Is Gold a High-Quality Liquid Asset?

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Abstract

This paper examines if gold is a High-Quality Liquid Asset (HQLA) based on the criteria set by the Basel Committee on Banking Supervision. We describe fundamental and market-related characteristics of HQLAs and assess whether gold meets these criteria and how it performs relative to Level 1 HQLAs such as US Treasury bonds. In a second step, we analyze whether gold offers diversification opportunities within the current HQLA-ranked asset classes with a special focus on crisis periods such as the 2023 US banking crisis. We find that gold meets all market-related criteria, namely low bid-ask spreads, high volumes, relatively low volatility and negative correlation with risky assets during stress periods. Gold generally performs similar to a 30-year US Treasury bond. Adding gold to a portfolio of HQLA enhances its resilience.

Keywords: gold, HQLA, Basel III, government bonds

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1 Introduction

In 2013, the Basel Committee on Banking Supervision (BCBS) (Basel Committee on Banking Supervision, 2013) introduced a Liquidity Coverage Ratio (LCR). Its objective is to promote the short-term resilience of the liquidity risk profile of banks. It does this by ensuring that banks have an adequate stock of unencumbered high-quality liquid assets (HQLA) that can be converted easily and immediately in private markets into cash to meet their liquidity needs for a 30-day liquidity stress scenario. The BCBS expects that the LCR will improve the banking sector's ability to absorb shocks arising from financial and economic stress thus reducing the risk of adverse spillovers from the financial sector to the real economy.

Given gold's long history as money and a store of value, and its reputation as a safe haven asset, i.e. an asset that holds its value in times of stress, it may be surprising that gold is not part of the commonly accepted set of Level 1 HQLA The fact that central banks use gold as a reserve asset may add to the surprise.[1]

This document describes the LCR, the definition and associated criteria of a HQLA and analyzes whether gold should be defined as an HQLA and thus included by banks as protection against liquidity shocks.

This paper sits between various strands of the academic literature, namely high-quality liquid assets (HQLA), the liquidity coverage ratio (LCR), banking regulation, bond liquidity, flight to quality, safe haven assets, safe assets, and the volatility of gold.

HQLA are analyzed by Ihrig, Vojtech, and Weinbach (2019) and Grandia, Hänling, Russo, and

[1] See Aizenman and Inoue (2012); Gopalakrishnan and Mohapatra (2018); Monnet and Puy (2020); Rathi, Mohapatra, and Sahay (2022)

Aberg (2019). Bergmann, Connolly, and Muscatello (2020) provides an Australian perspective and highlights a special case represented by a lack of HQLA in Australia.

Liquidity Coverage Ratios (LCR) are studied in Fuhrer, Müller, and Steiner (2017). Garcia-Macia and Villacorta (2022) analyze liquidity requirements and liquidity panics. Raz, McGowan, and Zhao (2022) focus on LCRs and banking regulation, Roberts, Sarkar, and Shachar (2023) study the impact of LCRs on fire-sale risk of banks, Macchiavelli and Pettit (2021) examine effects on broker-dealers, and Sundaresan and Xiao (2024) analyze the effects of liquidity regulation on the banking system. They find that regulation has reduced liquidity risk but also decreased bank lending.

The liquidity of bonds is analyzed in Schestag, Schuster, and Uhrig-Homburg (2016), O'Hara and Zhou (2021), Longstaff (2004), Liang and Parkinson (2020), Vissing-Jorgensen (2021) and Krishnamurthy and Li (2022). The safe asset literature is studied by Aggarwal, Bai, and Laeven (2021); Caballero, Farhi, and Gourinchas (2017); Dang, Gorton, and Holmstrom (2013); Eisenbach and Phelan (2022); Gorton, Lewellen, and Metrick (2012); Gorton (2017); Holmstrom (2015). Caballero et al. (2017) define safe assets similar to safe haven assets except that the definition focusses on debt which excludes other assets such as gold and real estate.

Gold as a safe haven during financial crises or turmoil is studied in Baur and Lucey (2010); Baur and McDermott (2010). Baur and Smales (2020) show that gold reacts positively to geopolitical risks and that both stocks and bonds react negatively to such risks. Gold's volatility is studied by Baur (2012) and Nguyen and Walther (2020).

Importantly, we are not aware of any study that examines the liquidity of gold and the potential role of gold as a HQLA. While there are studies that look at select criteria of HQLAs such as the safe haven property of gold and the volatility of gold, there is no study that examines whether gold is a

HQLA and how gold compares with existing high-quality liquid government bonds.

The study thus contributes to the academic literature.

The main finding of this study is that gold meets all key criteria of HQLAs. The paper also shows that inclusion of gold to existing HQLA portfolios leads to more stable and more resilient portfolios.[2] The latter is relevant to policy makers concerned with financial stability as our results demonstrate that the stability of the banking system can be enhanced with the inclusion of gold and thus a broadening of the set of eligible high-quality liquid assets.

The rest of this paper is structured as follows. Section 2 describes the HQLA criteria. Section 3 the data. Section 4 presents the qualitative analysis of the fundamental HQLA criteria and the quantitative analysis of the market-based HQLA criteria. Section 5 analyzes the stability and resilience of different portfolios and Section 6 discusses other aspects such as the sovereign - bank nexus relevant to existing HQLAs but not part of the HQLA criteria. Finally, Section 7 summarizes the main results and concludes.

2 HQLA criteria

This section describes the characteristics of an HQLA based on a report by the Basel Committee on Banking Supervision (2013). We use the characteristics to derive quantitative measures of HQLAs.

The Liquidity Coverage Ratio (LCR) is defined by the value of the stock of HQLA over the total net cash outflows over the next 30 calendar days. The ratio should be 100% or larger. In other words, under the LCR regulation, banks must hold their next 30-day outgoing payments in the form

[2] We define "more stable" portfolios as portfolios with a lower standard deviation or less risk. "More resilient" portfolios are defined as being more stable and providing a higher return thereby more compensating for losses.

of HQLAs. In order to qualify as HQLA, assets should be liquid in markets during times of stress and, ideally, be central bank eligible.

The Basel Committee on Banking Supervision (2013) has proposed two types of characteristics of HQLA: (i) fundamental characteristics and (ii) market-related characteristics.[3]

Fundamental characteristics

The fundamental characteristics are comprised of four sub-categories as follows:

- Low risk: assets that are less risky tend to have higher liquidity. High credit standing of the issuer and a low degree of subordination increase an asset's liquidity. Low duration, low legal risk, low inflation risk and denomination in a convertible currency with low foreign exchange risk all enhance an asset's liquidity.

- Ease and certainty of valuation: an asset's liquidity increases if market participants are more likely to agree on its valuation. Assets with more standardised, homogeneous and simple structures tend to be more fungible, promoting liquidity. The pricing formula of a high-quality liquid asset must be easy to calculate and not depend on strong assumptions. The inputs into the pricing formula must also be publicly available. In practice, this should rule out the inclusion of most structured or exotic products.

- Low correlation with risky assets: the stock of HQLA should not be subject to wrong-way (highly correlated) risk. For example, assets issued by financial institutions are more likely to be illiquid in times of liquidity stress in the banking sector.

[3] The characteristics are copied word by word from the Basel document as they are the basis for the qualitative and quantitative analysis.

- Listed on a developed and recognised exchange: being listed increases an asset's transparency.

Market-related characteristics

Market-related characteristics are comprised of three sub-categories as follows:

- Active and sizable market: the asset should have active outright sale or repo markets at all times. This means that:

- There should be historical evidence of market breadth and market depth. This could be demonstrated by low bid-ask spreads, high trading volumes, and a large and diverse number of market participants. Diversity of market participants reduces market concentration and increases the reliability of the liquidity in the market.

- There should be robust market infrastructure in place. The presence of multiple committed market makers increases liquidity as quotes will most likely be available for buying or selling HQLA.

- Low volatility: Assets whose prices remain relatively stable and are less prone to sharp price declines over time will have a lower probability of triggering forced sales to meet liquidity requirements. Volatility of traded prices and spreads are simple proxy measures of market volatility. There should be historical evidence of relative stability of market terms (e.g. prices and haircuts) and volumes during stressed periods.

- Flight to quality: historically, the market has shown tendencies to move into these types of assets in a systemic crisis. The correlation between proxies of market liquidity and banking system stress is one simple measure that could be used.

Based on the above criteria, a high-quality liquid asset is expected to generate liquidity, by way of sale or repo, at all times even in periods of severe market stress or turmoil. More specifically, a HQLA is expected to generate liquidity based on its pre-stress or pre-turmoil market value. In other words, a perfect or ideal HQLA does not trade at a lower price in a period of market stress than before such a period.

3 Data

We use a variety of data sets and data frequencies for our analysis. We source high-frequency 5-min, hourly and daily bid and ask prices from LSEG for government bonds and gold, daily transaction data from FINRA for US Treasuries and corresponding transaction data on gold from the LBMA. The hourly data sample spans the 31/12/2010 to 30/12/2023 period. The FINRA data spans end of day prices from 13/02/2023 - 26/06/2024, and the daily data spans the period from 01/01/2000 to 31/08/2024.

Different data frequencies and sample periods are expected to provide a robust picture of the characteristics of HQLA not dependent on specific data frequencies or sample periods.

4 Analysis

This section presents the analysis of gold as an HQLA. We first qualitatively examine whether gold meets the fundamental characteristics and then quantitatively analyze whether gold meets the market-related characteristics of HQLAs as defined by the Basel Committee on Banking Supervision (2013).

