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THE WORLD BANK
Treasury | RAMP

GOLD INVESTING HANDBOOK FOR ASSET MANAGERS

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INTRODUCTION

Throughout history, gold has played a vital role as a financial asset in the global financial system. It has been prevalent as a currency in many civilizations, including Ancient Greece, Rome, and Egypt. In the modern era, gold continues to play a critical role in the global financial system, serving as a hedge against inflation, a safe haven asset, and a reserve asset for central banks.

In the 20th century, how gold was used in financial systems underwent significant changes. The gold standard, which tied the value of paper currency to the price of gold, prevailed until the 1930s, when it was abandoned by most major countries due to the Great Depression. However, the gold standard remained a critical part of the international monetary system until 1971, when the US government ended its convertibility to gold.

In recent years, gold has regained its importance as a financial asset, with many investors using it as a hedge against inflation and market volatility. In addition, central banks and other financial institutions continue to hold significant amounts of gold as part of their reserve assets.

The role of gold as a reserve asset for central banks has been a significant driver of demand for the precious metal. Gold is also considered a safe haven asset during times of economic uncertainty and geopolitical turmoil, making it a popular among investors looking to hedge against market volatility.

In addition to its role as a reserve asset, gold is a widely traded commodity in financial markets. Gold futures and options are actively traded on commodity exchanges, providing investors with a range of investment opportunities. Gold is also used in the production of various industrial and consumer products, including electronics, jewelry, and medical devices.

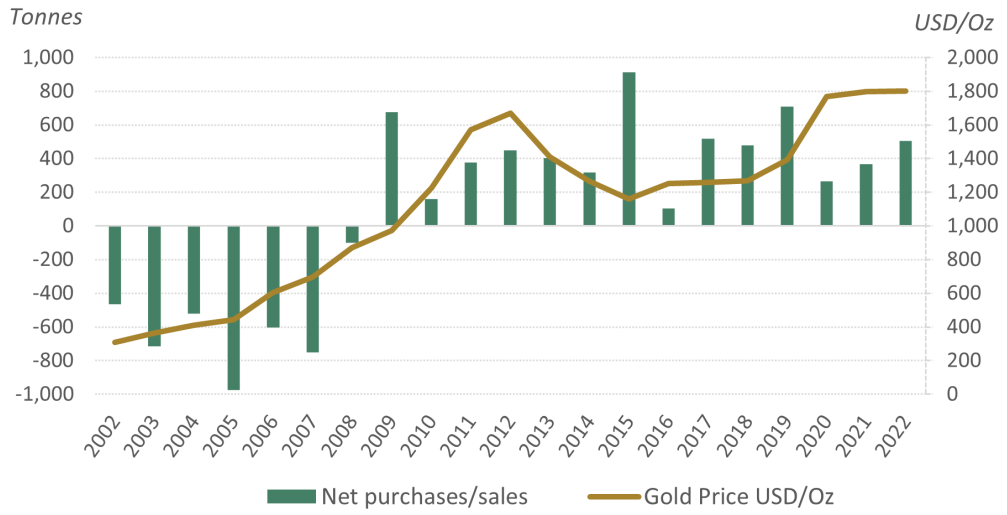
The increasing awareness of environmental, social, and governance (ESG) issues in the investment community has led to a growing interest in responsible sourcing and use of gold. Initiatives such as the LBMA's Responsible Sourcing Program (RSP) and the World Gold Council's Responsible Gold Mining Principles (RGMP) aim to promote sustainable and ethical practices in the gold mining industry.

The role of gold in the global financial system has evolved over time, with changes in monetary policy, economic conditions, and technological advancements influencing demand and supply dynamics. Despite these changes, gold remains a crucial component of the global financial system and is likely to continue to play an essential role in the future.

The market disruptions brought about by the 2008 Global Financial Crisis (GFC), the US and China trade war, Brexit, and the COVID-19 pandemic, as well as a prolonged period of negative real interest rates and geopolitical uncertainties caused by financial sanctions imposed on Russia to freeze its foreign reserves, reinforced the strategic importance of gold as a buffer against financial instability. Asset managers' changing sentiments are reflected in a 2022 World Gold Council (WGC) survey in which respondents marked "historical position" and "performance during times of crisis" as the most relevant factors for holding gold. Central banks in 2022 were also more optimistic on gold as a reserve asset, with 61 percent of respondents stating that they expect global gold reserves to increase over the next 12 months.

Central banks' stance against gold shifted in the period following the GFC, and they have been the net buyers since then, despite ever-increasing gold prices, after having been net sellers in preceding periods (Figure 1).

FIGURE 1. CENTRAL BANK NET GOLD PURCHASES AND SALES



Source: Bloomberg, World Gold Council.

Two main factors may explain recent increase in gold purchases by central banks. First, gold is viewed as a safe haven and desirable asset during times of economic, financial, and geopolitical uncertainty as well as a portfolio diversifier. Second, gold is seen as a safe asset when countries are subject to financial sanctions and asset freezes. Skeptics, however, point to drawbacks in reliance on gold, including its cost to transport, warehouse, and secure and its lack of interest. Despite these disadvantages, gold remains a popular asset for central banks due to its historical track record and the well-regulated markets for trading.

The available empirical evidence suggests that some reserve managers respond to relative costs and returns by increasing the share of gold in their reserves when the expected return on financial assets such as US Treasury securities is low, while viewing gold as a hedge against economic and geopolitical risks. Notably, the proportion of gold held in reserves

by both advanced economies and emerging markets tends to increase with measures of economic uncertainty, with advanced economies showing an additional increase in response to measures of geopolitical risk (Arslanalp, Eichengreen, and Simpson-Bell 2023).

This report first discusses the credentials of gold as a strategic asset by analyzing its historical risk and return characteristics, its correlation with various asset classes, and the historical and future performance of several stylized institutional portfolios with varying allocations to gold.

The later part of the report addresses practical aspects for reserve managers of investing into gold and discusses various gold buying practices; gold trading, storing, and accounting; and gold liquidity management strategies. ESG considerations for gold investments are covered in the final chapter.

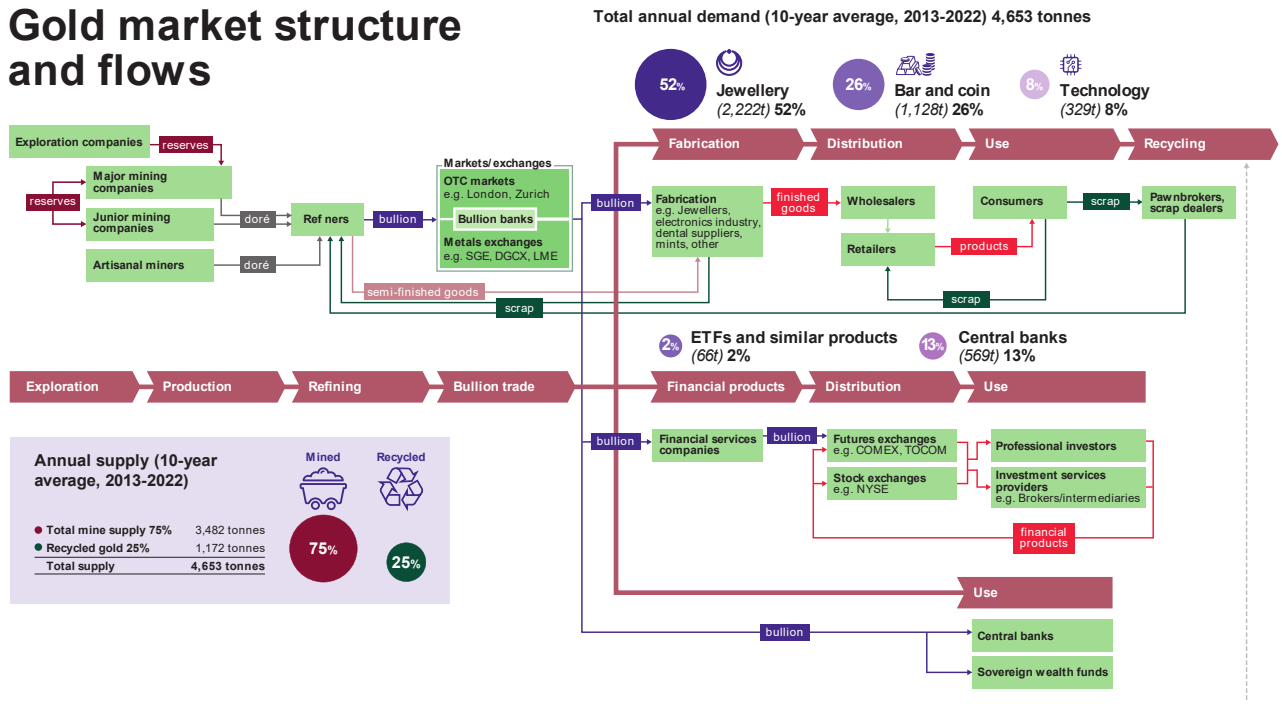
I. BACKGROUND ON THE GOLD MARKET

MARKET STRUCTURE

The gold market structure consists of several key players and components that influence the price and availability of gold (Figure 2).

At the top of the structure are the gold mining companies, which extract gold from the ground and sell it to refiners. Refiners then process the gold and sell it to bullion banks, which are responsible for trading large volumes of gold on a daily basis. Bullion banks also act as market makers, providing liquidity to the market and facilitating transactions between buyers and sellers.

FIGURE 2. STRUCTURE OF THE GOLD MARKET



Source: World Gold Council.

Investors and institutions are also key players in the gold market, buying and selling gold for a variety of reasons. Retail investors typically buy physical gold in the form of coins or bars, while institutional investors use futures contracts or exchange-traded funds (ETFs) to gain exposure to the gold market.

Because gold has multiple sources of demand and supply as compared to other major asset classes, its liquidity is less likely to dry up during times of market volatility. A large fraction of the demand comes from the physical side, as gold is actively used to produce jewelry and technology as well as being bought physically by central banks; taken together, these factors accounted for 76 percent of the total demand in 2022 (Table 1).

TABLE 1: GOLD SUPPLY/DEMAND CHANNELS

	2022Q4
Supply	
Mine production	3,611.9
Net producer hedging	-1.5
Recycled gold	1,144.1
Total supply	**4,754.5**
Demand	
Jewelry fabrication	2,189.8
Technology	308.5
Investment	1,106.8
Total bar and coin	1,217.1
ETFs & similar products	-110.4
Central banks & other institutions	1,135.7
Gold demand	4,740.7
OTC and other	13.8
Total demand	**4,754.5**

Source: Metals Focus, Refinitiv GFMS, World Gold Council.

