

$$G_t = \alpha + \beta_1 UMP_t + \beta_2 FOMCST_t + \varepsilon_t \tag{7}$$

where G_t represents the return for the gold and silver variables. The variable UMP_t is the unexpected monetary policy rate change and $FOMCST_t$ is the variable for the surprise component of the FOMC statements. White Heteroskedasticity-Consistent standard errors, ε_t, are used in all regressions to account for any heteroskedasticity.

To assess the effects of Federal Reserve chairmen communications the Generalized Autoregressive Conditional Heteroskedasticity model (GARCH(1,1)) is used. The ordinary least squares regression model has the assumption of homoscedasticity, however, financial time series data is often characterized by periods of volatility clustering, skewness and leptokurtosis. The GARCH model is intended to deal with these issues, thus the outcomes and interpretations are more robust (Engle, 2001). Mills (2004) does statistical analysis of daily gold return data and finds that the series is highly leptokurtic. He also finds evidence of volatility clustering and long-run correlation.

The mean equation for the GARCH(1,1) communication regressions in section 4.2 is:

$$\begin{aligned} Y_t = c + Activity_t + Certainty_t + Optimism_t + Realism_t \\ + Commonality_t + \varepsilon_t \approx t.d.(0, \sigma_t^2, \nu) \end{aligned} \tag{8}$$

where c is a constant, $Activity_t$, $Certainty_t$, $Optimism_t$, $Realism_t$ and $Commonality_t$ are language variable from Diction 6.0 for the speeches and testimonies of each Federal Reserve chairman and ε_t is the error term with conditional variance and normal distribution except for SilverF (in the Greenspan analysis the Student t distribution was used to achieve convergence in the GARCH model). The variance equation for the GARCH (1, 1) is:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \delta_1 + \delta_2 + \delta_3 + \delta_4 + \delta_5 \tag{9}$$

where α_1 is the ARCH(1) factor and $\beta_1$is the GARCH(1) factor and δ_1, δ_2, δ_3, $\delta_4$and δ_5 are the language variables from Diction 6.0 (*Activity*, *Certainty*, *Optimism*, *Realism* and *Commonality*).

4. Empirical Results

4.1 Effect of unexpected monetary policy

Period to the financial crisis:

To investigate the effects of unexpected monetary policy and statements on the gold and silver market, the surprise component of the FOMC statement needs to be extracted from a forecast regression of the expected tone of FOMC statement, as described in section 3.3.2.

Table 5: Forecast regression for expected tone of FOMC statements

The table displays the FOMC statements tone forecast regression. The current FOMC Index value is regressed against the prior FOMC index value, PMI (purchasing managers' index), CPI (median inflation expectations) and Slope (slope of the short term yield curve, difference between the Federal funds 3month ahead futures rate and the current month futures rate). Observations are on days of FOMC meetings, May 1999-December 2007 excluding the 17th September 2001, 10th August 2007 and 11th March 2008 meetings. The econometric method is Maximum Likelihood-Ordered Probit (Quadratic hill climbing). Huber/White standard errors are used to compute t-statistics contained in parenthesis. L-B(1) shows the Ljung-Box test p-value for the null hypothesis of no first order autocorrelation. Coefficients marked with an asterisk ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	Index
$Index^{old}$	1.217***
	(3.649)
PMI	0.186***
	(2.964)
CPI	0.894
	(1.583)
Slope	1.768***
	(2.634)
Threshold coefficients	
λ_1	10.757***
	(3.048)
λ_2	13.694***
	(3.658)
L-B(1)	0.907
Log Likelihood	-29.641
Pseudo R-squared	0.612
Observations	71

The results for the expected FOMC tone regression is shown in table 6. From the table it is evident that the explanatory variables are statistically significant, except the CPI survey measure. They explain reasonably well the FOMC policy intentions in the statements as the goodness of fit measure Pseudo R-squared is 0.61. Thus the computed surprise component of the FOMC statements is assumed a reasonable measure of the unexpected news that the market did not expect prior to each FOMC meeting.

Table 7 displays the reaction of gold and silver markets to the unexpected changes in; 1) FOMC Federal funds target rate decisions and 2) the FOMC statements released after the target rate decisions. The results, computed using Eq. (7), show that the unexpected monetary policy change significantly affects gold and silver bullion prices. A 1% percentage surprise rate hike is associated with a 1.28% increase in gold bullion prices and a 1.53% increase in silver bullion prices. This result is quite interesting as it gives weight to prior research such as Capie, Mills and Wood (2005) and Baur and Lucey (2010) that gold has certain hedging and "safe haven" capabilities against other financial assets. Studies, such as Bernanke and Kuttner (2005) and Rigobon and Sack (2004), investigating the effect of surprise policy change on stock markets have usually found that a surprise rate hike is associated with a decline in stock prices, opposite to the results for gold and silver bullion prices. The gold and silver futures have the same sign as the bullion returns but are not significant. This result is similar to the Roache and Rossi (2010) finding where the FOMC rate decisions do not affect the gold futures price. The gold stock indexes have a negative sign as is expected from equity markets. However, the results are not significant.

The R square statistic is low for all regressions indicating the variation in gold and silver market returns are explained by other news than Federal Reserve monetary policy and statements. The unexpected change in the FOMC statements does not significantly affect any of the markets except silver futures. FOMC statements thus do not seem to contain news that is important to gold and silver markets. This result is opposite to equity markets as Rosa (2011) finds that up to 90% of the explainable variations in equity returns from FOMC monetary policy are due to unexpected information in the FOMC statements. Silver futures are however significantly affected by the FOMC statements and a surprise increase of 1 (equivalent to a surprise statement change from neutral to positive) is associated with a decline in silver futures prices by 0.7%. Furthermore for silver futures both the unexpected policy decision and the unexpected FOMC statements are jointly significant displayed by the F-statistic in table 7. None of the other series are jointly significant.