4.1 Fundamental characteristics

The fundamental characteristics are (i) low risk, (ii) ease and certainty of valuation, (iii) low correlation with risky assets and (iv) listed on a developed and recognised exchange. We interpret these characteristics as broader or more general characteristics in contrast to the market-related characteristics that can be tested empirically with market data. For example, while low risk seems to be similar to low volatility, the Basel Committee on Banking Supervision (2013) definition comprises different types of risk and not only market risk. More specifically, low risk also entails high credit standing of the issuer, low duration, low legal risk, low inflation risk and denomination in a convertible currency. While "high credit standing of the issuer" does not directly apply to gold as gold is not issued by governments, gold does not have any credit risk. In addition, gold does not have any duration but can be interpreted as low duration. Since gold is both an inflation hedge and a currency hedge (Capie, Mills, and Wood, 2005; Erb and Harvey, 2013), it has low inflation risk and low currency risk. In fact, it can be shown that gold moves inversely with its currency of denomination and thus provides a perfect hedge.[4]

Despite gold having a market value, there is no "certainty of valuation" such as for bonds but market participants can be assumed to agree on its value as they agree on the value of a bond. Notably, both gold and bond prices vary significantly. The major difference is that gold will not converge to a fixed value at maturity. However, gold clearly meets the criteria "standardized, homogeneous and simple structures". The valuation of gold is transparent and all inputs into that valuation are publicly available.

Gold's safe haven property (Baur and Lucey, 2010) implies a low or negative correlation with risky

[4]For example, a 1% fall in the value of the US dollar, will result in a 1% rise in the value of gold denominated in US dollar.

assets including no “wrong-way (highly correlated) risk”.

Finally, gold is listed on developed and recognized exchanges and thus also meets this fourth criterium. For example, gold is traded on both spot and futures exchanges in many countries including financial centers in the US, the UK and in China among many other locations globally.

We conclude that gold meets most if not all fundamental criteria. Importantly, established HQLAs such as government bonds do not meet all criteria either. Some of the “low risk” sub-criteria such as low inflation risk were clearly not met in the aftermath of the COVID-19 shock when rising inflation and interest rates pushed bond yields up and bond prices down.

4.2 Market-related characteristics

This section analyzes whether gold meets the market-related characteristics of liquidity, volatility and flight-to-quality.

4.2.1 Liquidity

This section presents different measures of liquidity based on (i) bid-ask spreads and (ii) volume.

Bid-ask spread

[Figure 1 about here.]

Figure 1 presents the hourly bid-ask spreads for US, UK, German, EU and Australian government bonds at different maturities ranging from 1-year to 30-years and gold over a 13-year period. The bid-ask spreads are sorted starting with the lowest spreads to the highest spreads. Not surprisingly, shorter maturities generally have smaller spreads than longer maturities. The 2-year US bond has the lowest and the 30-year Australian bond has the largest spread. Gold's bid-ask spread is in the middle with the 30-year US bond to the left and the 2-year EU bond to the right.

[Figure 2 about here.]

Figure 2 shows that a focus on the 2023 SVB banking crisis improves gold's relative position and places it more to the left representing a lower bid-ask spread relative to bonds. Hence, gold's liquidity is comparable with high-quality government bonds over both the longer sample period and during the 2023 banking crisis. Gold also takes a middle place for the volatility of the bid-ask spread across all government bonds (see Figure 6). The idea behind this measure is that a high-quality liquid asset should have relatively low bid-ask spreads on average but also relatively constant bid-ask spreads without large variations.

Volume-based measures of liquidity

Gold vs. US Treasuries

Table 1 presents another measure of liquidity, namely the Amihud's (2002) illiquidity measure, for US Treasury bonds and gold. The measure is based on the ratio of the absolute value of returns over the trading volume. Larger numbers imply a higher illiquidity or lower liquidity than smaller numbers. The equation is specified as:

$$ILLIQ = \frac{1}{N}\sum_{t=1}^{T}\frac{|Ret_t|}{Vol_t} \tag{1}$$

where Ret_t is the return on day t, Vol_i is the trading volume in trillion dollars, and T is the number of days during the sample period.

The transaction data for US Treasuries and for gold are sourced from FINRA,[5] and LBMA respectively. Restricted by data availability from FINRA, for each US Treasury bond tenor, we use the volume-weighted average price during the day to calculate daily returns, and the total traded par value as the measure of trading volume.

Gold is remarkably liquid with an Amihud measure of 0.102 compared with US Treasury bonds with Amihud measure estimates ranging from 0.055 (3-5 year bonds) to 1.321 (10-20 year bonds). The results are qualitatively similar for the March 2023 (SVB banking crisis) sub-sample. Gold's Amihud measure for this period is 0.178 compared with US Treasury bonds' Amihud measures ranging from 0.051 to 0.612. A 30-day rolling window of the Amihud illiquidity estimates for the 2023 - 2024 sample period are presented in Figure 3 and illustrates the high liquidity of gold relative to US Treasury bonds.

[Table 1 about here.]

[Figure 3 about here.]

Gold vs. Ginnie Mae Mortgage Backed Securities (GNMA MBS)

In addition to excess reserves (i.e., cash) and Treasury securities, Mortgage Backed Securities (MBS) issued by Ginnie Mae (GNMA) are classified as HQLA Level 1 under the current US liquidity regulations. In this section, we compare the liquidity of gold and GNMA MBS with the bid-ask spread and Amihud's illiquidity measure.

We source the transaction data on GNMA MBS from Trade Reporting and Compliance Engine (TRACE) via WRDS. We focus on to-be-announced, or TBA, markets because they are the most

[5] `https://www.finra.org/finra-data/browse-catalog/about-treasury/daily-file`

actively traded markets for MBS (Gao, Schultz, and Song, 2017).[6] Since bid-ask spreads are not available for the MBS dataset, we estimate the Roll (1984) measure which, under certain assumptions, is equal to percentage bid-ask spread (Liu, Song, and Vickery, 2021) and compare it with gold's bid-ask spreads presented in the previous section. The measure is computed as two times the square root of the negative covariance between consecutive returns. We calculate the measure for each MBS on each day t as:

$$Roll_t = 2\sqrt{-cov(R_{j-1,t}, R_{j,t})} \tag{2}$$

where $R_{j,t}$ is the percentage price change from $j-1$-th to j-th trades during day t. We discard observations with a negative covariance.

Figure 4 presents the daily cross-sectional mean of the Roll measure across all GNMA MBS (the black dotted line) in comparison with gold's percentage bid-ask spread. To make the hourly spread of gold comparable with daily estimates of MBS' Roll measure, we calculate the mean (red line) and max (blue dashed line) gold spread each day. The graph clearly shows that gold is more liquid than GNMA MBS on average and over time.

[Figure 4 about here.]

We next compare the Amihud illiquidity measures of gold and GNMA MBS. To facilitate the comparison, daily returns for MBS are calculated using the volume-weighted average closing price of all securities, in which closing price is the last transaction price of the day. Daily trading volume is the total trading volume of all MBS. Since the trading volume in the dataset is truncated, i.e., trading volume between \$10 million is reported as 10MM+, and trading volume greater than \$25 million is

[6]Although the data are available, we do not focus on existing MBS (i.e., specified pools) because their thin trading does not allow us to estimate the Roll measure, which requires a series of transactions within a single day.

reported as 25MM+, we first replace 10MM+ by \$10 million and 25MM+ by \$25 million and consider the calculated Amihud illiquidity measure as the upper bound of the true value.[7] Next, we replace 10MM+ by \$25 million and 25MM+ by \$25 billion and consider the calculated number as the lower bound.

Figure 5 presents the estimated Amihud illiquidity measures for gold and MBS using 30-day rolling windows. On average, gold illiquidity is comparable to the lower bound, and significantly smaller than the upper bound of GNMA illiquidity. The results indicate that gold is at least as liquid as Level 1 HQLA MBS, thus corroborating the above evidence using bid-ask spreads.

[Figure 5 about here.]

4.2.2 Volatility

Figure 6 presents the volatility of returns based on hourly data for the cross-country sample of government bonds used above. Hourly returns are calculated using mid-quotes. The volatility of gold is placed in the middle of all bonds, between the 20-year Australian bonds and the 7-year German bonds. The sorted volatilities from lowest to highest reveal that the short-term (mostly 1-year) bonds have the lowest volatility and the long-term (mostly 30-year) bonds have the highest volatility.

[Figure 6 about here.]

We next utilize high-frequency data at 5-minute intervals to estimate the daily realized volatility of gold and Treasury bonds following Andersen, Bollerslev, Diebold, and Labys (2001).[8] Figure 7a

[7] This is because trading volume is in the denominator.

[8] To avoid significant jumps in the price series (possibly due to bond expiring or rollover) that potentially inflates the estimated volatility, we exclude return observations with price intervals longer than 5 minutes.

presents the estimates for gold and for the 10-year and 30-year US Treasury bonds from January 2017 to August 2024.[9] In addition to realized volatility, we also display the time-series of good volatility and bad volatility calculated following Barndorff-Nielsen, Kinnebrouk, and Shephard (2010) in Figure 7b. Good volatility is the volatility for positive returns and bad volatility is the volatility for negative returns. The time-series plots show that the 10-year volatility is the lowest.[10] What is remarkable is that the 30-year US bonds have more spikes and appear less well behaved than gold (this will be tested further in the next section where we will analyze variations of volatility or volatility of volatility), and thus exhibit higher average volatility than gold.