Central banks are significant players in the gold market, holding large reserves of gold as a store of value and a hedge against currency risk. In addition to buying and selling gold, central banks also influence the market through their monetary policies, which can affect interest rates and inflation, both of which can impact the price of gold. The most recent data from April 2023 reveals that international organizations, including the IMF and the Bank for International Settlements (BIS), possess approximately 9 percent of the world's official gold holdings, as indicated in Table 2. The remaining gold reserves are distributed among countries, with advanced economies holding around two-thirds and emerging markets and developing economies accounting for one-third.

The United States and members of the Euro Area are the dominant owners of official gold, holding more than 50 percent of the total reserves. Meanwhile, the Russian Federation,

China, India, and Türkiye hold the largest amounts of gold among emerging markets. This suggests that gold remains a significant component of countries' reserve assets, and developed economies are currently the primary holders of this valuable resource.

TABLE 2: WORLD OFFICIAL GOLD HOLDINGS

Holder	Tonnes	% of Reserves	% of Total
United States	8,133	67%	23%
Germany	3,355	67%	9%
IMF	2,814	-	8%
Italy	2,452	64%	7%
France	2,437	66%	7%
Russian Federation	2,330	24%	7%
China	2,050	4%	6%
Switzerland	1,040	7%	3%
Japan	846	4%	2%
India	790	8%	2%
Netherlands	612	56%	2%
Turkey	587	33%	2%
ECB	507	27%	1%
Taiwan, China	424	4%	1%
Uzbekistan	393	67%	1%
Portugal	383	68%	1%
Kazakhstan	342	58%	1%
Saudi Arabia	323	4%	1%
United Kingdom	310	11%	1%
BIS	102	-	0.3%
Others	5,358	-	15%
World	**35,588**		

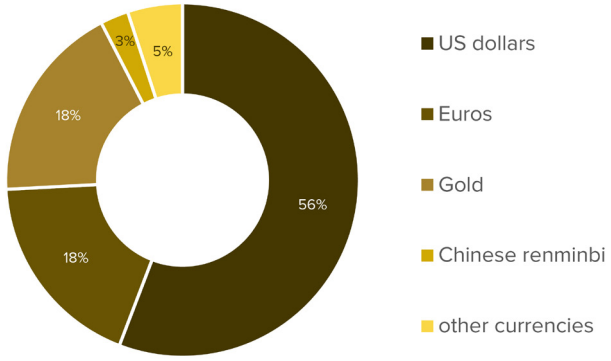
Source: IMF International Financial Statistics, April 2023.

After a period of decline that lasted for several decades and in the aftermath of the Global Financial Crisis, central banks' gold holdings have been increasing. However, this trend differs depending on whether a country is an advanced economy or an emerging market. Advanced economies have been diversifying away from gold reserves, while

emerging markets have been steadily increasing their holdings. The increase in gold reserves for emerging markets may be attributed to low interest rates on major reserve currencies, which has led to decreased return differentials between securities and gold (Gopalakrishnan and Mohapatra 2018).

Gold makes up around 18 percent (Figure 3) of the total reserves of the central banks, while the share of the US dollar in total global reserves has declined from 71 percent in 2000 to 56 percent in 2022 (according to the IMF Official Foreign Exchange Reserves (COFER)), reflecting the push among public asset managers to diversify their foreign reserves as their safety and capital preservation objectives became more difficult to achieve through investment in traditional assets and currencies, given the negative real yields environment.

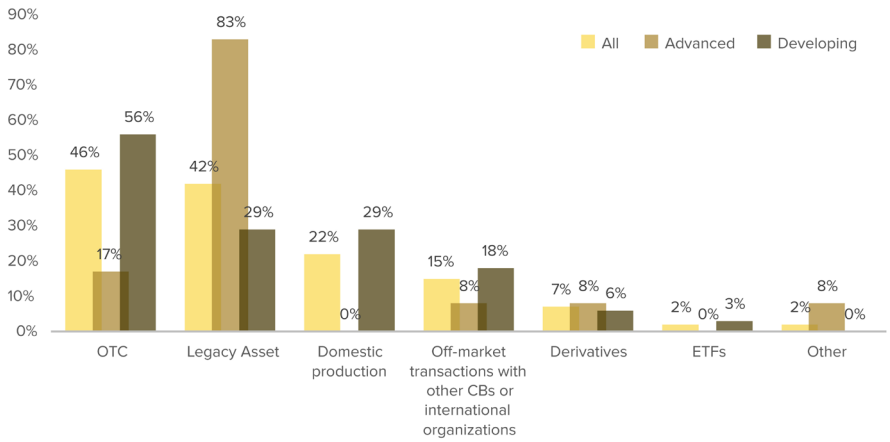
FIGURE 3. COMPOSITION OF OFFICIAL CURRENCY RESERVES



Source: COFER and World Gold Council (Q4 2022).

Most central banks have been adding gold to their reserves through purchases in over-the-counter (OTC) markets or local procurement programs (Figure 4). Some central banks have stocks of inherited gold that may not conform to market standards, and they have been engaging in gold upgrading programs. Gold ETFs have become a popular instrument among investors. This allows them to potentially integrate the gold asset class in their tactical asset allocation.

FIGURE 4. HOW CENTRAL BANKS PURCHASE GOLD



Source: World Gold Council.

The London Bullion Market Association (LBMA), which is the world's largest over-the-counter (OTC) gold trading platform, is a major player in the gold market. The LBMA facilitates trading among its members, which include bullion banks, refiners, and other market participants. This OTC trading accounts for a significant portion of the gold market, with the LBMA estimating that it accounts for around 56 percent of the total trading volume.

The flexibility of OTC trading allows anonymity, which is a significant advantage for some market participants. OTC trading also provides more flexibility in terms of price negotiation and trade execution. However, lack of regulation in OTC trading can sometimes make it more susceptible to price manipulation and fraud.

In contrast, exchanges and exchange-traded funds (ETFs) are more regulated trading platforms that account for around 43 percent of the trading volume in the gold market. These platforms provide a centralized location for gold trading and play a crucial role in establishing benchmark prices for gold. Some well-known gold exchanges include the COMEX in New York, the Shanghai Gold Exchange, and the Tokyo Commodity Exchange.

ETFs offer investors a way to gain exposure to gold without having to take physical delivery of the metal. ETFs hold physical gold in their custody and issue shares that can be bought and sold like stocks on a stock exchange.

TABLE 3: GOLD TRADING VOLUMES (MARCH 2023)

DAILY AVERAGES IN US$ BILLION

Holder	Tonnes	In US$ Billions	% of Total
OTC	LBMA trade data	82.04	45.0%
	Non-LBMA trade data	16.41	9.0%
	Shanghai Gold Exchange trade data	4.18	2.3%
	Total OTC	102.63	56.2%
Exchanges	COMEX	59.60	32.7%
	Shanghai Futures Exchange	14.14	7.7%
	Shanghai Gold Exchange	1.09	0.6%
	All other exchanges	2.47	1.4%
	Total Exchanges	77.31	42.4%
ETF	North America	2.20	1.2%
	Europe	0.09	0.0%
	Asia	0.25	0.1%
	Other	0.02	0.0%
	Total Gold ETF	2.57	1.4%
Total		**182.51**	

Source: World Gold Council.

The United States dominates the gold ETF market, as evidenced by the presence of several significant funds, such as SPDR Gold Shares, iShares Gold Trust, and Sprott Physical Gold Trust, which collectively account for a substantial portion of the total holdings. The US-based funds alone hold a combined total of 1,553 tonnes, highlighting the country's prominence in gold ETF investments (Table 4).

While the US leads in terms of quantity, other countries also make notable contributions to the gold ETF landscape. The United Kingdom stands out as a significant player, with iShares Physical Gold ETC, Invesco Physical Gold ETC, and WisdomTree Physical Gold funds listed. Collectively, these UK-based funds hold 536 tonnes of gold, indicating a significant presence in the market. The significant holdings of Germany's Xetra-Gold fund, with holdings of 230 tonnes, Switzerland's ZKB Gold ETF, with 154 tonnes, and French Amundi Fund, with 68 tonnes indicate these countries' reputations as hubs for financial services, including gold-related investments.

Overall, the gold market structure is complex and multifaceted, with a variety of players and components influencing gold's price and availability. Understanding the dynamics of the gold market is important for investors and traders looking to participate in this important asset class.

TABLE 4: LARGEST GOLD ETF FUNDS

Fund Brands	Country of Listing	Holdings as of Q1 2023 (to the nearest tonne)
SPDR Gold Shares	US	915
iShares Gold Trust	US	444
Invesco Physical Gold ETC	UK	230
Xetra-Gold	Germany	230
iShares Physical Gold ETC	UK	227
ZKB Gold ETF	Switzerland	154
Sprott Physical Gold Trust	US	97
SPDR Gold MiniShares Trust	US	96
WisdomTree Physical Gold	UK	79
Amundi Physical Gold ETC	France	68

Source: World Gold Council.

GEOPOLITICAL CONSIDERATIONS

Geopolitical risk is a major factor for asset managers to consider, especially in emerging markets. This is because geopolitical events can have significant impact on financial markets, as seen in the freezing of the assets of the Iranian Central Bank ($1.9 billion) in 2010, the Kazakhstan National Bank ($22.6 billion) in 2017, the Venezuelan Central Bank ($342 million) in 2020, the Afghan Central Bank ($7 billion) in 2021, and most recently the Russian Central Bank (estimated at $258 billion) (Eichengreen 2022).

Research by Baur and Smales (2020) established a positive relationship between gold prices and geopolitical risk, even when financial market uncertainty is taken into consideration. The authors distinguish between expected or perceived geopolitical risk and actual or realized geopolitical risk, concluding that the latter is more important in driving gold prices. According to Arslanalp, Eichengreen, and Simpson-Bell (2023), reserve managers consider gold to be a means of protecting against economic and geopolitical risks, and they therefore tend to increase their gold holdings during times of uncertainty or high geopolitical risk. Additionally, reserve managers in emerging markets tend to increase their gold holdings when there is a risk of financial sanctions. The largest increases in gold holdings by central banks often occur when the banks anticipate or face financial sanctions. The study's econometric analysis revealed that both the volume and the value of gold reserves tend to rise in response to sanctions imposed by major economies such as the Euro Area, Japan, the United Kingdom, or the United States, in either the current or the immediately preceding years.