Table 6: Effect of unexpected monetary policy and surprise statements on gold and silver prior to the financial crisis

The table displays results from regressions of gold and silver daily return series´ on a constant, unexpected monetary policy change (UMP) and surprise FOMC statements (FOMCST). The ordinary least squares econometric method is used with White Heteroskedastisity-Consistent t-statistics in parenthesis. There are 72 observations on days of FOMC meetings from May 1999 to December 2007 excluding the 17th September 2001, 10th August 2007 and 11th March 2008 meetings. The daily returns are computed from the closing price on the day prior to FOMC meetings to the closing price on the day of the meetings. Price data is gathered from Datastream. Adj. R^2 stands for adjusted R^2. F-statistic tests the null hypothesis that all explanatory coefficients equal zero. Coefficients marked with an asterisk ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	GoldB	GoldF	SilverB	SilverF	FTSE	HUI
C	0.001	0.001	0.002	0.001	0.002	0.003
	(0.93)	(1.427)	(1.036)	(0.713)	(0.721)	(0.99)
UMP	1.281**	0.073	1.53*	0.824	-0.961	-1.616
	(2.337)	(0.243)	(1.761)	(1.162)	(-0.559)	(-1.373)
FOMCST	0.004	-0.001	-0.007	-0.007**	-0.004	0.004
	(1.328)	(-0.579)	(-1.32)	(-2.284)	(-0.691)	(0.594)
R^2	0.046	0.005	0.054	0.071	0.007	0.014
Adj. R^2	0.019	-0.024	0.027	0.044	-0.022	-0.015
F-statistic	1.669	0.158	1.971	2.647*	0.25	0.491

The financial crisis - full sample period:

This section investigates the effect of 1) FOMC Federal funds target rate decisions and 2) the FOMC statements released after the target rate decisions over the entire sample period from May 1999 to June 2012. As with the previous period analysis, to compute the surprise component of the FOMC statements a forecast regression is estimated. Results, which can be seen in Appendix A, are very similar those shown in table 6 for the period prior to the financial crisis.

Table 8 shows the results computed using Eq. (7). When the entire sample period is analysed both gold and silver bullion are no longer significantly affected by unexpected monetary policy change and the coefficients are not statistically different from zero. It is not entirely surprising that the unexpected monetary policy change insignificantly affects the gold and silver bullion and futures markets over the period as markets have been able to better anticipate the rate movements of the Federal Reserve since rates reached the zero bound level in December 2008. Unexpected monetary policy change has a statistically significant effect on the gold stock index, FTSE, and the gold ETF, GLD, where a 1% surprise rate hike is associated with a decline of 9.88% and 3.28% respectively. The HUI gold stock index is also very close to being significantly affected and has a similar size reaction as the FTSE gold stock index. The results for the gold stock indexes are in line with prior research investigating the effects on stock markets in general. The results also show that gold equities have a larger absolute size reaction to unexpected Federal Reserve policy than the broader stock markets in previous studies.

Table 7: Effect of unexpected monetary policy and surprise statements on gold and silver including the financial crisis

The table displays results from regressions of gold and silver daily return series on a constant, unexpected monetary policy change (UMP) and surprise FOMC statements (FOMCST). The ordinary least squares econometric method is used with White Heteroskedastisity-Consistent t-statistics in parenthesis. Observations are on days of FOMC meetings from May 1999 to June 2012 excluding the 17th September 2001, 10th August 2007 and 11th March 2008 meetings. All series have 110 observations expect GLD and SLV which have 63 and 52. The daily returns are computed from the closing price on the day prior to FOMC meetings to the closing price on the day of the meetings. Price data is gathered from Datastream. Adj. R^2 stands for adjusted R^2. F-statistic tests the null hypothesis that all explanatory coefficients equal zero. Coefficients marked with an asterisk ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	GoldB	GoldF	SilverB	SilverF	FTSE	HUI	GLD	SLV
C	0.002	0.001	0.002	0	0.004	0.006**	0.001	0.004
	(1.422)	(0.779)	(0.754)	(0.056)	(1.536)	(2.178)	(0.479)	(1.145)
UMP	0.164	-1.293	-1.13	-0.841	-9.88**	-8.416	-3.276*	-2.016
	(0.131)	(-1.605)	(-0.838)	(-0.596)	(-2.045)	(-1.642)	(-1.988)	(-0.781)
FOMCST	0.003	0	0.003	0	-0.011	-0.006	-0.001	0.009
	(1.043)	(0.141)	(0.719)	(0.014)	(-1.531)	(-0.742)	(-0.235)	(1.09)
R^2	0.014	0.024	0.008	0.003	0.143	0.1	0.091	0.035
Adj. R^2	-0.005	0.006	-0.011	-0.016	0.127	0.083	0.061	-0.004
F-statistic	0.741	1.321	0.411	0.137	8.931***	5.962***	3.015*	0.897

None of the series are affected by the surprise FOMC statements, which is a surprising result given the increased importance of the FOMC statements after the Federal Reserve began employing a zero target rate policy. However, according to the F-statistic the unexpected policy change and the surprise component of the FOMC statements are jointly significant for both gold stock indexes, FTSE and HUI and also for the gold ETF, GLD.

As in the previous period analysis, the Federal Reserve communication does not explain a big part of the return variation of the gold and silver market displayed by the R-squared statistic, which is low for all series except the gold stock indexes, FTSE and HUI. As the financial crisis is included in the analysis the percentage of variation in the returns of FTSE and HUI explained by the surprise Federal Reserve monetary policy and statements, rises considerably as the Adjusted R^2 goes from negative to 0.127 and 0.083, respectively.

4.2 Federal Reserve chairmen communication

This section analyses the Federal Reserve chairmen communication (speeches and testimonies) with computerized content analysis software Diction 6.0. The communications from former chairman Alan Greenspan and current chairman Ben Bernanke are analysed and compared using five language characteristics variables computed from the Diction 6.0 software. These variables are *Activity*, *Certainty*, *Optimism*, *Realism* and *Commonality*.

Table 9 displays the mean and standard deviation for each communication type and language variable for each chairman. The table also shows the t-statistics for hypothesis tests on whether two communication types have the same mean for a certain language variable. For example the hypothesis test in the last row of panel A tests whether the speeches and

testimonies by Alan Greenspan have the same mean for a given language characteristic. Panel C computes the same tests but between each chairmen. The main finding from both Panel A and Panel B is that there does not seem to be a difference in the language used in speeches and testimonies, except there is significantly more *Certainty* contained in Ben Bernanke´s testimonies compared to his speeches.

The main finding of Panel C, where the communication of chairmen is compared displays a significant difference in the language between Greenspan and Bernanke. When all communication from the chairmen is compared (both speeches and testimonies) the tests show that there is significantly more *Activity* and *Realism* in Greenspan´s communication whereas there is significantly more *Optimism* in Bernanke´s communication. The amount of *Certainty* and *Commonality* is not statistically different between chairmen. The results are similar when their speeches are compared, except Bernanke has significantly more *Commonality* than Greenspan and there is no longer a difference in the *Optimism* between them. When their testimonies are compared Greenspan has more *Realism* and Bernanke more *Optimism*, however, there is no difference in *Activity, Certainty* or *Commonality.* The results show that Bernanke has overall more *Optimism* whereas Greenspan has more *Activity* and *Realism* in his communication.