[Figure 7 about here.]

[Figure 8 about here.]

The 120-day rolling volatility estimates based on daily data presented in Figure 8 confirm that gold's volatility is similar to the volatility of US 30-year bonds which are both larger than the 10-year and 2-year US bond volatilities. Specifically, the average volatilities are 0.98 for gold, 0.09 for 2-year, 0.46 for 10-year, 0.90 for 30-year Treasury bonds and 1.07 for the S&P500.

The time-series plots also contain vertical lines that present the 2008 GFC, the 2020 COVID-19 crisis and the 2023 SVB banking crisis and the 2024 August market turmoil.

The volatilities in crisis periods displayed in Table 2 confirm the pattern identified above for longer sample periods: gold is more volatile than 2-year and 10-year US Treasury bonds but less volatile than 30-year US Treasury bonds. An exception is the 2008 Global Financial Crisis where gold volatility is greater than all Treasury bond volatilities including the 30-year Treasury bonds.

[9]For comparison, we also estimate realized volatility using the hourly data from the analysis above, which spans from 2011 to 2023. The results are presented in Figure 12a in the Appendix.

[10]The 1-hour realized good and bad volatility is presented in Figure 12b in the Appendix.

[Table 2 about here.]

Table 3 displays the good and bad volatilities for these four crisis periods. Good volatility is generally larger than bad volatility for safe haven assets. This result is expected because safe haven assets tend to increase in price during times of stress or turmoil, i.e. during safe haven events, and revert back to the price when the shock dissipates. This price increase and subsequent price correction implies a higher volatility than in periods of bad volatility when the price falls. The increased volatility may also be due to volatility spillovers from stressed assets.

Generally, bad volatility is always greater than good volatility for the S&P500. Gold is generally more volatile than short-term US bonds, but slightly less volatile than 30-year US bonds.

[Table 3 about here.]

Volatility of Volatility

This section examines variations of volatility over time or volatility of volatility. The basis for this analysis is the idea that the (average) volatility of an asset can be misleading if it significantly varies over time. Instead, the volatility of volatility measures such variation.

Table 4 presents the volatility of daily realized volatility estimated using either 5-minute or hourly returns. The volatility of volatility (VoV) of gold is the lowest followed by the 10-year Treasury bonds and the 30-year Treasury bonds.

Table 4 also contains a separation of volatility in good volatility (when returns are positive) and bad volatility (when returns are negative). Although good volatility is larger than bad volatility for US Treasury bonds, good volatility is smaller than bad volatility in the case of gold.

[Table 4 about here.]

The VoV estimates for daily data based on a 120-day rolling window yield qualitatively similar results (see Figure 11 in the Appendix).

Since gold does not belong to the fixed income asset class and is relatively more difficult to value compared to bonds, investors and policy makers may assume that it is more volatile. Thus, it may be surprising that gold is not clearly more volatile than US 30-year Treasury bonds.

4.2.3 Flight-to-Quality

This section analyzes whether HQLA are flight-to-quality assets, i.e., are sought out by investors during crisis periods or financial turmoil such as the SVB banking crisis in March 2023 and the financial turmoil associated with the outbreak of COVID-19 in March 2020. In the context of banking regulation and HQLAs, the SVB banking crisis is more relevant, and thus the focus of this section.

If there is indeed a flight-to-quality, such quality asset prices will increase and thus help to absorb shocks and losses. Since stable or higher prices do not automatically imply that the asset is also more liquid, we examine both changes in the price and the liquidity of assets.

It is important to note that the flight-to-quality phenomenon is closely linked the safe haven property. The former describes the dynamics and an action of investors while the latter describes a (non-dynamic) property and outcome.

Figure 9 illustrates the performance of HQLA assets, gold and the S&P500 during the 2023 SVB banking crisis and the financial turmoil due to the outbreak of COVID-19. Both time series plots show that HQLA and gold increased in value consistent with flight-to-quality and the safe-haven property of these assets.

[Figure 9 about here.]

The price effects in the two crises periods differ in at least two key ways: the reaction of bonds and gold is positive and relatively homogeneous in the 2023 SVB crisis. In contrast, for the COVID-19 outbreak, the reaction of bonds and gold is positive initially but becomes more heterogeneous after about 10 days. While the weak safe haven effect for gold is unique to the COVID crisis, the short-lived safe haven effect is not. In other words, an initial price increase is often followed by a correction generally occurring within 10 trading days (see Baur and McDermott (2016)). The different reaction of gold and US Treasuries could also be due to central bank intervention as reported in Vissing-Jorgensen (2021). In fact, a closer look at the statistics of the "Total Assets of the Federal Reserve" show an increase between March 2020 and May 2020 from about 4.5 trillion to 6.5 trillion US dollars.[11]

Figure 10 presents the crisis effects for the 2008 Global Financial Crisis (GFC) for comparison. The graph shows a strong safe haven effect of gold at the start of the crisis followed by a small price drop after about 15 days. The gold price remained elevated over the 30-day period. Bond prices, in contrast, did not increase significantly and remained rather stable over the 30-day period.

[Figure 10 about here.]

Table 5 presents the average returns and bid-ask spreads based on hourly data for a selection of HQLAs and gold. The estimates show that HQLAs and gold exhibit positive average returns during the crisis period consistent with a flight-to-quality. The bid-ask spread for gold is the lowest among

[11] "During the crisis, bid-ask spreads [...] widened, and intermediaries were unable to find buyers for the bonds at listed prices. At this point, the Fed intervened and, acting as the buyer of last resort, bought approximately $1 trillion worth of Treasurys by the end of the first quarter of 2020, restoring liquidity to the bond market." (Matthew Wells, Averting a Treasury Market Crisis, Econ Focus First Quarter 2023, https://www.richmondfed.org/publications/research/econ_focus/2023/q1_feature2)

all bonds.

[Table 5 about here.]

5 Portfolio analysis

This section examines how a typical HQLA portfolio's risk and return characteristics change when gold is added.

Theoretically, the risk of a portfolio can be reduced if either a less risky asset is added to the portfolio or an asset with a similar risk profile but a correlation well below one is added to the portfolio.

Empirically, the risk of an asset or portfolio is measured with the standard deviation. The standard deviation of daily 10-year US Treasury price changes (returns) is 0.48 based on a sample of daily data from January 2000 to September 2024. If gold is added to a portfolio of 10-year bonds with 90% bonds and 10% gold, the standard deviation drops to 0.45. Importantly, this is despite the fact that gold is more volatile than 10-year US Treasury bonds. The reduction is due to the low correlation (0.13) of gold with these bonds.

Table 6 presents the risk and return over risk ratio for different portfolios.[12] All portfolios involving gold have lower risk except the 70/ 30 portfolio. However, its return over risk ratio is the highest among all portfolios due to the relatively high returns of gold.

[Table 6 about here.]

[12] The return over risk ratio is equal to the Sharpe Ratio (SR) if the risk-free rate is assumed to be zero.

5.1 Crisis performance

Table 7 Panel A shows how a bank's HQLA portfolio would have performed during the US banking crisis of 2023 if gold had been included. The results are similar and consistent with the analysis for the full sample period. Adding gold to a portfolio of US Treasury bonds lowers the risk of the portfolio and thus makes the portfolio more stable. The higher return over risk ratio further enhances the resilience because higher returns compensate for losses. The higher return over risk ratio is due to gold's safe haven property which results in relatively high gold returns during safe haven events. Panels B and C present the analysis for the 2020 COVID-19 outbreak and the 2008 GFC with similar results, respectively.

[Table 7 about here.]

6 Other considerations

Beyond the quantitative analysis based on bid-ask spreads, volume, return volatility and volatility of volatility as examined above, there are other, more qualitative, considerations to broaden the current set of HQLAs.

The fact that regulated banks are required to hold HQLAs such as sovereign bonds creates a sovereign - bank nexus (e.g. see Seoane (2020); Hardy, Bryan and Zhu, Sonya (2023)). Whilst the sovereign debt link with regulated banks may result in fundamental issues such as a lack of debt needed by banks or excess sovereign bond volatility due to excess debt issuance, there are also direct effects such as sovereign credit risk spillovers. Fratzscher and Rieth (2018) show that sovereign credit risk is reflected in bank credit risk. Caballero et al. (2017) discuss an extreme case after the

2008 financial crisis when the government bonds of several EU countries lost their high-quality safe asset status.[13] Since gold has no credit risk and no default risk[14], the nexus could be weakened and the risk be lowered if gold was added to the set of HQLAs that are held by banks. It is also important to mention that both the supply and the demand for gold is driven by relatively free market forces without a dominating government or central bank. This is clearly not the case for the supply and the demand of government bonds. The supply of bonds is determined by governments and the demand of bonds is at least partially driven by regulatory requirements for banks.

Another nexus is created by central bank monetary policy through bond purchases (Quantitative Easing (QE)) or bond sales (Quantitative Tightening (QT)). This may create a conflict of objectives between the monetary policy and banking stability. Specifically, QE may reduce the availability of HQLAs for banks and add significant interest rate risk to the portfolio of bond holdings. Since gold is not used for monetary policy despite being a significant and growing central bank reserve asset[15], adding gold to the set of HQLAs may reduce the impact of monetary policy and enhance the stability and the resilience of banks.