In their research, Baur and Smales (2018, 2020) make a distinction between expected or perceived geopolitical risk and actual or realized geopolitical risk, and conclude that the former is more significant in determining gold prices.

Central banks hold their reserves in a variety of assets, including fixed-income products (such as government bonds), deposits with commercial banks or money market instruments, currency deposits with other central banks or multilateral organizations (such as the Bank for International Settlements or the International Monetary Fund), Special Drawing Rights (SDRs) with the IMF, and gold. Around 85 percent of their currency reserves are held in US dollars, euros, or British pounds (IMF COFER 2022Q3). This means that they may not be able to access these reserves if there are problems with these currencies. Gold differs from other central bank assets in that it can be stored in the home country and is insulated from geopolitical risks. However, gold stored locally can only be exchanged for domestic currency or used to settle obligations with countries that accept it as payment. It cannot be used as collateral for swaps and loans. Although geopolitical risks are likely to strengthen gold's role as a reserve asset, the disadvantages of using physical gold for financial transactions must be carefully considered.

Recent sanctions against Russia have raised the possibility that other countries' central banks may shift their reserves from foreign exchange into gold. This is because gold is a physical asset that can be stored domestically, unlike foreign exchange reserves, which can be frozen by sanctions.

In half of the ten highest annual increases in gold stockpiles since 1999, the affected country was sanctioned during the previous year or two. Other cases revealed that the increases occurred in response to unforeseeable political events such as financial crises or coup attempts, which is consistent with previous findings (Table 5). Furthermore, gold purchases by "active diversifiers" frequently coincided with political, economic, or financial shocks. This lends credence to the notion that geopolitical events influence gold price movements and may be linked to fears about future penalties (Arslanalp, Eichengreen, and Simpson-Bell 2023).

The shift to gold could have implications for the global economy. If more countries start to hold gold, it could boost the price of gold and make it more expensive for countries to use gold as a reserve asset.

There is an argument that, in the aftermath of Russia's supply-side crisis and the sanctions imposed on Russia, the world is transitioning from the Bretton Woods era, which was backed by gold bullion, to Bretton Woods II, which was backed by inside money (treasuries with unhedgeable confiscation risks), to Bretton Woods III, which was backed by outside money (gold bullion and other commodities) (Pozsar 2022). The belief is that the Russian sanctions create incentives for central banks to abandon the dollar in favor of gold and for governments to cash in their dollar reserves for stocks of other commodities.

Overall, the recent sanctions against Russia highlight the importance of gold as a reserve asset. It remains to be seen whether other countries will follow Russia's lead and increase their gold holdings.

TABLE 5: TOP 10 ANNUAL INCREASES IN THE SHARE OF GOLD IN RESERVES, 2000–2021

Country	Year	Increase in Gold Share (in ppt of reserves)	Increase in Gold Volume (in percent)	Concurrent Events (current or two preceding years)
Turkiye	2020	21%	29%	Sanctions by the US (2018) and EU (2019); COVID-19 pandemic (2020)
Belarus	2010	17%	57%	Sanctions by Russia in 2010
Lao PDR	2001	10%	328%	A series of bomb blasts in 2000 before presidential elections in 2001
Turkey	2017	9%	50%	Coup attempt in 2016; constitutional referendum in 2017
Sri Lanka	2009	8%	299%	Purchase of gold from IMF following the Global Financial Crisis
Paraguay	2012	8%	1,141%	Sanctions by Mercosur and Unasur in 2012
Hungary	2021	8%	200%	COVID-19 pandemic in 2020
Belarus	2006	8%	25%	Sanctions by the EU and US in 2006
Sri Lanka	2000	7%	437%	1997–98 Asian crisis; assassination attempts before elections in 2000
Belarus	2008	7%	33%	Sanctions by the EU and US in 2006

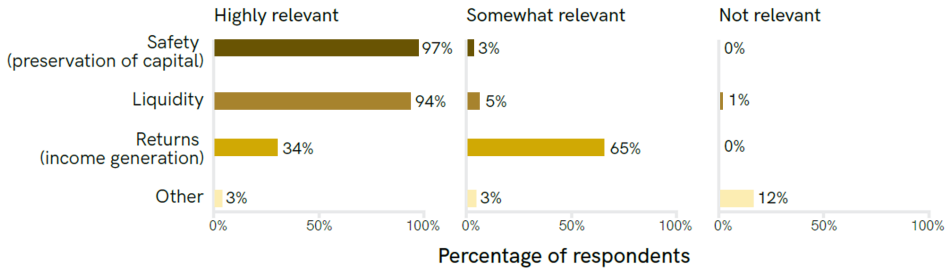
Source: Arslanalp, Eichengreen, and Simpson-Bell 2023.

II. GOVERNANCE AND STRATEGIC ASSET CREDENTIALS OF GOLD

Central banks are responsible for managing a country's monetary policy and financial stability. One of their primary functions is to hold foreign reserves, which are assets held in foreign currencies or other financial instruments, such as bonds and equities, for the purpose of supporting a country's economy and international transactions.

The investment principles of the financial institutions drive their asset allocation decisions. When it comes to foreign reserves, central banks typically have three main objectives: safety, liquidity, and return generation. According to the latest World Bank survey, the majority of central banks—over 94 percent of the respondents—consider safety and liquidity to be highly relevant principles. On the other hand, only one-third of the banks gave high relevance to income generation or returns, while 65 percent considered it somewhat relevant. Although central banks hold foreign reserves that are crucial for their financial statements, generating returns is not as important to them as maintaining safety and liquidity (Figure 5).

FIGURE 5: INVESTMENT PRINCIPLES OF THE CENTRAL BANKS



N=119

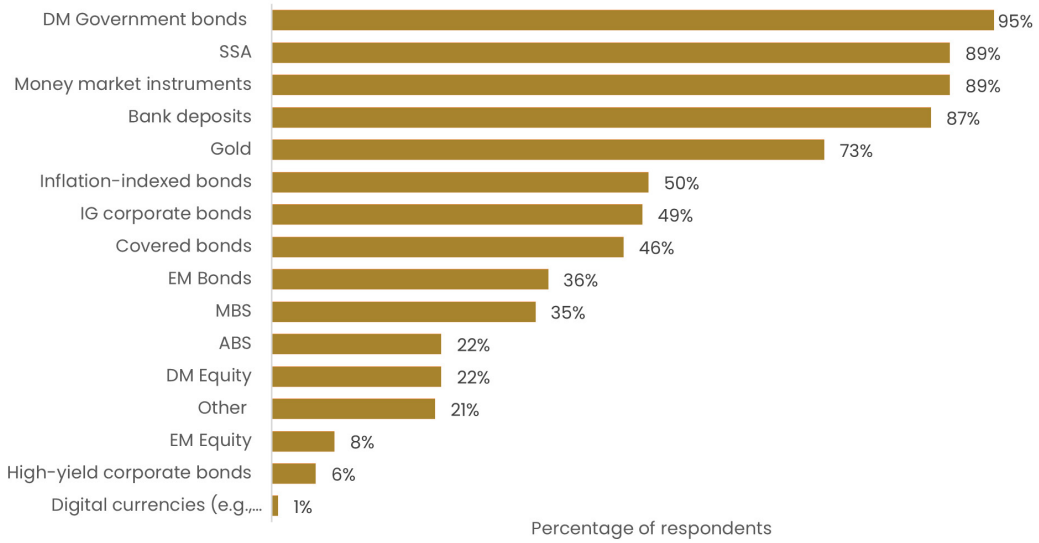
Source: Third RAMP survey on the Reserve Management Practices of Central Banks.

According to the preliminary results of the fourth RAMP survey (2023), 73 percent of the central banks allowed investments in gold. Among the eligible investment options, gold was more commonly allowed than inflation-indexed bonds, which were permitted by only 50 percent of the respondents. Additionally, almost all of the central banks surveyed were eligible to invest in bonds, bank deposits, SSA securities, and money market instruments, with percentages ranging from 87 percent to 95 percent (Figure 6).

On average, respondents allocated 8 percent of their portfolios to gold. It is worth noting that although 60 percent of central banks hold gold in their reserve portfolios, only 20 percent include it as a part of their strategic asset allocation. The allocation of gold in central

bank reserve portfolios is usually not determined based on considerations of risk and return or correlations with other asset classes. In some countries, the level of gold holdings is influenced by historical factors or the need to purchase from local producers, which means it is not considered in the optimization framework.

FIGURE 6: ELIGIBLE ASSET CLASSES OF THE CENTRAL BANKS



N=121

Source: Fourth RAMP survey on the Reserve Management Practices of Central Banks (preliminary results).

Gold has long been a mainstay in central bank portfolios because it delivers on these investment principles. Historically, gold has long been the asset of choice, attracting safe haven inflows during financial crises owing to its better performance as compared to other traditional reserve assets. However, gold may not be a good asset from a capital preservation perspective. Indeed, since reserves are valued either in dollars or domestic currency, gold price can have significant volatility levels.

According to Baur and Lucey (2010), gold serves as an average hedge against equities while also operating as a safe haven under extreme stock market situations. This safe haven property is attributed to the positive skewness of gold returns, which contrasts with the negative skewness observed in other asset classes (Lucey, Tully, and Poti 2006). Erb and Harvey (2013), on the other hand, reject the safe haven hypothesis, citing data showing that gold and stocks decrease together in 17 percent of the months, contradicting the notion of gold as a genuine safe haven.

Van Vliet and Lohre (2023) report that a small allocation to gold can minimize the downside risk of standard stock-bond portfolios, albeit at the expense of returns. Low-volatility equities, on the other hand, can more efficiently minimize losses without compromising returns. As a result, an allocation strategy that includes low-volatility equities in a mix of stocks, bonds, and gold may benefit significantly by boosting the equity allocation while decreasing the bond allocation.

Zulaica (2020) suggests that, due to the significant volatility of gold returns, only a modest fraction of gold is quantitatively justifiable in most cases. However, evidence exists for gold's potential insurance value in adverse scenarios, which may support higher gold allocations in cases where reserve management requires protection against tail risks.