Panel A of table 10 displays the summary statistics for the gold and silver market return series' on days of chairmen communication. The gold stock indexes are the most volatile with silver more volatile than gold. The Jarque-Bera test rejects the hypothesis of normality of the return data for all series'. The table also shows that tests of fifth order autocorrelation are significant for both FTSE and HUI as shown by the Ljung-Box p-value. All series show signs of leptokurtosis with Kurtosis values considerably higher than 3, which is the value for a normal distribution.

Panel B shows the results of tests for ARCH effects in the return series data. Each series is regressed on three lagged values and a constant. The standardized squared residuals are then tested for autocorrelation with the Ljung-Box test p-values at 9 lags. All series except GoldF and GoldB show signs of 9^{th} order autocorrelation in the squared-residuals as the test is rejected at the 5% level of significance. Formal tests of ARHC effects are also computed where the squared residuals are regressed on 5 lags and a constant. The results are shown in the F-stat and Chi-squared test p-values which show significant signs of ARCH effects in GoldB, FTSE and HUI. Thus these results show the series´ show signs of ARCH effects and leptokurtosis.

Table 8: Summary statistics and hypothesis tests – language variables

The table displays selected descriptive statistics for Diction 6.0 software language variables and Federal Reserve chairmen communication types. Observations are on days when Federal Reserve chairmen hold speeches and testimonies. The sample consists of 386 observations; 57 testimonies and 132 speeches from Alan Greenspan and 54 testimonies and 143 speeches from Ben Bernanke. The period is from 20th May 1999 to 10th May 2012. Std. Dev. depicts standard deviation. Test depicts the t-statistic for the null hypothesis of equal language variable means between different communication types and different chairmen using a t-Test assuming unequal variance. Coefficients marked with an asterisk * indicate statistical significance at the 5% level.

Communication type	Statistic	Activity	Optimism	Certainty	Realism	Commonality
Panel A: Alan Greenspan						
Testimony	Mean	49.76	50.42	46.38	46.72	52.00
	Std. Dev.	2.92	1.83	2.83	2.66	11.07
Speech	Mean	50.05	50.34	46.50	46.64	50.48
	Std. Dev.	2.44	2.21	2.59	2.09	1.93
All	Mean	49.96	50.36	46.46	46.67	50.94
	Std. Dev.	2.59	2.10	2.66	2.27	6.30
Test	Speech=Testimony	0.670	-0.245	0.263	-0.192	-1.03
Panel B: Ben Bernanke						
Testimony	Mean	49.01	51.52	46.77	45.07	51.99
	Std. Dev.	2.65	3.18	2.75	2.04	2.49
Speech	Mean	48.15	50.96	45.68	45.16	51.71
	Std. Dev.	4.58	3.04	4.28	2.69	2.84
All	Mean	48.38	51.12	45.98	45.14	51.79
	Std. Dev.	4.15	3.08	3.95	2.52	2.75
Test	Speech=Testimony	-1.635	-1.105	-2.117*	0.246	-0.68
Panel C: Chairmen comparison						
Test	Greenspan All = Bernanke All	4.513*	-2.816*	1.427	6.264*	-1.710
	Greenspan speech = Bernanke speech	4.356*	-1.957	1.944	5.124*	-4.241*
	Greenspan test = Bernanke test	1.421	-2.223*	-0.735	3.668*	0.007

Table 9: Summary statistics for return series' in chairmen analysis

The table displays descriptive statistics in Panel A. Panel B depicts Heteroskedasticity tests for the regression of the dependant variables on three lags of the same variable. Observations are on days when Federal Reserve chairmen hold speeches and testimonies. The period is from 20th May 1999 to 10th May 2012. The daily logarithmic returns are calculated from closing price data, obtained from Datastream. All return statistics are expressed in percentage terms. Std. Dev. depicts standard deviation. Jarque-Bera tests for normality in the return data and shows the p-values. L-B(5) shows the Ljung-Box test p-value for the null hypothesis of no 5th order autocorrelation. F-stat. and Chi-Sq.-stat. depict p-values for the null hypothesis of no ARCH effects in the squared residuals of the lagged regressions. The L-B(9) is the Ljung-Box test p-value for the null hypothesis of no autocorrelation in the standardized squared residuals 9th order lags.

	GoldB	GoldF	SilverB	SilverF	FTSE	HUI
Panel A: Summary Statistics						
Mean	-0.018	-0.048	-0.022	-0.097	-0.198	-0.193
Std. Dev.	1.223	1.347	2.141	2.346	2.621	2.775
Maximum	7.006	8.887	7.377	7.549	12.020	9.804
Minimum	-5.319	-7.574	-12.796	-14.794	-14.862	-15.527
Kurtosis	7.317	11.006	9.559	12.337	6.884	6.253
Skewness	0.041	0.202	-1.101	-1.654	-0.529	-0.518
Jarque-Bera	0.000	0.000	0.000	0.000	0.000	0.000
L-B(5)	0.384	0.695	0.287	0.418	0.039	0.004
Observations	386	386	386	386	386	386
Panel B: Lagged value regressions - Heteroskedasticity tests						
F-stat.	0.049	0.965	0.209	0.134	0.000	0.000
Chi-Sq.-stat.	0.050	0.964	0.208	0.134	0.000	0.000
L-B(9)	0.094	0.985	0.000	0.000	0.000	0.000

4.2.1 Federal Reserve chairmen sentiment influence

This section investigates the effect Federal Reserve chairmen sentiment, found in the speeches and testimonies from Greenspan and Bernanke, has on the gold and silver markets. Table 11, panel A, displays the results from a GARCH(1,1) regression that estimates Eq. (8) and Eq. (9) where the return series for each gold and silver variable is regressed against the five language variables, *Activity*, *Certainty*, *Optimism*, *Realism* and *Commonality* to assess the influence sentiment has on these markets. The language variables are both in the mean equation and variance equation to assess the effects sentiment has on both the returns and volatility of the gold and silver markets. The main findings show that when all the communication from the chairmen is combined, the sentiment has no statistically significant effect on the returns of any of the gold and silver series´.

However when the effects on volatility are examined the language variables are found to be statistically significant. Most notable is that all the language variables, except *Optimism,* significantly affect the volatility in the silver bullion market. An increase in *Activity, Certainty* and *Realism* all significantly decrease the silver bullion market volatility, whereas an increase in *Commonality* increases the volatility. GoldB and GoldF are also significantly affected by an increase in *Certainty* where it increases the volatility in both markets. FTSE´s volatility increases with increased *Optimism* and *Commonality*. HUI is only affected by the amount of *Commonality*. These results show that the language used by Federal Reserve

chairmen has a statistically significant effect on the gold and silver markets volatility. However, the size affect is small where for example a 1% increase in *Certainty* decreases SilverB´s volatility by 0.0005%.