While sovereign bond holdings (Fang, Hardy, and Lewis, 2022) and gold holdings are both geographically dispersed, gold holdings are arguably more diverse because gold is held by central banks, institutional investors (Baur, Hoang, and Casavecchia, 2021) and retail investors (Narayanan, Gopalakrishnan, and Sahay, 2020; World Gold Council, 2017). Regulated banks generally have insignificant gold holdings compared with their required sovereign bond holdings.

Of the total above-ground stock of gold estimated at 212.5 thousand tons, 45% is held as jewellery,

[13] see also Aggarwal et al. (2021)

[14] Gold is also a currency hedge, unlike government bonds. Since gold is inversely related to a country's currency, gold reserves could be particularly useful if a country faces a currency crisis. Gold could help to stabilize portfolios in such periods.

[15] see World Gold Council `https://www.gold.org/goldhub/data/gold-reserves-by-country`

22% is held as bars and coins including gold backed ETFs, 17% is held by central banks and 15% is unspecified (see World Gold Council[16]).

These diverse gold holdings potentially add to the stability of gold and enhance the stability of any portfolio that contains a fraction of gold. In addition, while retail investors often add to the volatility of an asset or asset class, there are many studies that indicate that this is not the case for gold. For example, gold is used as self insurance in emerging market countries (e.g. see Narayanan et al. (2020); Sinha, Aghabarari, and Rostom (2022)) and retail investors are generally reluctant to sell gold.

7 Summary and Conclusions

This paper studied whether gold meets key high-quality liquid asset (HQLA) criteria and in which way gold differs from top tier HQLAs such as US Treasury bonds. The quantitative analysis shows that gold is highly liquid and among the most liquid assets across a sample of top tier government bonds. Estimates of the volatility of gold further revealed that gold's volatility is comparable with US Treasury bonds and other sovereign bonds. Specifically, gold is more volatile than most short-maturity US Treasury bonds but clearly less volatile than 30-year US Treasury bonds. Gold performs particularly well during crisis periods especially during the SVB 2023 crisis with both higher returns and lower bid-ask spreads than most government bonds including US Treasury bonds. A portfolio analysis further demonstrates that adding gold to an existing portfolio of government bonds lowers its volatility. The strong positive price effects of gold during safe haven events in comparison to government bonds can compensate for losses and thus further enhance the stability of HQLA portfolios. The findings are based on a variety of data sources, data frequencies including high-frequency 5-min

[16] `https://www.gold.org/goldhub/data/how-much-gold`

and hourly data and sample periods. Importantly, the results are similar across this variety of data indicating that the results are robust and not based on the sample selection.

The Silicon Valley Banking crisis of March 2023 has highlighted risks associated with an exclusive focus on government bonds. This study showed that these risks can be mitigated by broadening the set of HQLAs with the inclusion of gold.

Furthermore, the focus of regulatory banking requirements on sovereign bonds and their use for monetary policy creates a link between governments and banks with the potential for adverse spillovers from government policies to banks and from banks to governments. This nexus could be weakened by the addition of an asset that is independent of governments and not used for monetary policy.

Since this is the first study on the potential role of gold as a HQLA, there are ample opportunities for future research.

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Appendix

[Figure 11 about here.]

[Figure 12 about here.]

Figure 1: Effective bid-ask spread (hourly data) 2010 - 2023

The barplot shows the sorted average bid-ask spreads of a selection of government bonds with different maturities and gold spot (XAU=) prices. The spreads are averaged over the 2010 - 2023 sample period. The averages are based on hourly prices. The US 2-year Treasury bond has the lowest bid-ask spread, the 30-year Australian bond has the highest bid-ask spread. Gold (XAU=) has a bid-ask spread below the median which lies between the 30-year US Treasury bond and the EU 2-year Treasury bond.

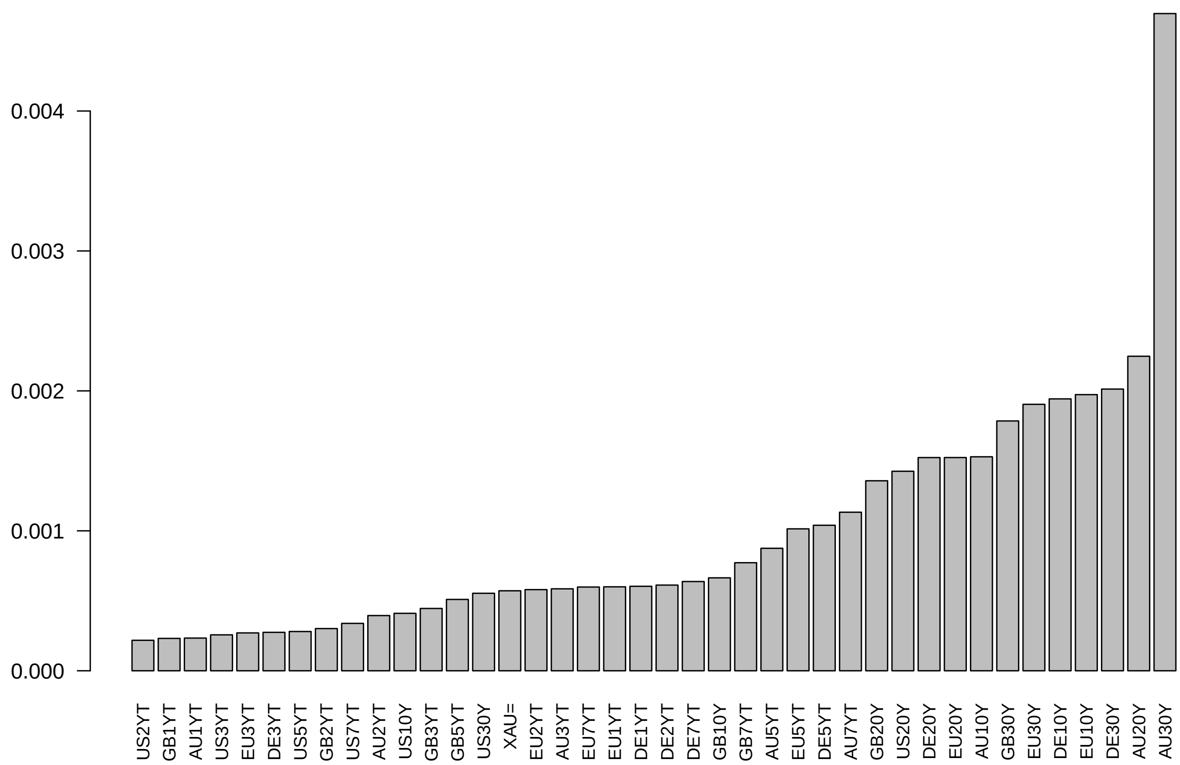


Figure 2: Effective bid-ask spread (hourly data) - SVB crisis March 2023

The barplot shows the sorted average bid-ask spreads of a selection of government bonds with different maturities and gold spot (XAU=) prices. The spreads are averaged over the 30-day March 2023 sample period. The averages are based on hourly prices. The UK 1-year Treasury bond has the lowest bid-ask spread, the 30-year UK bond has the highest bid-ask spread. Gold (XAU=) has a bid-ask spread in the lower tercile which lies between the 5-year UK Treasury bond and the EU 7-year Treasury bond.

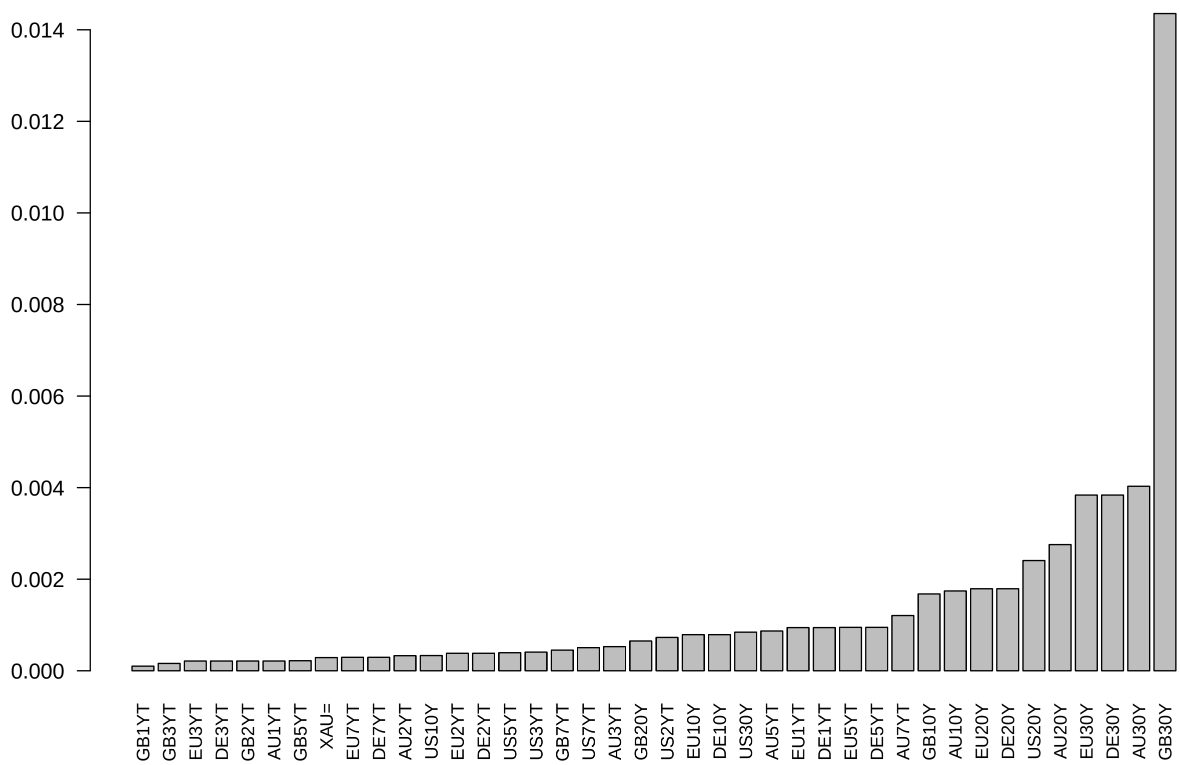


Figure 3: Amihud's (2002) illiquidity - US Treasury bonds vs. Gold - Rolling Windows