CAPITAL PRESERVATION

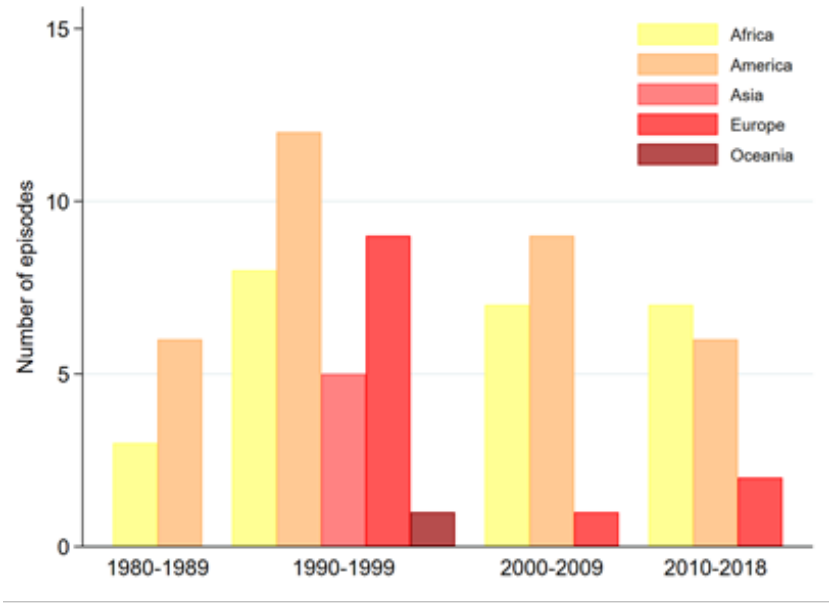
Since the end of the gold standard and Bretton Woods, gold does not preserve capital due to its price volatility. Nevertheless, there is evidence that including gold in a portfolio may help mitigate potential losses during market downturns, as will be shown later.

Typical central bank portfolios predominantly consist of investment-grade fixed-income instruments. Unfortunately, even the highest quality debt instruments are not entirely free from credit risk. Over the last 40 years, the world has seen numerous instances of sovereign debt defaults or restructurings (Figure 7) (Erce, Mallucci, and Picarelli 2022).

Also, when held in specific form and place, the gold has no credit, default, or political risk, conditions that no other traditional safe haven asset can offer.

Gold's liquidity surpasses the major financial assets and government debt markets of many developed economies. In relative terms, it is more liquid than major sovereign debt markets. Over the long term, gold provides returns comparable to equities outperforming the high-grade fixed-income and other commodities. It also performs in periods of both financial stress and growth. A notable characteristic of gold is its ability to perform during times of crisis because the safe-haven investment flows it provides help spur gold price rallies.

FIGURE 7: DEFAULT EPISODES BY CONTINENT

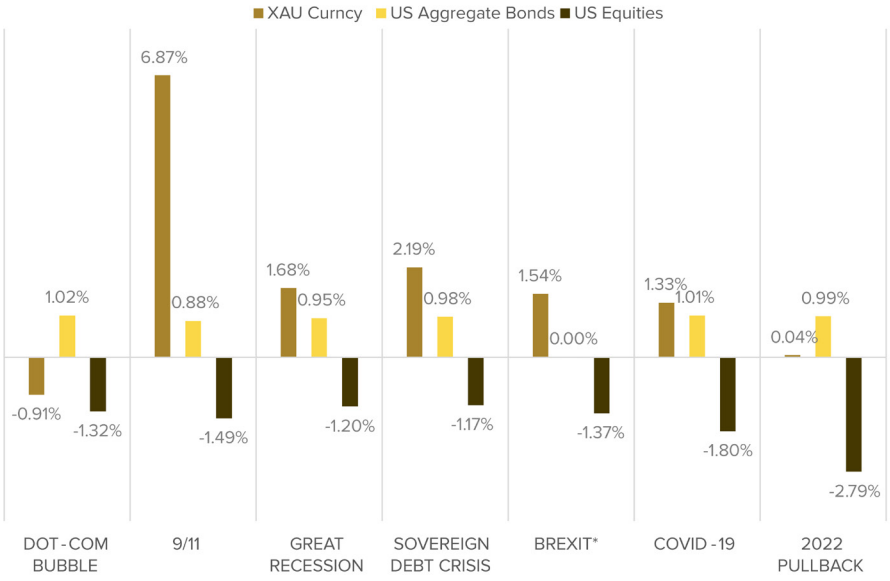


Source: Erce, A, et al, 2022.

According to estimates, gold has outperformed both US Aggregate bonds and US equities during five of seven significant crises. Additionally, during all periods of systemic risk, gold has provided a positive return, with the exception of the dot-com bubble in the 2000s. In particular, gold recorded its best performance during the aftermath of the 9/11 event, with monthly returns averaging 6.9 percent, while US equities experienced a decline of approximately 1.5 percent.

Furthermore, according to the World Gold Council (2022), gold has performed advantageously when compared to US treasuries during recoveries subsequent to systemic market selloffs. This data indicates that gold may serve as a valuable asset to investors seeking to protect their portfolios against potential financial instability and volatility. Gold's ability to maintain positive returns during times of crisis and to outperform traditional investment vehicles highlights its potential as a diversification tool and hedge against market risk (Figure 8).

FIGURE 8: GOLD PERFORMANCE DURING CRISES



Source: Author's calculations based on monthly asset returns.

*Calculation based on the daily return. Dot-com bubble: 3/31/2000–3/31/2001; 9/11: 8/31/2001–9/30/2001; Great Recession: 10/31/2007–2/27/2009; Sovereign Debt Crisis: 1/31/2010–10/31/2011; Brexit: 6/23/2016–6/27/2016; COVID-19: 1/31/2020–3/31/2020; 2022 Pullback: 1/31/2022–12/31/2022.

TABLE 6: GOLD AS CAPITAL PRESERVATION ASSET 2000–2022

	Gold	US Bonds	US Equities
Maximum drawndown	-14.6%	-6.5%	-18.5%
Downside volatility	2.7%	1.1%	3.3%
Sortino ratio	0.24	0.14	0.09
Loss probability	53.3%	59.8%	60.9%
Value at risk	-6.2%	-2.8%	-8.3%
Expected loss	-9.0%	-3.8%	-10.1%
Minimum return	-16.9%	-5.5%	-17.2%

Source: Author's calculations based on monthly returns.

On a stand-alone basis, gold exhibits a high level of risk compared to US bonds and equities, thereby challenging its role as a portfolio value preservation asset. Nonetheless, it presents relatively favorable performance compared to US equities based on several critical metrics, such as maximum drawdown, where gold's value at -14.6 percent is better than that of US equities (-18.5 percent) (Table 6).

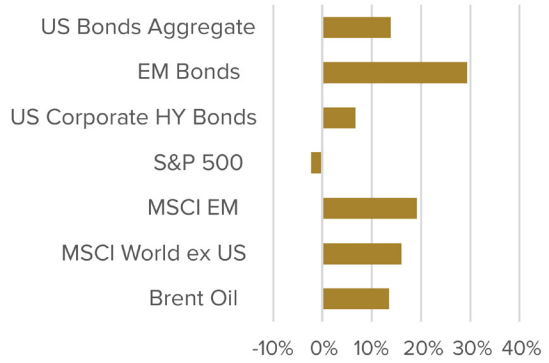
In addition, the downside volatility, measured by semideviation, is also high for gold, standing at 2.7 percent, compared to 3.3 percent for equities and 1.1 percent for bonds, with the Sortino ratio, which gauges the return per unit of downside volatility, at 0.24 for gold, 0.14 for bonds, and 0.09 for equities.

Although gold is generally considered riskier than bonds in terms of metrics such as value at risk, expected loss, and minimum return, it compares favorably to equities. Notably, bonds have a higher probability of loss, at 59.8 percent, compared to that of gold (53.3 percent) but less than that of equities (60.9 percent). The preceding analysis demonstrates the importance of viewing gold through the lens of its correlation with significant assets when incorporating it in a reserve portfolio.

Gold can be a valuable countercyclical asset in a portfolio, as it has very little to no correlation with other major asset classes (Figure 9). Since 1980, the correlation of gold against the major asset classes averaged below 30 percent and even negative against the S&P 500.

This percieved diversification effect can be misleading for the typical central bank portfolio with predominantly fixed-income assets, since gold's volatility is several magnitudes higher compared to broad, high-grade US Treasury or US Aggregate benchmark indices. This implies that unless the correlation between gold and these indices is negative or zero, there will be no reduction in total portfolio risk by adding gold. In this scenario, the addition of gold to a portfolio will lead to the substitution of risk from fixed income to gold and the performance of the overall portfolio will heavily depend on the performance of the latter.

FIGURE 9: GOLD CORRELATION AGAINST MAJOR ASSETS



Source: Author's calculations.

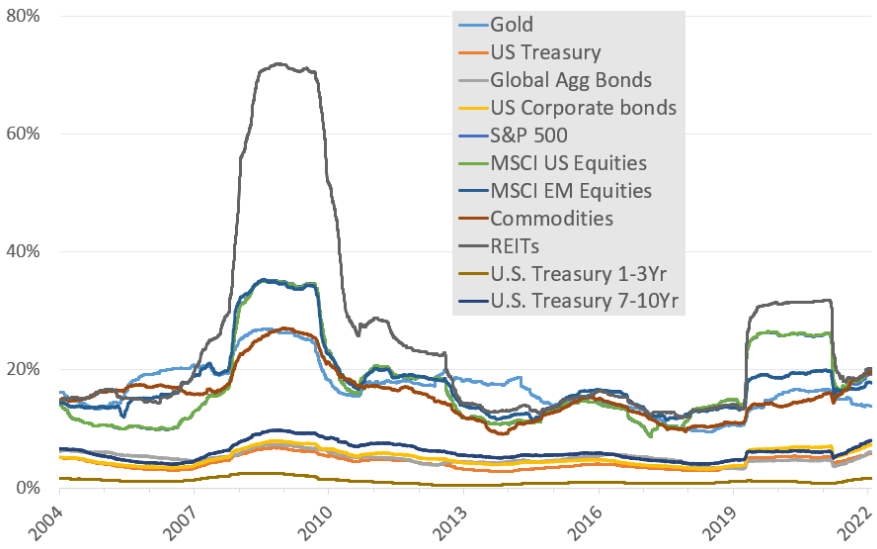
Calculated from monthly return frequency data for 1980-2023. Data as of 16 Mar, 2023

Gold has become a popular investment asset due to its perceived ability to serve as a hedge against economic and geopolitical uncertainties. The gold market is characterized by a large-scale, liquid, and diverse source of demand, which makes it less volatile as compared to some other major asset classes.