Panel B and panel C of table 11 show the goodness of fit tests for the GARCH(1,1) model. Notably the series' show no sign of ARCH effects, where the Ljung-Box test p-value for autocorrelation is insignificant for all series´ as well as the formal F-statistic and Chi-squared ARCH hypothesis test p-values. Thus the model is deemed a good fit for the data as there are no longer any ARCH affects evident.

4.2.2 Different influence of Federal Reserve chairmen

This section investigates whether former Federal Reserve chairman Greenspan has a different effect on the gold and silver markets compared to current Federal Reserve chairman Bernanke. Given the finding in table 9 that there is a statistically significant difference in the language used by these two chairmen in their communication, it is important to analyse whether they have different effects on the gold and silver markets. To analyse the different influence, the language variables for each chairman are regressed on the gold and silver return series´ in separate GARCH(1,1) models estimating Eq. (8) and Eq. (9). The GARCH(1,1) model for Greenspan has 189 observations and a sample period from May 1999 to January 2006. The GARCH(1,1) model for Bernanke has 197 observations and a sample period from January 2006 to June 2012. Table 12 shows the results for Greenspan´s communication and table 13 shows the results for Bernanke's communication. Panel A in both tables shows the results from the GARCH(1,1) model regressions.

The tables show a striking difference in the influences each chairman has on the returns of the gold and silver markets through communication. None of the sentiment in Bernanke´s communication has significant effects on any gold or silver return series. However, an increase in *Certainty* in the communication from Greenspan significantly increases the returns of all the series´ except GoldB and SilverF. This is a very interesting finding, where a 1% increase in the amount of *Certainty* in Greenspan´s communication is associated with an increase of 0.039% in the return of silver bullion prices and 0.08% and 0.09% in the returns of FTSE and HUI, respectively. Thus Greenspan´s *Certainty* has a statistically significant and economically important positive effect on the gold and silver markets. Furthermore, a 1% increase in *Realism* in Greenspan´s communication significantly decreases the returns in the silver bullion market by roughly 0.05%. The results show that Federal Reserve chairman sentiment can move the gold and silver markets and more importantly the impact is very different between the chairmen.

Table 10: Effect of all Federal Reserve chairmen communication on gold and silver

The table displays the results from GARCH(1,1) regressions of daily return series´ in Panel A on the language variables *Activity*, *Certainty*, *Optimism*, *Realism and Commonality*. Panel B displays tests for ARCH effects in the regressions. Observations, 386, take place on days of Federal Reserve chairmen speeches and testimonies. Parentheses hold t-statistics. The period is from 29th May 1999 to 10th May 2012. Daily returns are computed from closing prices gathered from Datastream. The coefficients α_1 and β_1 represent the ARCH (1) and GARCH (1) coefficients in the GARCH model´s variance equation. The coefficients δ1, δ2, δ3, δ4 and δ5 show variance equation results for *Activity*, *Certainty*, *Optimism*, *Realism and Commonality,* respectively. F-stat. and Chi-Sq.-stat. depict p-values for the null hypothesis of no ARCH effects. L-B(9) is the Ljung-Box test p-values for the null hypothesis of no autocorrelation in the standardized squared residuals 9th order lags. Coefficients marked with an asterisk ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively. All coefficients in Panel A (except α_1 and β_1) have been multiplied by 100 for ease of interpretation.

	GoldB	GoldF	SilverB	SilverF	FTSE	HUI
Panel A: GARCH(1,1)						
Constant	-7.2007	1.5163	-8.8199	-0.9372	-6.2483	-5.8156
	(-0.81)	(0.13)	(-0.53)	(-0.09)	(-0.4)	(-0.32)
Activity	0.5909	-0.4723	0.5433	0.5478	-0.0211	-0.8162
	(0.88)	(-0.49)	(0.3)	(0.38)	(-0.01)	(-0.46)
Certainty	-0.1435	0.4533	1.2932	1.9654	1.8371	1.7953
	(-0.16)	(0.5)	(0.7)	(1.22)	(1.28)	(1.19)
Optimism	0.7287	-1.2075	0.9946	-0.178	-2.0389	-1.678
	(0.58)	(-0.9)	(0.5)	(-0.07)	(-1)	(-0.63)
Realism	-0.326	0.3912	0.3747	-0.3004	1.311	0.6987
	(-0.31)	(0.32)	(0.18)	(-0.17)	(0.57)	(0.31)
Commonality	0.9762	0.4613	-0.8973	-1.7441	0.5694	1.5283
	(0.78)	(0.3)	(-0.45)	(-0.88)	(0.26)	(1.53)
α1	0.106**	0.095**	0.024*	0.148***	0.116***	0.118**
	(2.52)	(2.19)	(1.79)	(3.35)	(3.62)	(2.49)
β1	0.653***	0.633***	0.838***	0.707***	0.836***	0.797***
	(6.51)	(4.61)	(26.88)	(9.26)	(18.12)	(11.26)
δ1	0.0031	0.0011	-0.045***	-0.0372	0.0186	0.0183
	(0.33)	(0.45)	(-3.25)	(-0.68)	(1.32)	(1.2)
δ2	0.0148***	0.017**	-0.051***	-0.006	0.0024	0.0264
	(32.07)	(2.27)	(-7.55)	(-0.27)	(0.18)	(0.84)
δ3	-0.024***	-0.028***	0.0191	0.0091	0.0065	0.0036
	(-3.45)	(-2.54)	(1.23)	(0.16)	(0.3)	(0.07)
δ4	-0.027***	-0.0185	-0.084***	-0.032**	-0.042*	-0.0655
	(-4.00)	(-1.46)	(-6.06)	(-2.27)	(-1.93)	(-1.32)
δ5	0.0011	0.0116	0.0377***	0.02	-0.018***	-0.047**
	(0.1)	(0.8)	(2.58)	(0.7)	(-21.93)	(-2.43)
Panel B: Heteroskedasticity Test						
F-stat.	0.832	0.596	0.62	0.701	0.583	0.365
Chi-Sq.-stat.	0.832	0.595	0.619	0.7	0.582	0.364
L-B(9)	0.98	0.989	0.035	0.38	0.813	0.335

Table 11: Greenspan´s influence on gold and silver markets

The table displays the results from GARCH(1,1) regressions of daily return series´ in Panel A on the language variables *Activity*, *Certainty*, *Optimism*, *Realism and Commonality,* respectively. Panel B displays tests for ARCH effects in the regressions. Observations, 189, take place on days of Alan Greenspan speeches and testimonies. Parentheses hold t-statistics. The period is from 20th May 1999 to 14th December 2005. Daily returns are computed from the closing prices gathered from Datastream. The coefficients α_1 and β_1 represent the ARCH (1) and GARCH (1) coefficients in the GARCH model´s variance equation. The coefficients δ1, δ2, δ3, δ4 and δ5 show the variance equation results for the language variables *Activity*, *Certainty*, *Optimism*, *Realism and Commonality,* respectively. F-stat. and Chi-Sq.-stat. depict p-values for the null hypothesis of no ARCH effects in the model residuals. L-B(9) is the Ljung-Box test p-values for the null hypothesis of no autocorrelation in the standardized squared residuals 9th order lags. Coefficients marked with an asterisk ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively. All coefficients in Panel A (except α_1 and β_1) have been multiplied by 100 for ease of interpretation.