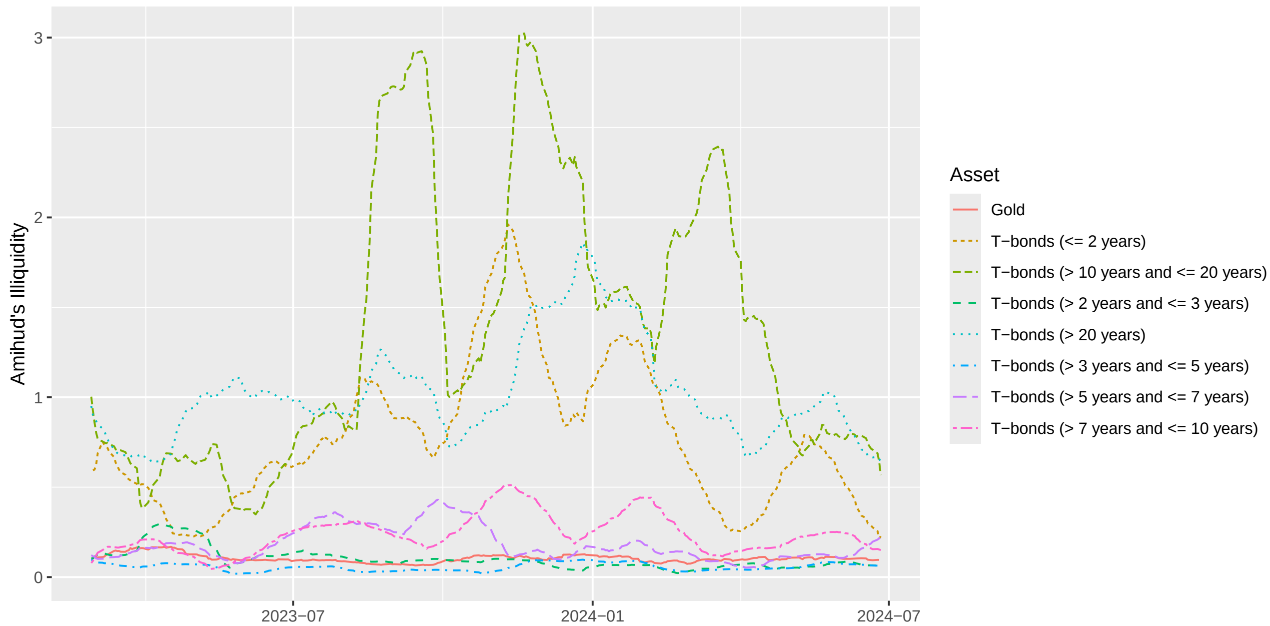


Figure 4: Gold vs. GNMA MBS bid-ask spread

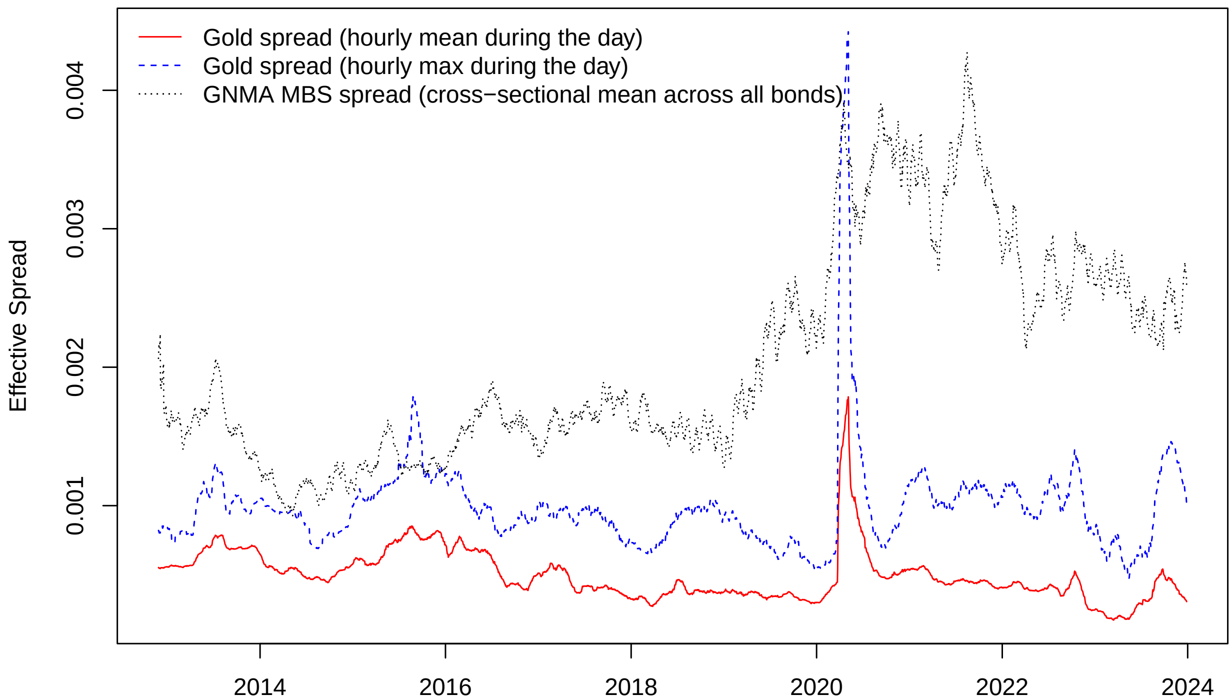


Figure 5: Amihud's (2002) illiquidity - GNMA MBS vs. Gold - Rolling Window

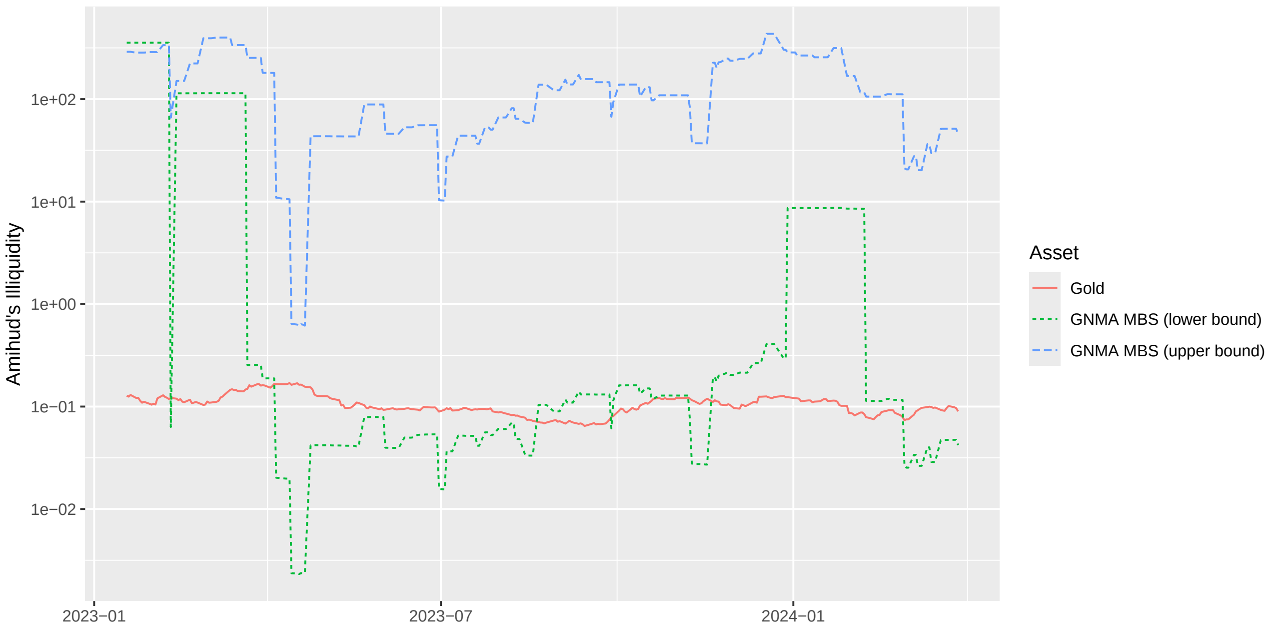


Figure 6: Volatility of hourly returns (midpoint)

The barplot shows the sorted volatility of hourly returns (standard deviation of returns of midpoint) of a selection of government bonds with different maturities and gold spot (XAU=) prices. The sample period is 2010 - 2023. The EU 1-year Treasury bond has the lowest volatility, the 3-year US bond has the highest volatility. Gold (XAU=) lies in the center of the volatility distribution between the 20-year Australian Treasury bond and the German 7-year Treasury bond.