When we look at the rolling volatility of gold, it is found to be similar to the wider commodities index, but smaller than major US and Emerging Markets (EM) Equity and Real Estate indices, as depicted in Figure 10. This indicates that gold is relatively stable in terms of its price fluctuations.

Moreover, gold tends to exhibit higher volatility compared to the broad spectrum of US equities during relatively calm market conditions. However, during times of crisis, gold prices remain stable and do not exhibit high correlation with equities and real estate. This stability is primarily due the variety of sources of the demand for gold, such as investment, jewelry, central bank reserves, and industrial applications. Therefore, shocks to one demand source are less likely to significantly impact gold prices.

FIGURE 10: GOLD VOLATILITY AGAINST MAJOR ASSETS



Source: Author's calculation based on Bloomberg data

*500 day rolling period, daily return frequency. Data as of 22 Mar, 2023

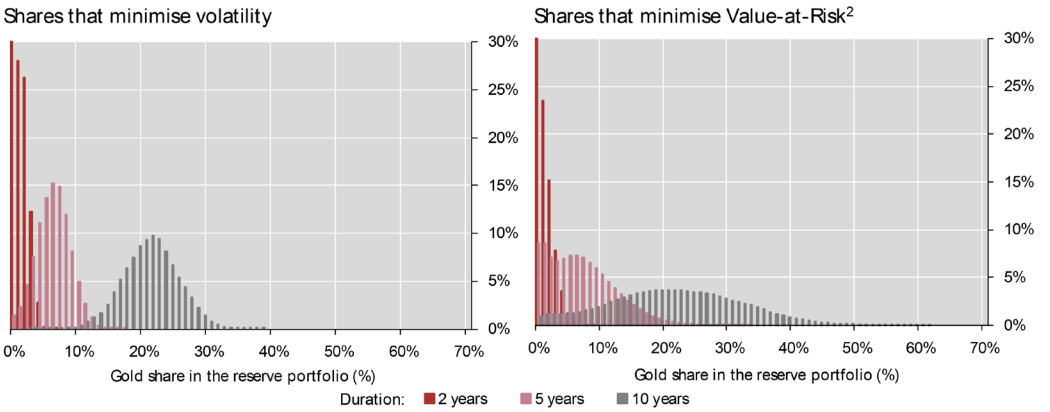
Gold (BBG Gold USD Spot), Global Agg Bonds (BBG Agg TR index), US Treasury (BBG US Treasury index), US Corporate Bonds (BBG US Corp Bonds index), EM Equities (MSCI EM index), US Equities (MSCI US index), Commodities (BBG Commodities index), REITs (FTSE REITs index).

The latest empirical research establishes various optimal allocations to gold that can help achieve central banks' capital preservation objectives.

The distribution of gold allocations that will minimize risk varies for portfolios of SDR government bonds with different durations. The distribution that minimizes portfolio volatility in the two-year SDR fixed-income model portfolio is concentrated between 0 percent and 2 percent, but holding gold up to 4.75 percent may help reduce portfolio variation during very implausible events (Zulaica 2020).

As the duration increases, the distributions become less skewed and tend to support higher gold weights. The 10-year portfolio shows a more symmetric distribution, with allocations to gold mostly in positive territory, with a suggested median share of gold in the reserve portfolio around 22 percent. The results based on the VaR metric are similar, indicating that gold holdings can help investors face tail-risk events better as the model portfolio becomes more sensitive to yields. Investors with a higher tolerance for interest rate risk may find greater diversification benefits in gold than investors with lower duration portfolios, both on average and during tail events (Figure 11).

FIGURE 11: OPTIMAL GOLD ALLOCATIONS ACROSS 2-, 5-, AND 10-YEAR SDR PORTFOLIOS[1]



[1] These distributions are based on 5,000 simulations with 10 years of monthly data each. One optimal weight of gold results from each simulated scenario. The density functions have been normalised to facilitate reading and comparison. [2] Estimated at 97.5% confidence.

Source: Zulaica, O., 2020.

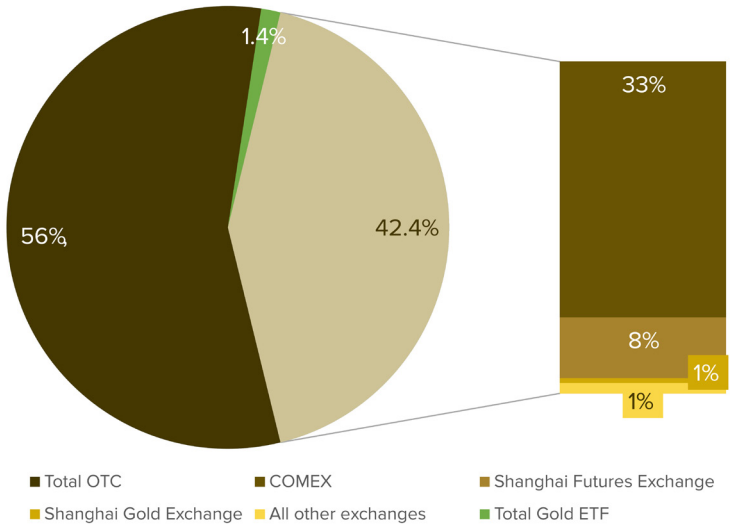
According to research by Van Vliet and Lohre (2023), incorporating gold into a portfolio can dramatically minimize downside risk. The best gold allocation in a portfolio is 10 percent, which, when combined with a 30/70 equity-bond mix, results in a 3.3 percent downside volatility. This "gilded mix" has lower negative volatility than a 30/70 equity-bond combination with bonds. A 10 percent gold allocation to a fixed equity-bond portfolio reduces downside volatility by 0.3 percentage points, or 10 percent. Except for exceptionally stock-heavy portfolios, when the proportional reduction in downside volatility is approximately 15 percent, this conclusion holds over the whole range of stock-bond ratios. As a result, gold has the potential to be a useful capital preservation asset in a portfolio.

LIQUIDITY CONSIDERATIONS

According to the general economic theory, frictionless and well-functioning markets tend to produce efficient outcomes that benefit consumers (Varian 1992). This is facilitated by features such as low transaction costs, immediacy in execution, and the ability to execute large transactions without significantly impacting prices. The Committee on the Global Financial System (CGFS 2014) defines market liquidity as the ability to execute large transactions quickly with minimal price impact, meaning that recent transactions should not have a significant effect on the overall market price in deep and liquid markets.

Gold is liquid across various investment platforms. According to the latest World Gold Council data on Q1 2023, the average daily trading volume is spread between over-the-counter (OTC) markets (US $97bn), open interest through derivatives traded on various exchanges (US $64bn), and gold ETFs (US $2bn) (Figure 12).

FIGURE 12: GOLD LIQUIDITY SOURCES

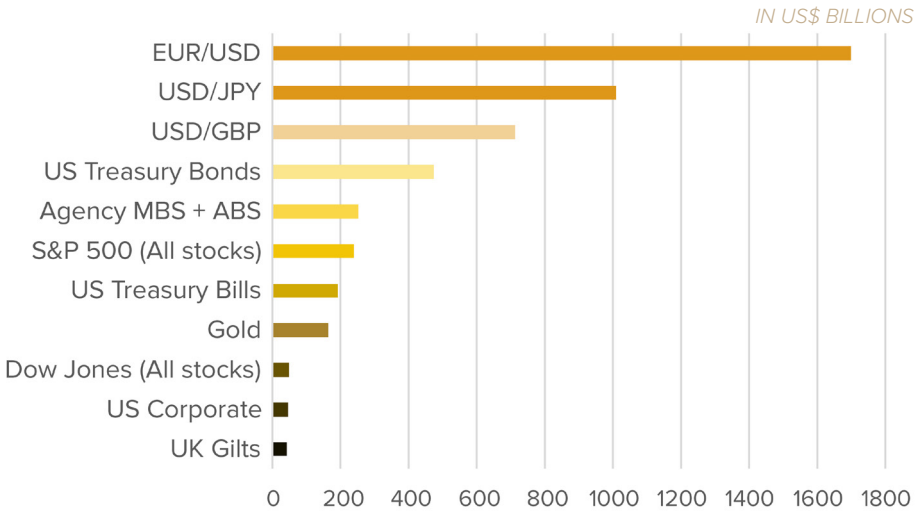


Source: WGC data.

*Daily average trading volume for Q1 2023.

The liquidity of the gold market is comparable to the Treasury bills, US Agency MBS and ABS, all traded stocks in S&P 500 with the average trading volume at around US$164 billion per day in 2022 (Figure 13). The liquidity is higher than most of the major financial markets such as the Dow Jones Industrial Average, UK and German bonds, and US corporate bonds. Physical gold holdings by investors and central banks are estimated to be worth $4.9 trillion, with an additional $1.2 trillion in open interest through derivatives traded on exchanges or the (OTC) market.

FIGURE 13: GOLD LIQUIDITY AGAINST MAJOR ASSETS



Source: Author's calculation based on BIS, SIFMA, UK DMO, WGC data.

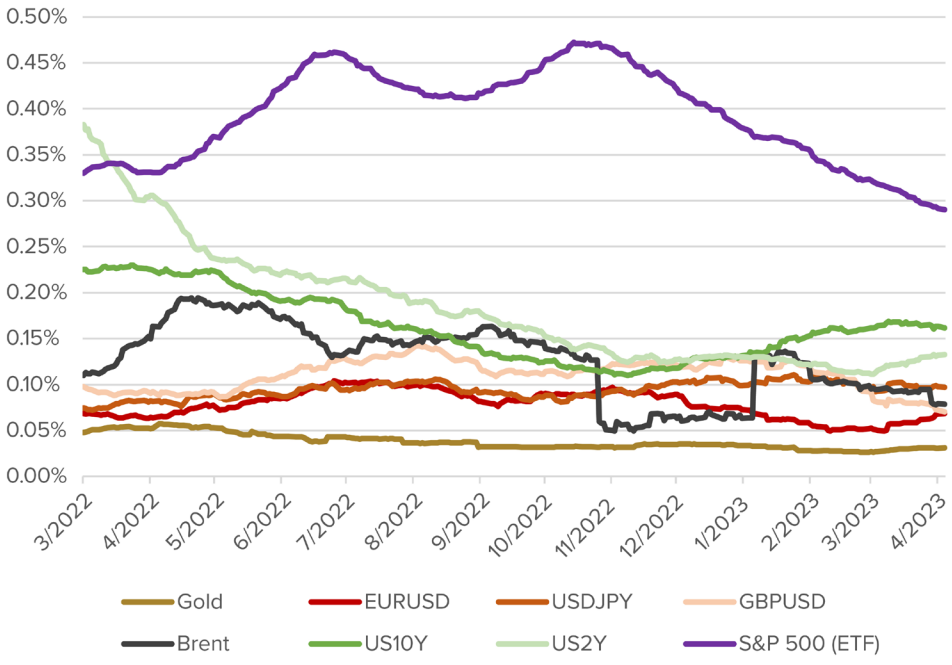
*Daily average trading volume for Q1 2023.