	GoldB	GoldF	SilverB	SilverF	FTSE	HUI
Panel A: GARCH(1,1)						
Constant	-7.993	-3.790	-3.678	2.249	-13.655	-12.018
	(-0.48)	(-0.17)	(-0.19)	(0.11)	(-0.43)	(-0.33)
Activity	2.112	2.747	3.459*	-0.860	1.224	-1.996
	(1.45)	(1.13)	(1.67)	(-0.33)	(0.37)	(-0.69)
Certainty	1.864	3.273**	3.928*	2.049	8.206**	9.429**
	(1.33)	(2.02)	(1.81)	(1.25)	(2.34)	(2.42)
Optimism	-0.826	-2.637	-1.390	0.142	-7.382*	-4.170
	(-0.37)	(-0.97)	(-0.63)	(0.04)	(-1.85)	(-0.87)
Realism	-2.208	-3.265	-5.327**	-2.785	-0.623	-2.348
	(-1.09)	(-1.26)	(-1.98)	(-1.06)	(-0.15)	(-0.48)
Commonality	1.093	0.849	0.250	0.832	2.170	2.272
	(0.63)	(0.32)	(0.12)	(0.35)	(0.59)	(0.62)
α1	0.036	0.002	0.093***	0.091*	0.078	-0.003
	(0.76)	(0.08)	(2.69)	(1.78)	(0.85)	(-0.09)
β1	0.552	0.517	0.842***	0.645***	0.521	0.931***
	(1.29)	(0.94)	(16.11)	(6.7)	(0.91)	(13.53)
δ1	0.005	0.011	0.002	0.005	0.027	0.010
	(0.29)	(0.45)	(0.15)	(0.25)	(0.25)	(0.22)
δ2	0.010	0.015	-0.011***	-0.032***	0.007	0.009
	(0.75)	(0.87)	(-97.45)	(-2.86)	(0.07)	(0.57)
δ3	-0.017	-0.020	-0.012	-0.005	0.011	0.017***
	(-1.54)	(-1.23)	(-0.5)	(-0.16)	(0.08)	(3.11)
δ4	0.002	-0.003	0.007	0.020	-0.015	-0.033***
	(0.14)	(-0.09)	(0.25)	(1.44)	(-0.16)	(-3.22)
δ5	-0.006	-0.008	-0.005	-0.005	-0.036	-0.030
	(-0.6)	(-0.61)	(-0.34)	(-0.34)	(-0.52)	(-0.91)
Panel B: Heteroskedasticity Test						
F-stat.	0.79	0.87	0.77	0.66	0.81	0.80
Chi-Sq.-stat.	0.79	0.87	0.77	0.66	0.81	0.80
L-B(9)	1.00	1.00	0.21	1.00	0.51	0.99

Table 12: Bernanke´s influence on gold and silver markets

The table displays the results from GARCH(1,1) regressions of daily return series´ in Panel A on the language variables *Activity*, *Certainty*, *Optimism*, *Realism and Commonality,* respectively. Panel B displays tests for ARCH effects in the regressions. Observations, 197, take place on days of Ben Bernanke speeches and testimonies. Standard errors are shown in parenthesis. The period is from 6th February 2006 to 10th May 2012. Daily returns are computed from the closing prices gathered from Datastream. The coefficients α_1 and β_1 represent the ARCH (1) and GARCH (1) coefficients in the GARCH model´s variance equation. The coefficients δ1, δ2, δ3, δ4 and δ5 show the variance equation results for the language variables *Activity*, *Certainty*, *Optimism*, *Realism and Commonality,* respectively. F-stat. and Chi-Sq.-stat. depict p-values for the null hypothesis of no ARCH effects in the model residuals. L-B(9) is the Ljung-Box test p-value for the null hypothesis of no autocorrelation in the standardized squared residuals 9th order lags. Coefficients marked with an asterisk ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively. All coefficients in Panel A (except α_1 and β_1) have been multiplied by 100 for ease of interpretation.

	GoldB	GoldF	SilverB	SilverF	FTSE	HUI
Panel A: GARCH(1,1)						
Constant	-3.628	5.091	-13.832	-11.989	18.554	14.138
	(-0.32)	(0.33)	(-0.51)	(-0.44)	(0.75)	(0.48)
Activity	0.260	-0.511	0.560	0.237	-0.346	-0.988
	(0.25)	(-0.35)	(0.26)	(0.11)	(-0.11)	(-0.32)
Certainty	-0.128	0.311	-0.018	0.397	0.521	-0.045
	(-0.08)	(0.21)	(-0.01)	(0.13)	(0.27)	(-0.02)
Optimism	0.616	-1.983	3.533	0.852	-2.815	-2.514
	(0.39)	(-0.92)	(1.01)	(0.19)	(-0.8)	(-0.75)
Realism	0.716	2.198	2.334	2.191	1.467	1.896
	(0.43)	(1.07)	(0.63)	(0.65)	(0.4)	(0.48)
Commonality	-0.522	-1.219	-2.747	-0.475	-3.453	-1.857
	(-0.28)	(-0.6)	(-0.64)	(-0.11)	(-0.8)	(-0.37)
α1	0.156*	0.134	0.004	0.050***	0.129***	0.127*
	(1.95)	(1.6)	(0.29)	(2.85)	(2.61)	(1.91)
β1	0.619***	0.775***	0.945***	0.902***	0.835***	0.825***
	(3.98)	(5.8)	(29.06)	(34.63)	(11.56)	(10.03)
δ1	0.004	0.000	-0.039***	-0.048	0.019**	0.016
	(0.22)	(0.02)	(-2.77)	(-1.63)	(2.27)	(0.51)
δ2	0.015*	0.011	-0.005	0.001	0.005	0.042
	(1.83)	(0.9)	(-0.33)	(0.06)	(0.28)	(1.55)
δ3	-0.022	-0.013	0.031***	0.035***	-0.005***	-0.044
	(-1.42)	(-0.66)	(41.16)	(24.69)	(-4.63)	(-0.57)
δ4	-0.008	-0.014	-0.061***	-0.027	-0.048***	-0.128**
	(-0.57)	(-0.66)	(-11.65)	(-1.58)	(-2.48)	(-2.29)
δ5	0.003	0.009	0.022	0.000	-0.013	-0.047***
	-0.100	(0.32)	(0.68)	0.000	(-0.38)	(-4.13)
Panel B: Heteroskedasticity Test						
F-stat.	0.69	0.75	0.44	0.58	0.90	0.57
Chi-Sq.-stat.	0.69	0.75	0.43	0.58	0.90	0.56
L-B(9)	0.09	0.74	0.03	0.08	0.36	0.01