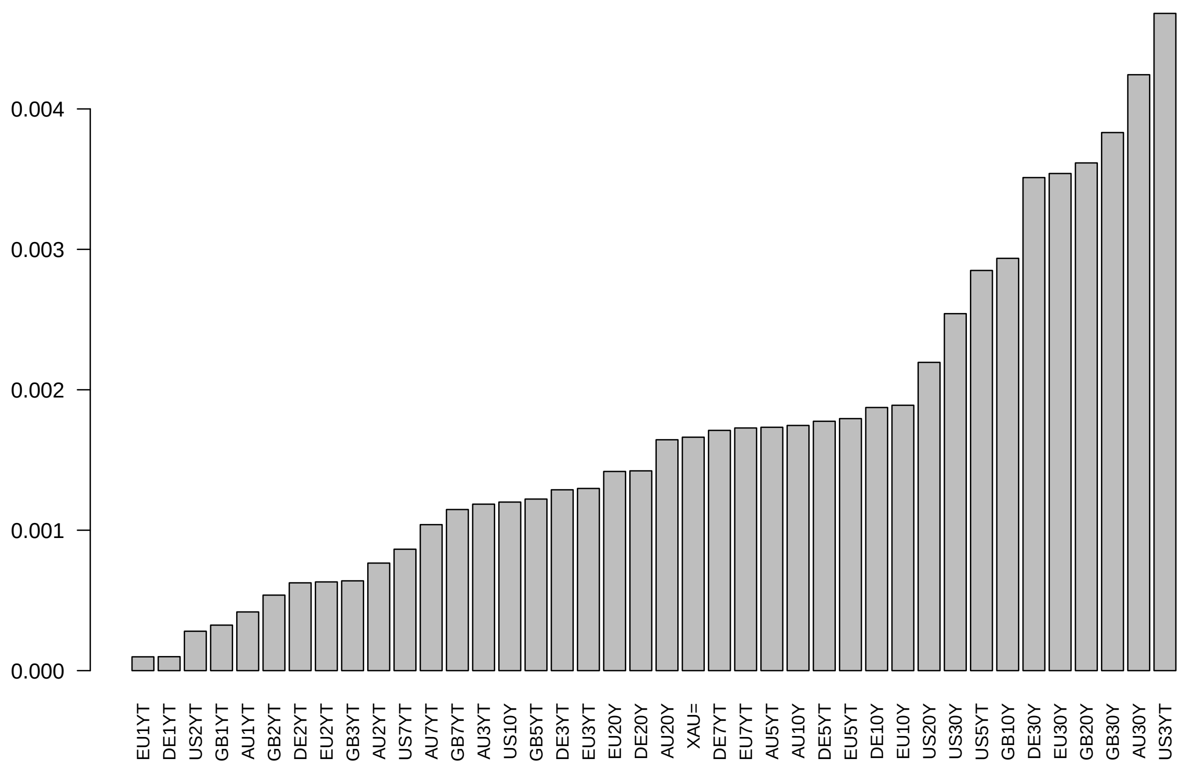
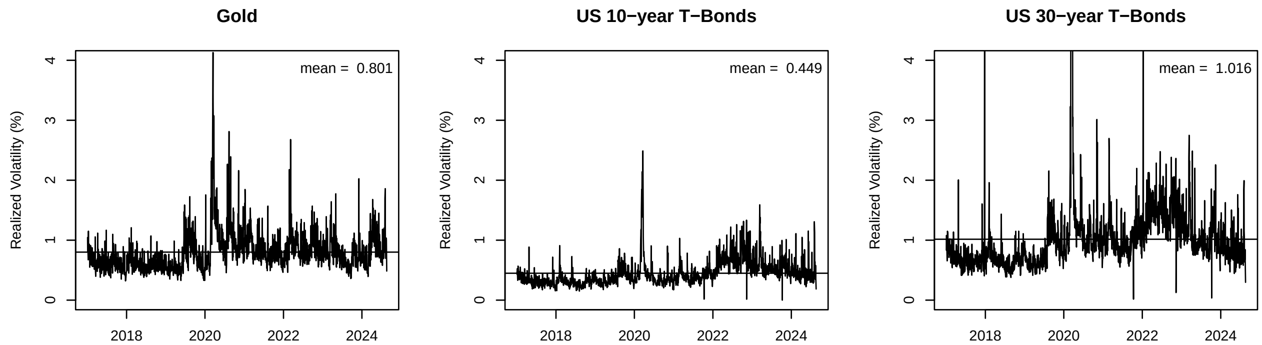


Figure 7: Daily realized volatility (calculated using 5-min returns)

This figure presents the time-series of daily total, good, and bad volatility of gold and 10-year and 30-year US Treasuries (in percentage). Realized volatility is estimated as the square root of the sum of squared 5-minute returns during the corresponding sample period when the data is available. Good volatility and bad volatility are estimated in the same manner as realized volatility but only using positive and negative returns during the day, respectively.

(a) Total Realized Volatility



(b) Good vs. Bad Realized Volatility

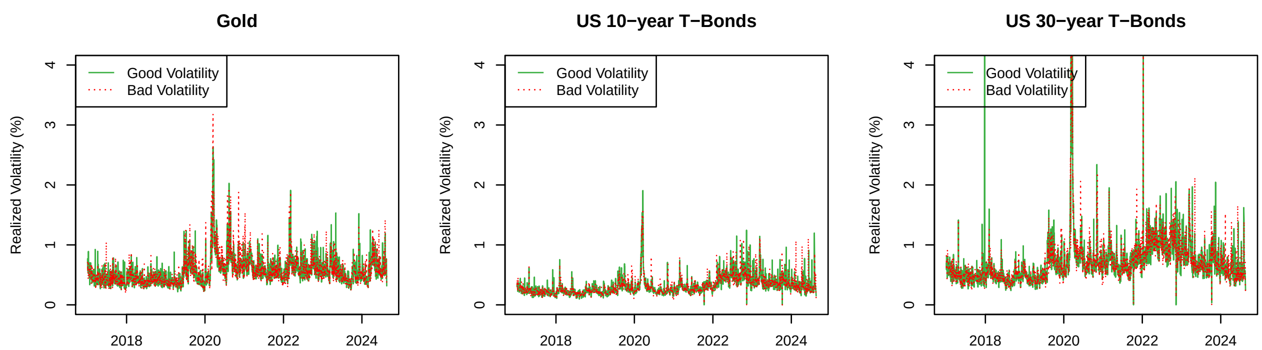


Figure 8: 120-day Rolling Window Daily Volatility

This figure presents the time-series of volatility based on 120-day rolling window standard deviations of daily returns. The volatility estimates are presented for gold, 2-year, 10-year, 30-year US Treasury bonds and for the S&P500. The vertical dashed lines (grey) indicate four crisis periods, the 2008 Global Financial Crisis, the 2020 COVID-19 outbreak, the 2023 SVB banking crisis and the 2024 August market turmoil.

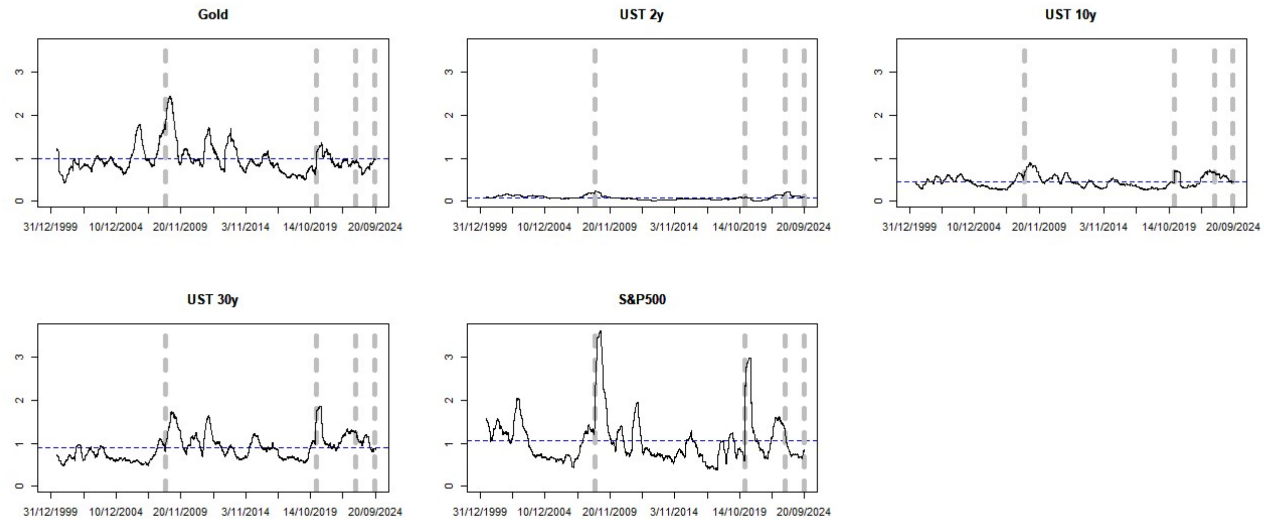
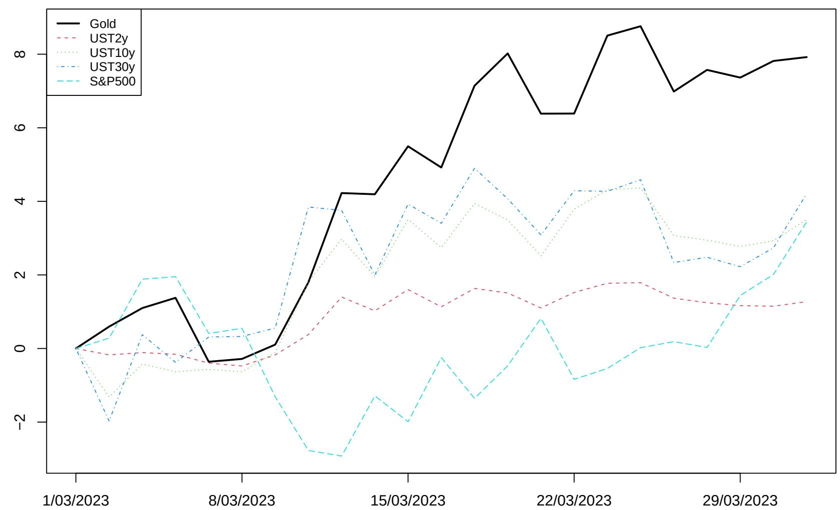


Figure 9: Daily prices during crises

Panel A shows the evolution of gold, US Treasury bonds and the S&P500 for the 2023 SVB banking crisis. Panel B shows the evolution of the same assets for the COVID-19 outbreak in March 2023.