Liquidity is a multidimensional concept that can be measured in different ways depending on the capital market segment being considered. For example, the bid-ask spread has traditionally been a more suitable measure of liquidity differences across quote-driven markets such as gold and some of the largest assets, as demonstrated by Gabrielsen, Marzo, and Zagaglia (2011) and Fleming (2003).

Compared to other major asset classes, such as stocks, bonds, and currencies, the bid-ask spread for gold is relatively high. This is due to several factors, including the relatively low liquidity of the gold market compared to other asset classes, as well as the high cost of storing and transporting physical gold. However, when scaled by price, as suggested by Choi (1988), the bid-ask spread of the gold is relatively low compared to the major asset classes (Figure 14).

The bid-ask spread of gold exhibits similarity with highly liquid forex pairs, such as EURUSD, USDJPY, and GBPUSD, while showing a marginal difference when compared to the bid-ask spread of the US 2-year and 10-year Treasury bonds. However, when compared to the bid-ask spread of Oil and S&P 500 Index (ETF), the spreads of gold are notably lower.

FIGURE 14: GOLD BID-ASK SPREAD COEFFICIENT AGAINST MAJOR ASSETS



Source: Author's calculation based on Bloomberg data.

*Based on 50-day moving average of spread coefficient (bid-ask spread scaled to price).

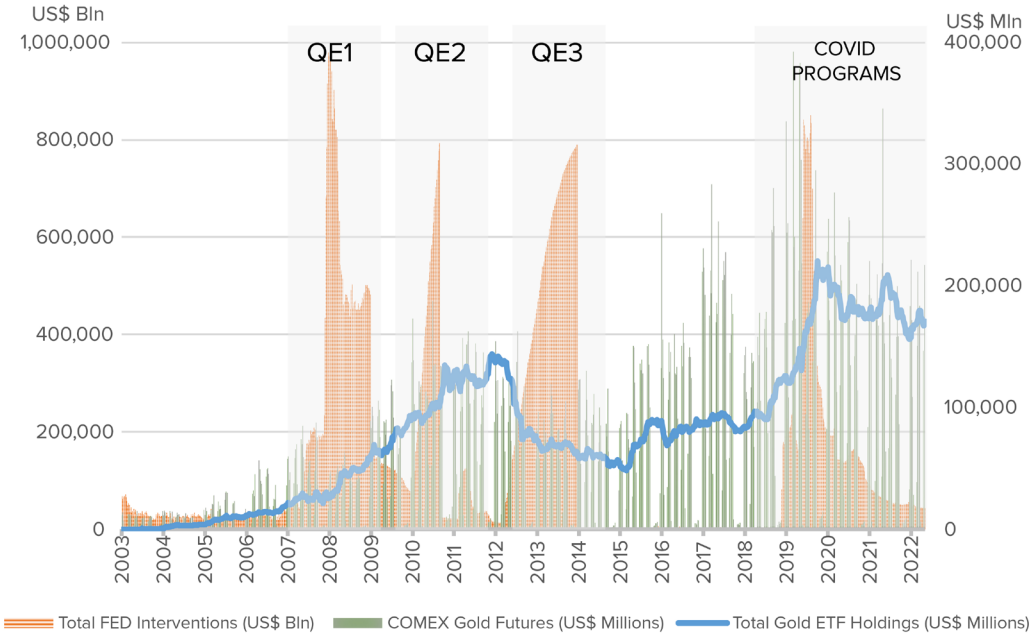
The implementation of quantitative easing by advanced-economy central banks has prompted a quest for alternative safe havens, such as gold (Gopalakrishnan and Mohapatra 2018). This may help explain why emerging and developing economies (EMDEs) have continued to increase their gold reserves, even after the financial crisis had peaked.

The analysis provides compelling indications that the rise in EMDE gold holdings during the post-crisis era is closely linked to the significant expansion of the balance sheets of advanced-economy central banks and the consequent surge in global liquidity. Notably, this post-crisis effect endures even after factoring in various country-specific variables, fluctuations in global gold prices, and global risk.

Gold trading volumes are sensitive to central banks' actions to stimulate their financial markets and economies in times of crisis. Particularly, investment demand for gold, and hence the trading volumes, have been heavily affected by the Federal Reserve's interventions. Gold trade volumes and investment demand have historically increased during periods when the Federal Reserve undertook their market operations (Figure 15), with safe haven flows contributing to gold's liquidity.

Against the backdrop of the banking crisis in the US and Europe, gold is expected to become the main defensive asset, and its liquidity stands to benefit from the expected bailout of the banking sector at the cost of an infusion of hundereds of billions of dollars from the Federal Reserve (MENA Report 2023).

FIGURE 15: GOLD INVESTMENT DEMAND VS FED INTERVENTIONS



Source: Author's calculation based on Bloomberg data.

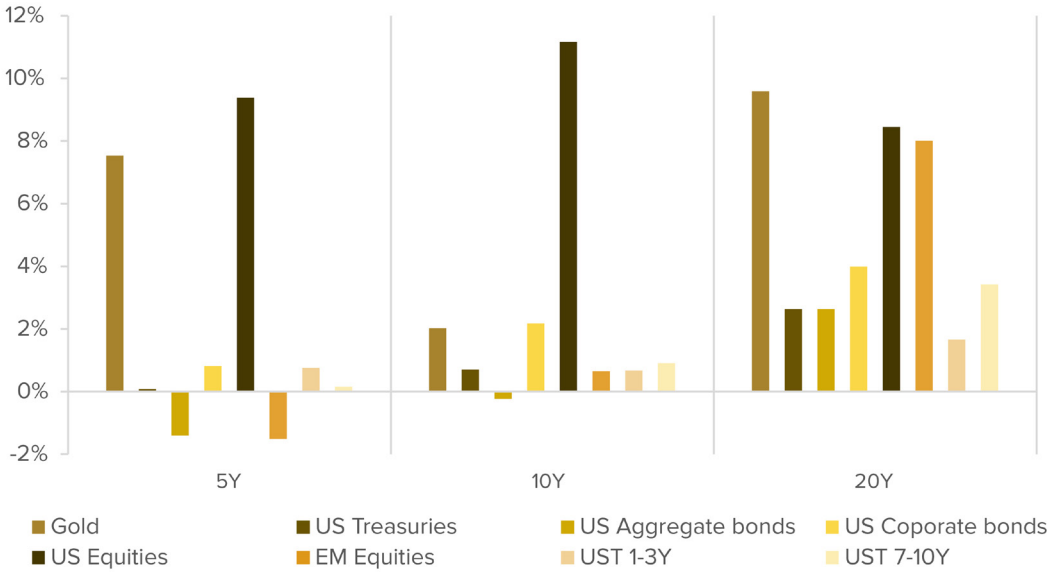
*Weekly data 11/7/2003-3/10/2023.

RETURN CONSIDERATION

Gold has proven to be a reliable and stable investment over the medium and long term. Since the fall of the "gold standard" in 1971, gold has delivered an average annual return of around 11 percent, with a compounded annual growth rate (CAGR) of 8 percent. One reason it can deliver stable returns is the diversity of its demand sources. Gold is not only used as a store of value or medium of exchange, it also has various industrial and technological applications, ensuring that its value does not depend solely on its use as a store of value. Although gold has the significant drawback of gold earning no interest return, if effectively managed, gold holdings can nonetheless generate positive returns in a rising market (Astrow 2012).

When compared to other major asset classes, such as equities, bonds, and real estate, gold has shown impressive performance over the long term, outpacing bonds and real estate. This makes it an attractive investment option for those looking to diversify and to hedge against economic uncertainty (Figure 16). Over the 5-year and 20-year time horizons, gold performs similarly to US equities, significantly outperforming against other major asset classes. Over a 10-year horizon, gold returned on par with US corporate bonds and significantly lower than US equities, but it still outperformed all other major assets. It is crucial to acknowledge that the additional return associated with gold investment entails considerable volatility, necessitating careful consideration when making investment decisions.

FIGURE 16: GOLD RETURN OVER VARIOUS TIME PERIODS



Source: Author's calculation based on Bloomberg data.

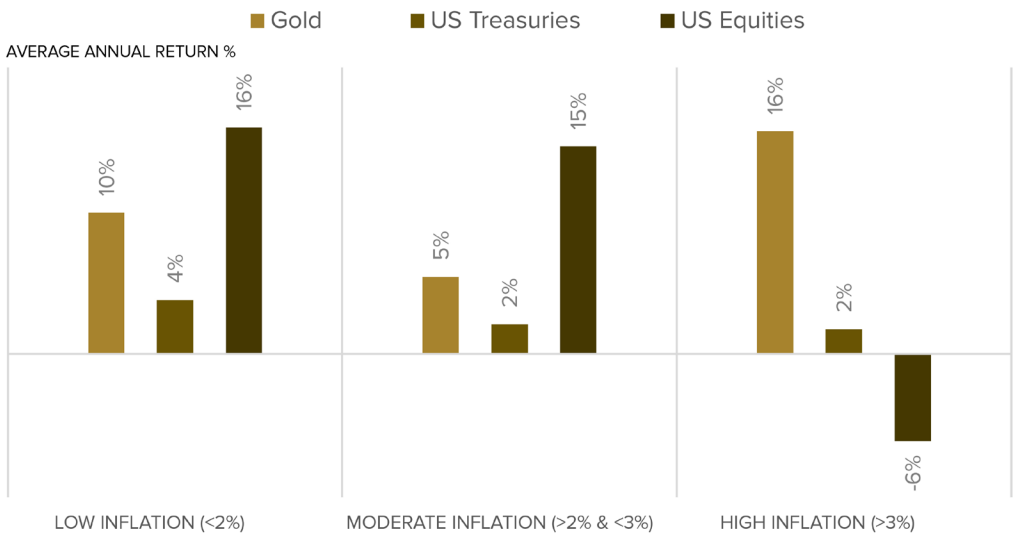
*Based on quarterly asset returns. The fixed income and equity returns are estimated from respective total return indices.