The effect of sentiment on volatility is also analysed in both tables. Table 12 shows that Greenspan´s communication does have significant effect on the volatility of returns. Greenspan affects the volatility of the silver market through his *Certainty*, where an increase is associated with decreasing volatility in both silver- bullion and futures markets. Furthermore Greenspan affects HUI´s volatility through his *Optimism* and *Realism* where an increase in each language variable is associated with an increase and decrease in the markets volatility, respectively. Bernanke´s communication influence on the volatility of the gold and silver markets is somewhat more than Greenspan´s and affects both the silver and gold equity markets. Bernanke significantly influences both the silver market´s and gold equities volatility through his *Activity, Optimism* and *Realism*. He also significantly affects GoldB´s volatility through his *Certainty.* Overall when the results are taken together, both chairmen affect the gold and silver market's volatility through their sentiment with different language variables affecting different markets. *Certainty, Optimism* and *Realism* seem to be the most important language variables with *Activity* and *Commonality* having fewer significant effects.

Panel B in both tables 12 and 13 shows tests for ARCH effects in the model. Panel B in table 12 shows no evidence of any ARCH effects in the data and thus the model is deemed a good fit for the data. However panel B in table 13 shows evidence of significant autocorrelation in SilverB and HUI as displayed by the Ljung-Box p-values at 9 lags at the 5% level of statistical significance. This indicates the data still has some ARCH effects and would need a higher order GARCH model to eliminate the ARCH effects. The formal ARCH tests however, do not reject the hypothesis of no ARCH effects. So the model in table 13 is also deemed a good fit.

5. Conclusion

This study investigates the effect Federal Reserve monetary policy and communication has on the gold and silver markets. The study is intended to add to the growing research into the gold and silver markets following the increasing importance, in recent years, of the metals in the financial world. Even though gold and silver have a strong link to the world´s monetary system, with their long history as a preferred mediums of exchange, the relationships between both markets and the Federal Reserve has seemingly been neglected by academics.

This study first examines the effect unexpected monetary policy change (Federal funds target rate changes) and the surprise component of the FOMC statements accompanying the rate decisions, have on the gold and silver bullion and futures markets and gold stocks. The relationship is examined over two time periods; 1) May 1999 to December 2007 and 2) May 1999 to June 2012. The first period does not include the recent financial crisis whereas the second period does. The structure and dynamic of the FOMC statements changed during the financial crisis which began according to the NBER in December 2007. Furthermore the Federal funds rate target level is at the zero bound level. Therefore these two periods are examined.

The results for the first period indicate that there is a significant positive relationship between the gold and silver bullion markets and unexpected monetary policy. A hypothesised 1% surprise rate hike is associated with a 1.28% increase in the gold bullion price and a 1.53% increase in the silver bullion price. This is very interesting and indicates that gold and silver bullion prices react opposite to the general stock market when the Federal Reserve has issued a surprise rate hike. Studies such as from Bernanke and Kuttner (2005) have documented a negative response from the general stock market to surprise rate hikes. This

result is further evidence of the hedging and "safe haven" aspect of gold, which was documented in Baur and McDermott (2010) and Baur and Lucey (2010). The results for the futures markets were also positive but not statistically significant, thus the futures market is not affected in the same way as the bullion market. The surprise component of the FOMC statements did not affect any of the markets except the silver futures market, where both the unexpected monetary policy and FOMC statements were jointly significant. Thus the information regarding the Federal Reserve future monetary policy outlook is, according to the results, unimportant information to the gold and silver markets.

Interestingly, in the second period, the results show that gold stocks move in the same direction as the general stock markets when reacting to unexpected monetary policy. The reaction is statistically significant and economically relevant. The reaction is also larger than in most studies investigating the general stock market, as a hypothesised 1% unexpected rate hike is associated with 9.88% decrease in the FTSE gold stock index. When the financial crisis is included in the study, the unexpected monetary policy changes do not affect the gold and silver bullion or futures markets. This is somewhat understandable as the Federal funds target rate reached the zero bound level in 2008 and since then the market has been able to anticipate the rate changes fairly well. However, surprisingly, the FOMC statements do not impact any of the markets when the crisis period is included. The importance of the FOMC statements increased when the target rate level became zero. However, this study only takes account of the forward looking outlook for Federal funds target rate decisions and thus does not interpret the changed dynamic of the Federal Reserve's monetary policies such as stimulus packages, Quantitative Easing, Operation Twist and various asset purchases. This fact might explain the insignificant impact of the statements on the gold and silver markets.

The second part of the study investigates the effect Federal Reserve chairman communication (speeches and testimonies) has on the gold and silver markets. More precisely, the type of language used by former Federal Reserve chairman Alan Greenspan and current Federal Reserve chairman Ben Bernanke is analysed with computerised content analysis software, Diction 6.0. Five variables from the software are analysed, *Activity*, *Certainty*, *Optimism*, *Realism* and *Commonality.* There is a statistically significant difference between the communications used by the chairmen; Greenspan has more *Activity* and *Realism* whereas Bernanke has more *Optimism* in his language. The *Certainty* and *Commonality* are virtually the same in both chairmen communications.

When investigating the impact the chairmen have on the gold and silver markets it is of interest to note that the chairmen have issued statements in the past with very different opinions on the importance and merit of gold and silver within the field of finance. The findings are very interesting and show that the impact each chairman has on the markets is very different. While the tone of the language used by Greenspan affects the returns of the markets, Bernanke´s does not. Greenspan affects the silver bullion market with his *Certainty, Activity* and *Realism.* A hypothesised 1% increase in the amount of *Certainty* in Greenspan´s tone of voice increases the silver bullion prices by 0.03%. For the gold stocks the amount of *Certainty* increases both FTSE and HUI by almost 0.1%. There is therefore evidence that the tone of voice in the communication from Alan Greenspan can move the gold and silver markets. Bernanke, however, does not move markets with the tone of his voice.