(a) SVB crisis (March 2023)



(b) COVID-19 crisis (March 2020)

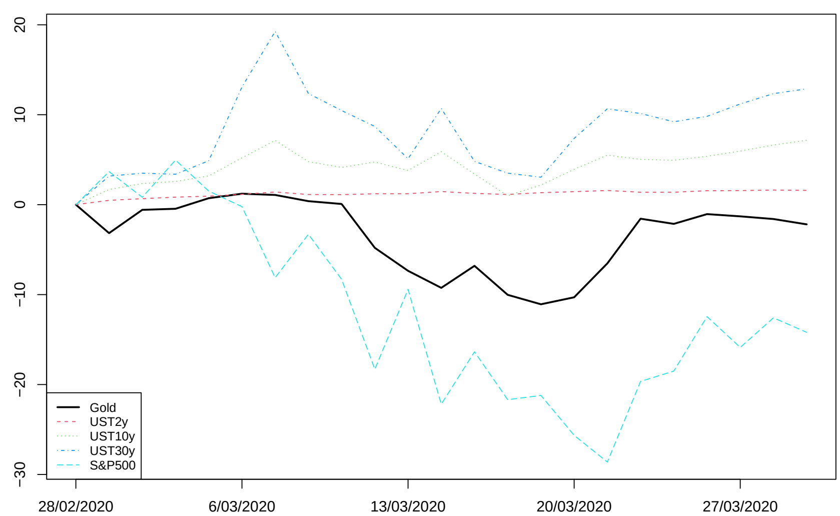


Figure 10: Daily prices during GFC (Sept 15, 2008 - Oct 15, 2008)

The graph shows the evolution of gold prices, US Treasury bond prices and the S&P500 index level during the 2008 Global Financial Crisis (September 15, 2008 - October 15, 2008).

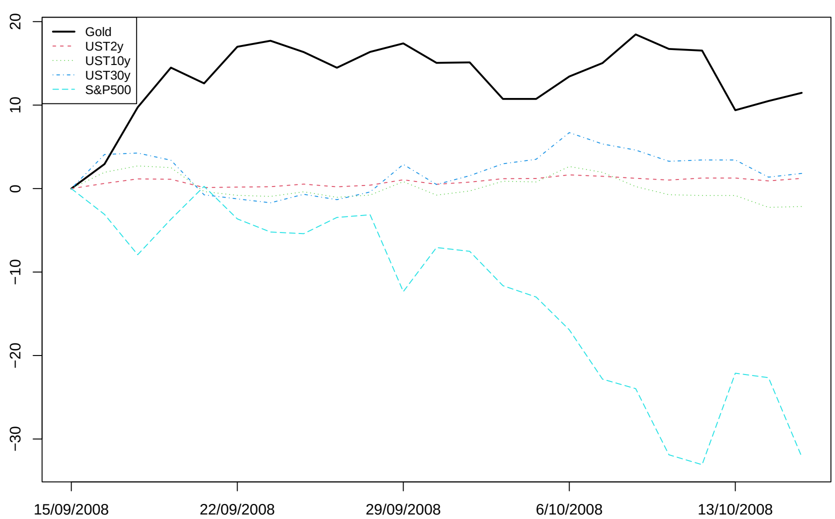


Figure 11: Volatility of volatility based on a 120-day rolling window

This figure presents the time-series of volatility of volatility (VoV) based on the standard deviation of the 120-day rolling window standard deviations of daily returns. The VoV estimates are presented for gold, 2-year, 10-year, 30-year US Treasury bonds and for the S&P500. The vertical dashed lines (grey) indicate four crisis periods, the 2008 Global Financial Crisis, the 2020 COVID-19 outbreak, the 2023 SVB banking crisis and the 2024 August market turmoil.

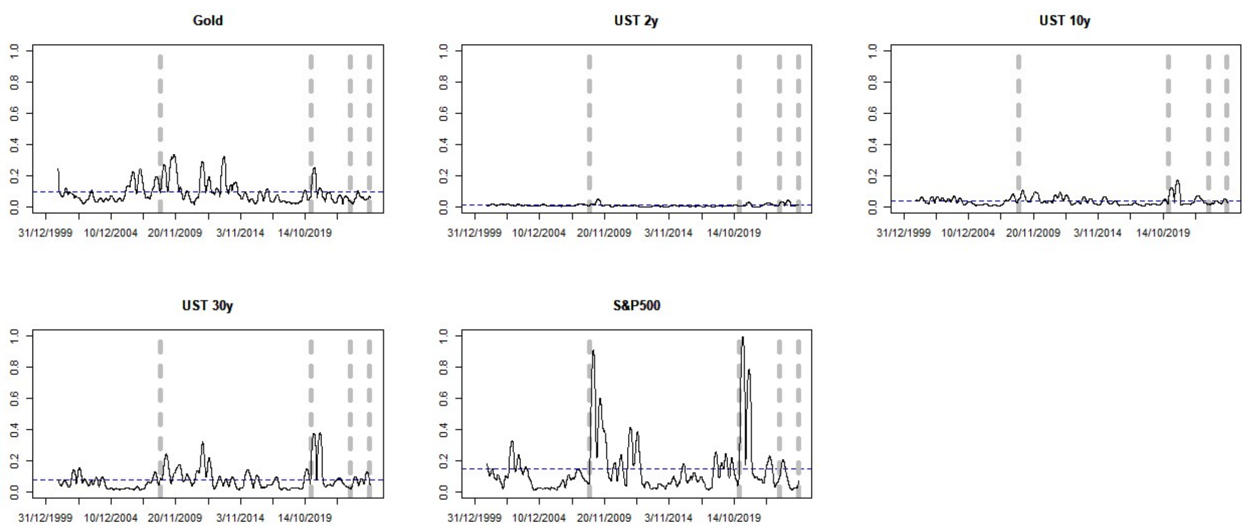
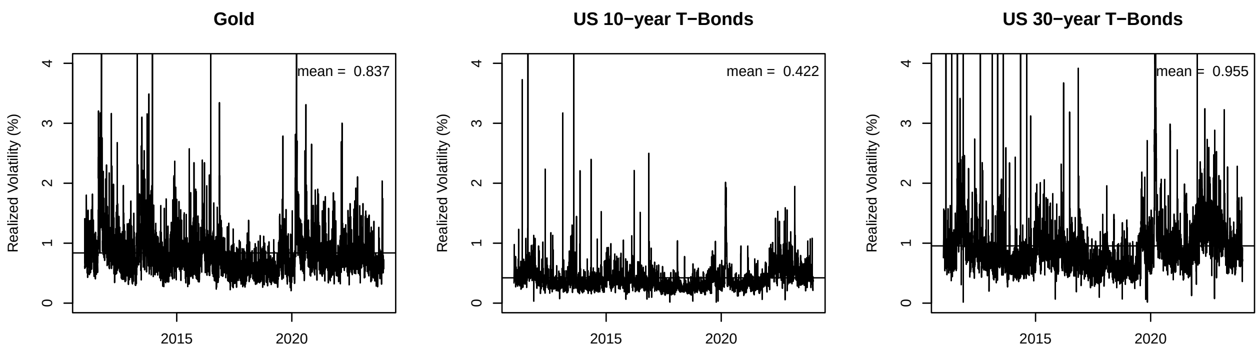


Figure 12: Daily realized volatility (calculated using hourly returns)

This figure presents the time-series of daily total, good, and bad volatility of gold and 10-year and 30-year US Treasuries (in percentage) calculated using hourly returns. Realized volatility is estimated as the square root of the sum of squared hourly returns during the corresponding sample period when the data is available. Good volatility and bad volatility are estimated in the same manner as realized volatility but only using positive and negative returns during the day, respectively.