Gold has been widely acknowledged as a preferred asset for hedging against inflation. Ghosh (2016) contends that the allocation of gold in reserve holdings is positively associated with volatility in exchange rates and inflation. Arslanalp, Eichengreen, and Simpson-Bell (2023) similarly establish that the level of inflation is the most significant determining factor influencing the share of gold in reserves of emerging and developing economies (EMDEs).

Gold offers positive real returns during periods of low, moderate, and high inflation (Figure 17). Notably, aggregate US Treasuries produced positive real returns only during periods of low inflation, whereas broad US equities, while offering high returns during periods of low and moderate inflation, typically suffer from large losses when inflation exceeds 3 percent on a consistent basis.

Gold's performance in a high inflation environment is unsurprising; however, it is worth investigating gold's ability to generate high returns in a low inflation environment. This is primarily due to increased investment demand for gold as a safe haven asset during the period of low inflation, which is often characterized by low interest rates and financial stress.

FIGURE 17: GOLD RETURN OVER VARIOUS INFLATION LEVELS



Source: Author's calculation based on Bloomberg data.

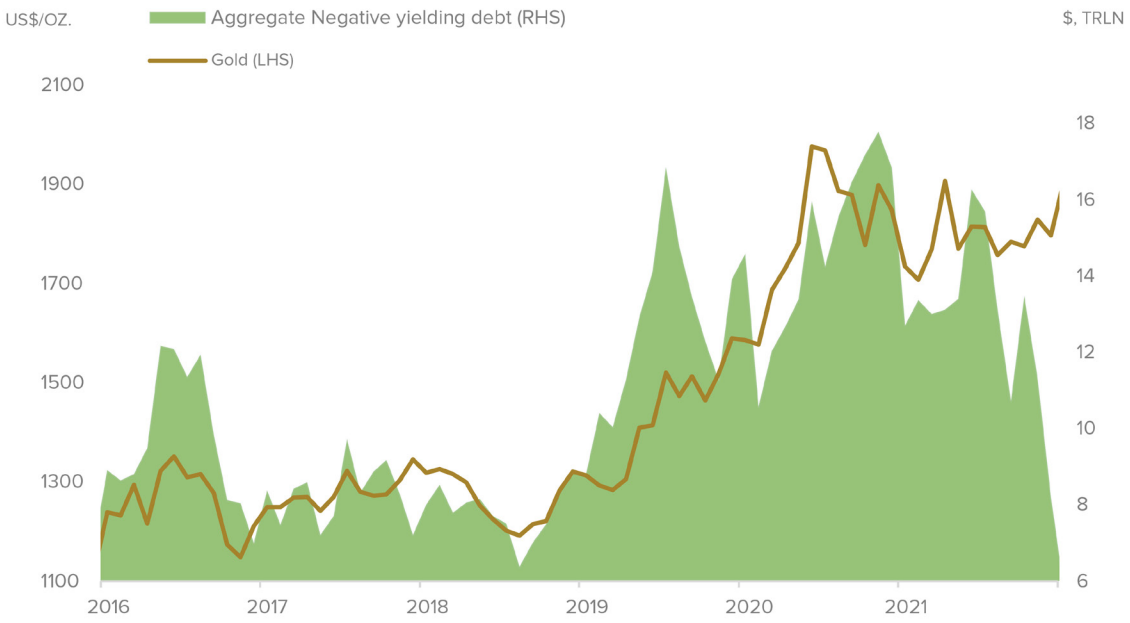
*As of 31 December 2022. Based on monthly nominal returns for gold USD spot price, Bloomberg US Treasuries Agg, MSCI US Equities and YoY US CPI since February 2003.

The low interest rate environment also reduces the opportunity cost of holding gold as a non-return-generating asset. Under these conditions, investors prefer to increase their holdings of gold over US Treasuries, as the latter become less appealing due to the lower carry earned by holding it.

Under the negative interest rate environment, as experienced by the EUR, JPY, and CHF investors, gold's appeal becomes more pronounced (Figure 18). This is because if the investor must pay interest to hold the risk-free asset, allocating funds into gold, which costs nothing to hold and yet offers potential capital gains, becomes an attractive option.

The negative yield environment was also accompanied by quantitative easing (QE) measures by central banks looking to improve financial conditions and foster economic growth. This condition, combined with the increasing money supply and low-to-negative interest rate environment, allowed gold to outperform US Treasuries.

FIGURE 18: GOLD RETURN VS NEGATIVE YIELDING DEBT



Source: Author's calculation based on Bloomberg data.

Another important factor to consider when evaluating gold's potential for return is its performance over various business cycles. Empirical data show that business cycles affect gold returns asymmetrically, with these returns responding more strongly during the recessionary than the booming phases of the cycle (Apergis and Eleftheriou 2016). Business cycles of the stock markets are countercyclical compared to the business cycles of gold investments (Chirila and Chirila 2012).

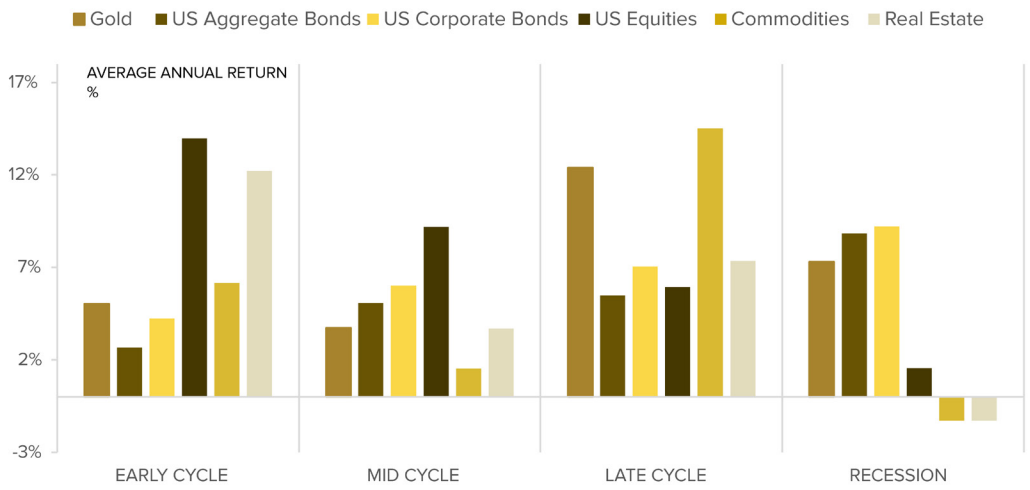
Since Q1 1990, only gold and bonds have consistently generated positive real returns above the US long-term average inflation target rate of 2 percent (Figure 19).

Equities and real estate are expected to outperform other asset classes during the early growth cycle but to fall short during the recessionary period. It is worth noting that the performance of US equities during the recessionary period is skewed by their exceptional performance during the COVID-19 pandemic, as aggressive rate cutting by the Federal

Reserve and accumulation of savings in the United States following economic relief from the US government spurred excessive investment into stocks, which is unusual during a recession.

Excluding the performance during the pandemic, the average annual return on US stocks during recessionary cycles is -11 percent. Bonds are an asset to invest in throughout the four economic cycles, particularly during times of financial distress, when they outperform all other asset classes. However, they tend to lag riskier assets when the economy is beginning to recover and when it is nearing the end of its cycle.

FIGURE 19: GOLD RETURN ACROSS BUSINESS CYCLES



Source: Author's calculations.

*All data from Q1 1990–Q4 2022. The economic cycles are based on internal formula-based model developed by World Bank Treasury considering the level, trend, and behavior of other indices and macroeconomic data. The performance of the asset classes in the different cycles is calculated as the annualized mean quarterly return of each asset in the identified cycles.

Gold's consistent performance across all four business cycles suggests that it can be viewed as both a defensive and a growth asset, performing well during both market stress and economic growth.

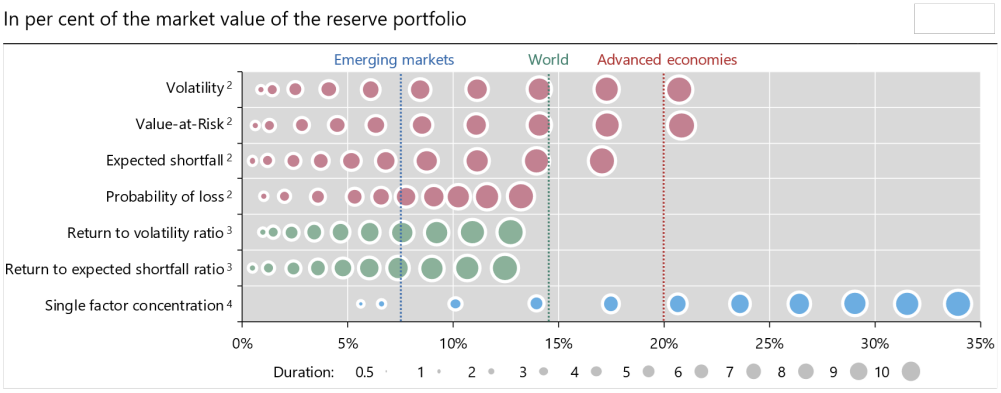
Considering typical central bank portfolios predominantly invested in fixed-income products invested in currencies comprising the SDR basket, a higher allocation to gold increases the uncertainty around such portfolios' expected returns.

By examining ratios of expected return relative to a selected risk metric, it is possible to integrate considerations of both risk and return. In particular, in the case of a portfolio with short-duration SDR government bonds, risk-adjusted returns exhibit a positive relationship with gold portfolio weights only for very small weights, whereas returns decline steeply

for higher weights, particularly those exceeding 10 percent. The return generated per unit of risk is maximized at a weight that falls slightly below 2 percent for both cases (Zulaica 2020).

However, the optimal gold allocation that maximizes a portfolio's return to volatility ratio differs for investors with longer-duration portfolios. As the willingness to bear interest rate risk gets higher, the optimal share of gold in the portfolio increases (Figure 20). For instance, the estimated optimal allocation to gold for the investor with a portfolio duration of 10 years is around 13 percent.