The study also shows that sentiment can have effects on the volatility of the gold and silver markets. There is evidence of this in the communication from both chairmen and also when all communication is taken together. The language variables that seem to be of most importance, which are able to affect the volatility of markets are *Certainty, Optimism* and

Realism with *Activity* and *Commonality* having less significance. Overall when the results are taken together, both chairmen affect the gold and silver market's volatility through their sentiment with different language variables affecting different markets. These results thus show that sentiment is an important driver of gold and silver market volatility.

Although I have found unexpected monetary policy change and the language used by Federal Reserve chairmen to affect the gold and silver markets by a reasonable size that is both statistically significant and economically important, it must be noted that these factors are only responsible for a small percentage of the variation in the prices of gold and silver. The variation is thus possibly explained by other sources of information such as macroeconomic news and the value of exchange rates.

It must be noted that caution should be taken when interpreting the results from the study. Rigobon and Sack (2004) argue that the event study approach is biased and underestimates the true impact of monetary policy changes. Thus the results could be even more robust when accounting for this bias. There is also the possibility of endogeneity and joint-response issues that could affect the results. Many recent studies use high-frequency data to try and avoid endogeneity issues. The use of daily data in this study could affect this endogeneity problem as other news and factors could impact the markets on the days of the events, which could hide the true response of the markets to these events. However, the use of the unexpected component should help prevent such problems. There is also the possibility of model misspecification. The OLS method is used in the first part and the GARCH(1,1) model is used in the second part of the study, however some series show signs of heteroskedasticity which could affect the results. As has been explained before, other news and information explains the majority of the variation in gold and silver prices. This gives way to omitted variable bias as most factors explaining the price variations are not included in the model.

In future studies it would be interesting to include other information such as macroeconomic news to gain more understanding of what explains the price changes in the gold and silver markets. Furthermore future studies could analyse the impact of Federal Reserve monetary policy and chairman communication with high frequency data to prevent endogeneity and joint response problems. These possible issues should, however, not hide that fact that these results are fairly robust and are important to financial markets. This is a very promising area for future research.

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Appendix A: Forecast regression full sample period

Forecast regression for expected tone of FOMC statements for the full sample period

The table displays the FOMC statements tone forecast regression. The current Index value is regressed against the prior index value, PMI (purchasing managers' index survey), CPI (median inflation expectations survey) and Slope (slope of the short term yield curve, the difference between the Federal funds 3month ahead futures rate and the current month Federal funds futures rate). Observations are on days of FOMC meetings, May 1999-June 2012 excluding the 17th September 2001, 10th August 2007 and 11th March 2008 meetings. The econometric method is Maximum Likelihood - Ordered Probit (Quadratic hill climbing). Huber/White standard errors are used to compute t-statistics contained in parenthesis. L-B(1) shows the Ljung-Box test p-value for the null hypothesis of no first order autocorrelation. Coefficients marked with an asterisk ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	Index
$Index^{old}$	1.352***
	(5.469)
PMI	0.056**
	(1.999)
CPI	0.243
	(1.146)
Slope	2.459***
	(4.615)
Threshold coefficients	
λ_1	2.356*
	(1.659)
λ_2	5.227***
	(3.416)
L-B(1)	0.926
Log Likelihood	-56.126
Pseudo R-squared	0.506
Observations	111

Appendix B: Summary statistics full sample period
Summary statistics for the full period of FOMC meeting dates

The table displays descriptive statistics. Observations are on days of FOMC meetings, May 1999-June 2012 excluding the 17th September 2001, 10th August 2007 and 11th March 2008 meetings. The daily logarithmic returns are calculated from price data, obtained from Datastream. The daily returns are calculated using closing prices. All return statistics are expressed in percentage terms. Std. Dev. depicts standard deviation. Max. and Min. depict Maximum and Minimum. Kurt. And Skew stand for Kurtosis and Skewness. J-B depicts the Jarque-Bera test. The J-B tests for normality in the return data. L-B(5) shows the Ljung-Box test statistic for the null hypothesis of no fifth order autocorrelation. Obs. stands for observations. Fed is the actual Federal funds target rate change. UMP is the unexpected monetary policy change. Index is a variable constructed by the author from the FOMC statements. FOMCST is the surprise component of the FOMC statements. For other data variables see section 3.1. Coefficients in JB and L-B marked with an asterisk *, indicate statistical significance at the 5% level.

Variable	Mean	Std. Dev.	Max.	Min.	Kurt.	Skew.	JB	L-B	Obs.
Fed	-0.04	0.25	0.50	-1.00	4.8	-1.2	0.00	0.0	110
UMP	-0.02	0.12	0.17	-0.75	21.8	-4.0	0.00	0.1	110
Index	0.02	0.72	1.00	-1.00	2.0	0.0	0.09	0.0	110
FOMCST	0.01	0.42	1.00	-1.03	3.5	-0.2	0.30	0.0	110
GoldB	0.15	1.15	4.48	-2.66	5.5	0.7	0.00	0.1	110
GoldF	0.10	0.97	2.74	-3.07	3.9	-0.1	0.14	0.5	110
SilverB	0.19	2.21	13.66	-6.93	15.2	1.8	0.00	0.1	110
SilverF	0.03	1.94	10.93	-5.98	12.1	1.0	0.00	0.0	110
FTSE	0.64	3.29	15.92	-8.08	7.8	1.4	0.00	0.7	110
HUI	0.77	3.22	17.15	-5.96	9.3	1.7	0.00	0.4	110
GLD	0.16	1.30	3.38	-2.73	3.1	0.2	0.84	0.1	63
SLV	0.46	2.39	6.63	-5.15	3.8	0.2	0.35	0.7	52

Appendix C: FOMC target rate and statements data results
Federal funds target rate and FOMC index data table

The table displays the meeting dates of FOMC target rate meetings. UNS depicts dates of unscheduled meetings. Actual is the actual monetary policy change. Expected is the expected monetary policy change. Unexpected is the unexpected monetary policy change. FOMC is the statement content analysis wording indicator variable. Rate level is the Federal funds target rate level.