(a) Total Realized Volatility



(b) Good vs. Bad Realized Volatility

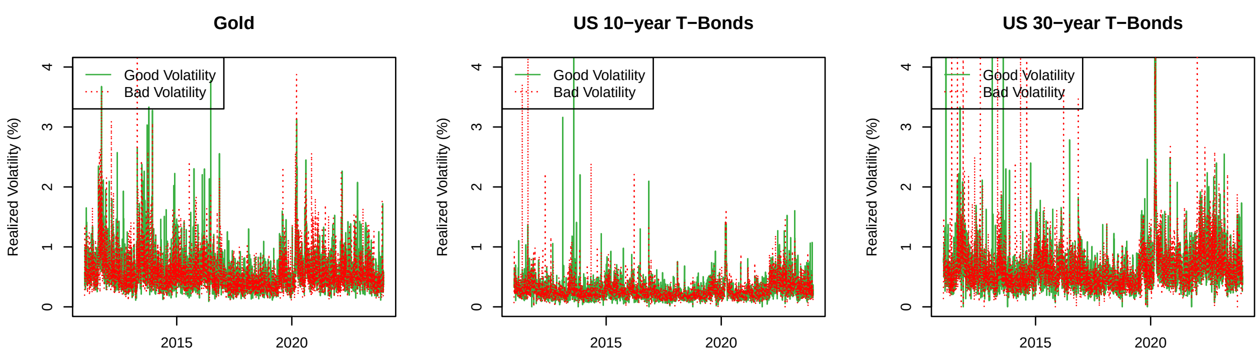


Table 1: Amihud's (2002) illiquidity - US Treasury bonds vs. Gold

Daily aggregate data on US Treasury bond trading are sourced from FINRA and daily data on gold are from LBMA. The sample is from February 13, 2023 to June 26, 2024. Amihud's (2002) illiquidity measure is then calculated as $ILLIQ = \frac{1}{N}\sum_{t=1}^{T}\frac{|Ret_t|}{Vol_t}$ where Ret_t is return on day t, Vol_i is the trading volume in trillion dollars, and T is the number of days during the sample period. Restricted by data availability, for US Treasury bonds, we use volume-weighted average price during the day to calculate daily returns for each bond tenor, and use the total traded par value as a measure of trading volume.

	Full sample		March 2023	
Bond Tenor	US Treasury bonds	Gold	US Treasury bonds	Gold
$<=$ 2 years	0.751	0.102	0.446	0.178
$>$ 2 years and $<=$ 3 years	0.096	0.102	0.246	0.178
$>$ 3 years and $<=$ 5 years	0.055	0.102	0.051	0.178
$>$ 5 years and $<=$ 7 years	0.186	0.102	0.168	0.178
$>$ 7 years and $<=$ 10 years	0.234	0.102	0.232	0.178
$>$ 10 years and $<=$ 20 years	1.321	0.102	0.385	0.178
$>$ 20 years	1.000	0.102	0.612	0.178

Table 2: Volatility of daily returns during crisis periods

This table presents the average daily volatility for a 30-day period (22 trading days) for four crises or turmoil periods for gold, 2-year, 10-year and 30-year US Treasury bonds and the S&P500. The crisis periods are the 2008 GFC, the 2020 COVID-19 outbreak, the 2023 SVB banking crisis and the 2024 August turmoil. The crisis start dates are 15/9/2008, 28/2/2020, 01/03/2023, 01/08/2024.

	Gold	UST2y	UST10y	UST30y	S&P500
GFC 2008	3.068	0.414	1.181	1.778	4.849
COVID 2020	2.299	0.162	1.355	3.551	5.797
SVB 2023	1.143	0.372	0.884	1.327	1.135
AUG 2024	0.789	0.156	0.508	1.003	1.201

Table 3: Good and Bad Volatility during crises periods

This table presents the average good daily volatility and bad daily volatility for a 30-day period (22 trading days) for four crises or turmoil periods. Good volatility is the mean of positive returns. Bad volatility is the mean of negative returns. Panel A shows the average daily volatility for gold, 2-year, 10-year and 30-year US Treasury bonds and the S&P500 for the 2008 GFC period. Panel B shows the average volatility for the 2020 COVID-19 period. Panel C shows the average volatility for the 2023 SVB banking crisis period and Panel D shows the average volatility for the 2024 August turmoil period. The crisis start dates are 15/9/2008, 28/2/2020, 01/03/2023, 01/08/2024.

Panel A: GFC 2008	Good volatility	Bad volatility
Gold	1.902	1.766
UST2y	0.247	0.240
UST10y	0.657	0.758
UST30y	1.067	1.042
S&P500	2.640	3.122
Panel B: COVID-19 2020	Good volatility	Bad volatility
Gold	1.369	1.403
UST2y	0.108	0.080
UST10y	0.726	0.832
UST30y	2.360	1.922
S&P500	3.032	3.545
Panel C: SVB 2023	Good volatility	Bad volatility
Gold	0.790	0.589
UST2y	0.273	0.158
UST10y	0.602	0.409
UST30y	0.923	0.633
S&P500	0.649	0.644
Panel D: August 2024	Good volatility	Bad volatility
Gold	0.483	0.413
UST2y	0.118	0.068
UST10y	0.340	0.265
UST30y	0.662	0.534
S&P500	0.670	0.767

Table 4: Volatility of Volatility

This table present the volatility of volatility (in percentage), which is calculated as the standard deviation of daily realized, good, and bad volatility. Realized volatility is estimated as the square root of sum of squared 5-minute returns (Panel A) or hourly returns (Panel B) during the corresponding sample period when the data is available. Good volatility and bad volatility are estimated in the same manner as realized volatility but only using positive and negative returns during the day, respectively.

	Volatility of:		
	Realized Volatility	Good Volatility	Bad Volatility
Panel A: 5-minute data, 2017-2023			
Gold	0.336	0.236	0.254
10-year US Treasury bonds	0.559	0.477	0.319
30-year US Treasury bonds	1.187	0.957	0.753
Panel B: Hourly data, 2011-2023			
Gold	0.440	0.338	0.362
10-year US Treasury bonds	0.522	0.436	0.324
30-year US Treasury bonds	1.050	0.852	0.697

Table 5: SVB March 2023, hourly data

This table displays average returns and bid-ask spreads over a 30-day period in March 2023 based on hourly data of gold prices (XAU=) and for a selection of US, AU (Australia), EU (European Union), GB (UK) and DE (Germany) government bonds.

	return (x 100)	bid-ask spread (x 100)
XAU=	0.011	0.029
US2YT	0.0001	0.073
US5YT	0.002	0.039
US10Y	0.005	0.033
US30Y	0.007	0.084
AU10Y	0.007	0.174
EU10Y	0.004	0.079
GB10Y	0.004	0.168
DE10Y	0.004	0.079

Table 6: Portfolio Analysis

This Table demonstrates how the risk and return over risk ratio changes if gold is added to a portfolio of US Treasury bonds. P1 is a portfolio comprised of 100% 10-year US Treasury bonds; P2 is a portfolio comprised of 90% 10y US Treasury bonds and 10% gold; P3 is a portfolio comprised of 90% 10y US Treasury bonds and 10% 30y US Treasury bonds; P4 is a portfolio comprised of 80% 10y US T bonds, 10% gold and 10% 30 y T bonds; P5 is a portfolio comprised of 80% 10y US T bonds and 20% gold and P6 is a portfolio comprised of 70% US T bonds and 30% gold. Values highlighted in bold represent the lowest volatility and highest Return/ Risk allocation.

	10-year T b	Gold	30-y T b	Volatility	Return/ Risk
P1	1	0	0	0.477	0.007
P2	0.900	0.100	0	**0.455**	0.014
P3	0.900	0	0.100	0.517	0.007
P4	0.800	0.100	0.100	0.493	0.013
P5	0.800	0.200	0	0.457	0.021
P6	0.700	0.300	0	0.485	**0.026**

Table 7: Portfolio Analysis crisis periods (SVB 2023 banking crisis, COVID-19 Outbreak 2020, Global Financial Crisis 2008)

This Table demonstrates how the risk and return over risk ratio changes if gold is added to a portfolio of US Treasury bonds. Panel A shows the results for the 2023 SVB crisis period (March 2023), Panel B for the 2020 COVID-19 outbreak (March 2020) and Panel C for the 2008 Global Financial Crisis (15 Sept - 15 Oct, 2008). P1 is a portfolio comprised of 100% 10-year US Treasury bonds; P2 is a portfolio comprised of 90% 10y US Treasury bonds and 10% gold; P3 is a portfolio comprised of 90% 10y US Treasury bonds and 10% 30y US Treasury bonds; P4 is a portfolio comprised of 80% 10y US T bonds, 10% gold and 10% 30 y T bonds; P5 is a portfolio comprised of 80% 10y US T bonds and 20% gold and P6 is a portfolio comprised of 70% US T bonds and 30% gold. Values highlighted in bold represent the lowest volatility and highest Return/ Risk allocation.

Panel A: SVB crisis

	10-year T b	Gold	30-y T b	Volatility	Return/ Risk
P1	1	0	0	0.922	0.143
P2	0.900	0.100	0	**0.914**	0.168
P3	0.900	0	0.100	0.953	0.136
P4	0.800	0.100	0.100	0.943	0.160
P5	0.800	0.200	0	0.916	0.192
P6	0.700	0.300	0	0.926	**0.213**

Panel B: COVID-19

	10-year T b	Gold	30-y T b	Volatility	Return/ Risk
P1	1	0	0	1.355	**0.230**
P2	0.900	0.100	0	1.247	0.217
P3	0.900	0	0.100	1.542	0.218
P4	0.800	0.100	0.100	1.434	0.206
P5	0.800	0.200	0	1.188	0.194
P6	0.700	0.300	0	**1.187**	0.160

Panel C: GFC 2008

	10-year T b	Gold	30-y T b	Volatility	Return/ Risk
P1	1	0	0	1.181	-0.079
P2	0.900	0.100	0	**1.158**	-0.030
P3	0.900	0	0.100	1.232	-0.062
P4	0.800	0.100	0.100	1.207	-0.014
P5	0.800	0.200	0	1.215	0.021
P6	0.700	0.300	0	1.342	**0.063**