Date		Scheduled FOMC	Actual	Expected	Unexpected	Rate level	FOMC
1999	18/05/1999		0	+4	-4	475	+1
	30/06/1999		+25	+29	-4	500	0
	24/08/1999		+25	+23	+2	525	0
	05/10/1999		0	+4	-4	525	0
	16/11/1999		+25	+16	+9	550	0
	21/12/1999		0	-2	+2	550	0
2000	02/02/2000		+25	+30	-5	575	+1
	21/03/2000		+25	+28	-3	600	+1
	16/05/2000		+50	+45	+5	650	+1
	28/06/2000		0	+2	-2	650	+1
	22/08/2000		0	+2	-2	650	+1
	03/10/2000		0	0	0	650	+1
	15/11/2000		0	0	0	650	+1
	19/12/2000		0	-5	+5	650	-1
2001	03/01/2001	UNS	-50	-21	-29	600	-1
	31/01/2001		-50	-45	-5	550	-1
	20/03/2001		-50	-56	+6	500	-1
	18/04/2001	UNS	-50	+37	-87	450	-1
	15/05/2001		-50	-35	-15	400	-1
	27/06/2001		-25	-30	+5	375	-1
	21/08/2001		-25	-31	+6	350	-1
	02/10/2001		-50	-38	-12	250	-1
	06/11/2001		-50	-37	-13	200	-1
	11/12/2001		-25	-25	0	175	-1
2002	30/01/2002		0	-2	+2	175	-1
	19/03/2002		0	+3	-3	175	0
	07/05/2002		0	0	0	175	0
	26/06/2002		0	0	0	175	0
	13/08/2002		0	-5	+5	175	-1
	24/09/2002		0	-2	+2	175	-1
	06/11/2002		-50	-36	-14	125	0
	10/12/2002		0	0	0	125	0
2003	29/01/2003		0	-2	+2	125	0
	18/03/2003		0	-5	+5	125	0
	06/05/2003		0	-2	+2	125	-1
	25/06/2003		-25	-40	+15	100	-1
	12/08/2003		0	0	0	100	0
	16/09/2003		0	0	0	100	0
	28/10/2003		0	0	0	100	0
	09/12/2003		0	0	0	100	0

2004	28/01/2004		0	-5	+5	100	+1
	16/03/2004		0	0	0	100	+1
	04/05/2004		0	+1	-1	100	+1
	30/06/2004		+25	+26	-1	125	+1
	10/08/2004		+25	+22	+3	150	+1
	21/09/2004		+25	+23	+2	175	+1
	10/11/2004		+25	+24	+1	200	+1
	14/12/2004		+25	+25	0	225	+1
2005	02/02/2005		+25	+25	0	250	+1
	22/03/2005		+25	+25	0	275	+1
	03/05/2005		+25	+25	0	300	+1
	30/06/2005		+25	+25	0	325	+1
	09/08/2005		+25	+25	0	350	+1
	20/09/2005		+25	+24	+1	375	+1
	01/11/2005		+25	+25	0	400	+1
	13/12/2005		+25	+25	0	425	+1
2006	31/01/2006		+25	+24	+1	450	+1
	28/03/2006		+25	+25	0	475	+1
	10/05/2006		+25	+25	0	500	+1
	29/06/2006		+25	+30	-5	525	0
	08/08/2006		0	+5	-5	525	0
	20/09/2006		0	0	0	525	0
	25/10/2006		0	0	0	525	0
	12/12/2006		0	0	0	525	0
2007	31/01/2007		0	0	0	525	0
	21/03/2007		0	0	0	525	0
	09/05/2007		0	-1	+1	525	0
	28/06/2007		0	-1	+1	525	0
	07/08/2007		0	-5	+5	525	0
	17/08/2007	UNS	0	-6	+6	525	-1
	18/09/2007		-50	-35	-15	475	0
	31/10/2007		-25	-23	-2	450	0
	11/12/2007		-25	-26	+1	425	0
2008	22/01/2008	UNS	-75	-1	-74	350	-1
	30/01/2008		-50	-40	-10	300	-1
	18/03/2008		-75	-92	+17	225	-1
	30/04/2008		-25	-20	-5	200	0
	25/06/2008		0	+3	-3	200	0
	05/08/2008		0	+1	-1	200	0
	16/09/2008		0	-6	+6	200	0
	08/10/2008	UNS	-50	-36	-14	150	-1
	29/10/2008		-50	-44	-6	100	-1
	16/12/2008		-100	-88	-12	25	0

2009	28/01/2009	0	0	0	25	0
	18/03/2009	0	+1	-1	25	-1
	29/04/2009	0	+	-	25	0
	24/06/2009	0	+2	-2	25	0
	12/08/2009	0	+1	-1	25	0
	23/09/2009	0	0	0	25	0
	04/11/2009	0	0	0	25	0
	16/12/2009	0	+1	-1	25	0
2010	27/01/2010	0	+2	-2	25	0
	16/03/2010	0	0	0	25	0
	28/04/2010	0	0	0	25	0
	23/06/2010	0	0	0	25	0
	10/08/2010	0	0	0	25	0
	21/09/2010	0	0	0	25	0
	03/11/2010	0	0	0	25	-1
	14/12/2010	0	0	0	25	0
2011	26/01/2011	0	0	0	25	0
	15/03/2011	0	0	0	25	0
	27/04/2011	0	0	0	25	0
	22/06/2011	0	+1	-1	25	0
	09/08/2011	0	0	0	25	-1
	21/09/2011	0	-1	+1	25	-1
	02/11/2011	0	-1	+1	25	0
	13/12/2011	0	0	0	25	0
2012	25/01/2012	0	0	0	25	-1
	13/03/2012	0	0	0	25	0
	25/04/2012	0	0	0	25	0

Appendix D: FOMC key wording and sentences

FOMC content analysis - key words and sentences

The table displays the key words and sentences used by the FOMC in their statements accompanying the Federal funds target rate decision. The key sentences and wording is used to assign each statement a number in the Index variable (+1, 0, -1). The reference date for an example of an FOMC statement where such wording is used is displayed in the first column.

Date	Important sentences and wording	Index
18/05/1999	Possibility of a firming in the stance of monetary policy	+1
21/03/2000	The risks are weighted mainly toward conditions that may generate heightened inflation pressures in the foreseeable future.	
04/05/2004	The Committee believes that policy accommodation can be removed at a pace that is likely to be measured.	
31/01/2006	Some further policy firming may be needed to keep the risks to the attainment of both sustainable economic growth and price stability roughly in balance.	
30/06/1999	Adopt a directive that includes no predilection about near-term policy action.	0
16/11/1999	The directive ... is symmetrical with regard to the outlook for policy over the near term.	
19/03/2002	The risks are balanced with respect to both goals.	
16/09/2003	The Committee believes that policy accommodation can be maintained for a considerable period.	
25/10/2006	The extent and timing of any additional firming that may be needed to address these risks will depend on the evolution of the outlook for both inflation and economic growth, as implied by incoming information.	
31/10/2007	The upside risks to inflation roughly balance the downside risks to growth.	
03/01/2001	The risks are weighted mainly toward conditions that may generate economic weakness in the foreseeable future.	-1
25/06/2003	The probability, though minor, of an unwelcome substantial fall in inflation exceeds that of a pickup in inflation from its already low level. On balance, the Committee believes that the latter concern is likely to predominate for the foreseeable future.	
06/05/2003	The balance of risks to achieving its goals is weighted toward weakness.	
18/03/2008	Downside risks to growth remain.	