FIGURE 20: OPTIMAL GOLD ALLOCATION ACROSS VARIOUS CRITERIAS



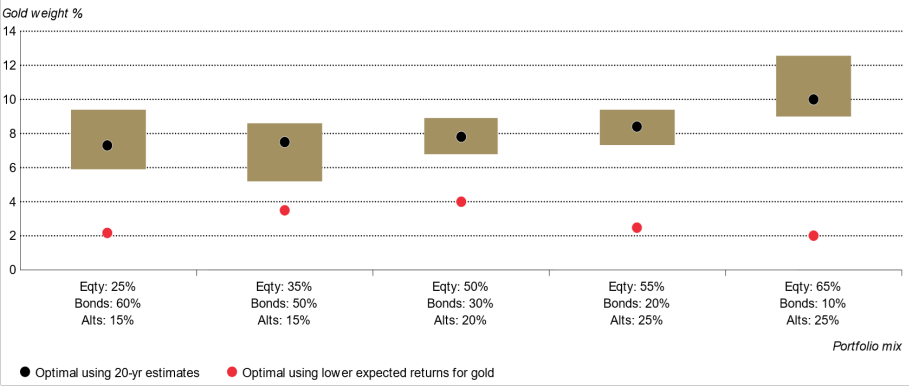
[1] Bubbles denote the average optimal weight across 5,000 simulations. [2] Allocation to gold that minimises the measure. [3] Allocation to gold that maximises the measure. [4] Allocation to gold that minimises the variance explained by the first principal component of a PCA analysis.

Source: Zulaica 2020.

For investors who possess a higher risk appetite and maintain a longer investment horizon, such as pension funds, sovereign wealth funds (SWFs), endowments, and certain central banks with multi-asset portfolios, gold may serve as a highly effective diversification tool.

The optimal allocation of gold that maximizes the Sharpe ratio for these investors may vary within the range of 7 to 10 percent, depending on the chosen allocation of portfolio assets, including equities, bonds, and alternatives, and based on the asset's returns over the last two decades (as depicted in Figure 21). However, an analysis based on a lower expected average annual gold return of 4.5 percent reveals that the optimal proportion of gold across portfolios may range from 2 to 4 percent. The same conclusion is applicable to investors who possess inflation-hedging assets, such as inflation-linked bonds, as well as those who hold alternative assets like real estate, private equity, and hedge funds.

FIGURE 21: OPTIMAL GOLD ALLOCATION ACROSS VARIOUS PORTFOLIO ALLOCATIONS



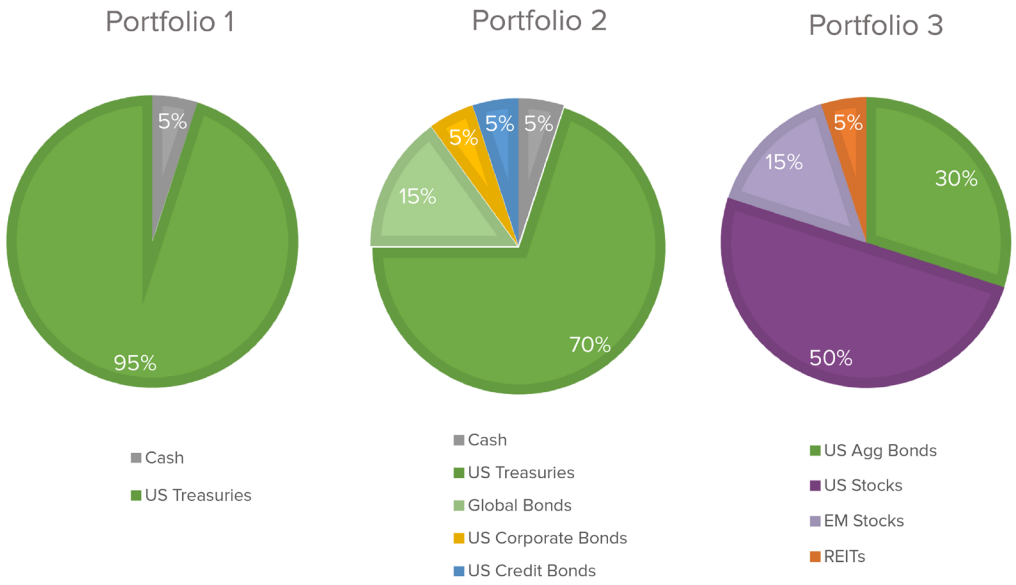
Source: World Gold Council.

GOLD PERFORMANCE ACROSS INSTITUTIONAL PORTFOLIOS

The impact of adding gold to institutional portfolios can be analyzed on the basis of three stylized portfolio compositions (Figure 22). Portfolio 1, with a very high allocation in high-quality US Treasuries, can be attributable to central banks with conservative portfolios, who are primarily concerned about the liquidity and capital preservation of their assets. Portfolio 2 illustrates both conservative and diversified fixed income portfolio pursuing return generation on top of its primary objectives and investing in assets such as international, corporate, and credit bonds, yet still maintaining a sizable allocation in US Treasuries. The third example, Portfolio 3, shows a sample pension fund/SWF/endowment portfolio with a long-term investment horizon and aiming to generate high return and fund future liabilities.

The historical performance of the portfolios will be backtested by adding 10 percent and 20 percent gold into each portfolio with the objective of analyzing whether the gold allocation would have improved the risk/return characteristics of the portfolio and its drawdowns during the periods of financial distress to help achieve institutional goals of holding reserves.

FIGURE 22: STYLIZED PORTFOLIOS OF VARIOUS INSTITUTIONS



Source: Author's calculations.

EM CENTRAL BANK PORTFOLIO (PORTFOLIO 1)

The performance of Portfolio 1 with 10 percent and 20 percent gold allocations (Table 7) was backtested using the historical asset returns for Q1 2000 to Q1 2023, with the particular interest paid to how the respective portfolios would have performed during some of the crises that occurred during this period.

TABLE 7: PORTFOLIO 1 WITH GOLD ALLOCATION

Asset	Base	Gold Allocation	
		10%	20%
Gold	-	10%	20%
Cash	5%	5%	5%
US Treasuries	95%	85%	75%

The addition of gold to the base portfolio would have resulted in a deterioration in most of the performance metrics aside from Sortino and diversification ratio, and the percent of the positive return periods. The portfolios with higher gold allocations experienced larger losses and higher volatility. Risk-adjusted measures such as the Sharpe ratio and Sortino ratio also worsened with higher gold allocations. While gold improved diversification to some extent, it resulted in lower returns and increased downside risk (Table 8). Also, the falling VaR and conditional VaR (CVaR) values are a clear indication that a central bank primarily concerned with safety irrespective of returns should be cautious when adding gold into the asset mix.

It is important to note that it is not appropriate to make decisions when the risk-adjusted metrics such as Sharpe ratio are negative (Sharpe, 1994).

TABLE 8: PERFORMANCE OF PORTFOLIO 1 WITH GOLD ALLOCATION (Q1 2000–Q1 2023)

Metric	Portfolio 1	Portfolio 1 (10% gold)	Portfolio 1 (20% gold)
Annualized return	-3.9%	-7.7%	-11.5%
Annualized standard deviation	4.3%	4.7%	5.5%
Max. drawdown	-5.5%	-6.6%	-7.7%
Sharpe ratio	-1.19%	-1.91	-2.32
Downside volatility	0.82%	0.84%	0.88%
Sortino ratio	-0.33	-0.30	-0.26
Diversification ratio	1.05	1.23	1.27
Historical value-at-risk (5%)	-1.7%	-1.9%	-2.3%
Conditional value-at-risk (5%)	-2.7%	-2.7%	-3.0%
Positive periods	57%	61%	62%

Source: Author's calculations.

Lastly, the percentage of positive periods, representing the proportion of periods in which the portfolios generated positive returns, shows a slight improvement with increasing gold allocation.

Incorporating gold into the portfolio would not have provided substantial protection during recent crises (Table 9). In fact, it would have resulted in larger drawdowns, indicating that gold's historical role as a safe haven asset may not hold true in all market downturns. Investors should carefully assess the effectiveness of gold as a hedge and consider its potential impact on portfolio performance during specific crisis periods.

TABLE 9: PERFORMANCE DURING RECENT CRISES

Asset	Base	Gold Allocation	
		10%	20%
Subprime crisis	-7.9%	-8.9%	-10.1%
Brexit	-2.4%	-3.0%	-3.6%
COVID-19 pandemic	-5.9%	-6.4%	-6.9%

Source: Author's calculations.

The Markowitz optimization framework can be used to determine the best gold allocations to fulfill the given goals that public institutions frequently pursue. The study is carried out

with the specific constraint of a maximum 5 percent allocation to cash to avoid the corner solutions typical of this form of optimization. According to the findings, a 95 percent gold allocation is necessary to maximize the portfolio Sharpe ratio, whereas no gold allocation is recommended to minimize variance or cVaR. A 12 percent allocation to gold maximizes portfolio diversification (Table 10). When deciding on the gold allocation in such a portfolio, investors should consider these criteria in light of their risk-return preferences.

TABLE 10: GOLD WEIGHT IN THE PORTFOLIO TO ACHIEVE SPECIFIC CRITERIA

Criteria	Gold Weight
Maximum Sharpe ratio	95%
Minimum variance	0%
Minimum cVaR	0%
Maximum diversification	12%

Source: Author's calculations.

DM CENTRAL BANK PORTFOLIO (PORTFOLIO 2)

Central banks with more advanced investment capabilities typically focus on generating returns and invest more in riskier fixed-income products, such as global or corporate bonds and SSAs, while maintaining a high allocation in US Treasuries (Table 11).

TABLE 11: PORTFOLIO 2 WITH GOLD ALLOCATION

Asset	Base	Gold Allocation	
		10%	20%
Gold	-	10%	20%
Cash	5%	5%	5%
US Treasuries	70%	70%	70%
Global bonds	15%	10%	5%
US corporate bonds	5%	5%	-
US credit bonds	5%	-	-

Source: Author's calculations.

Diversification into gold in a such portfolio would result in a deteriorating performance similar to that observed in Portfolio 1 (Table 12). The portfolios with higher gold allocations demonstrate a fall in performance, including lower returns, higher risk, and decreased risk-adjusted metrics. Additionally, both the historical value-at-risk (VaR) and conditional VaR

values increase with higher gold allocations, indicating higher potential losses. Despite some improvement in the diversification ratio, the overall impact of incorporating gold into Portfolio 2 appears to be negative, resulting in lower risk-adjusted metrics and increased downside risk.

TABLE 12: PERFORMANCE OF PORTFOLIO 2 WITH GOLD ALLOCATION (Q1 2000–Q1 2023)

Metric	Portfolio 2	Portfolio 2 (10% gold)	Portfolio 2 (20% gold)
Annualized return	-2.0%	-6.7%	-11.1%
Annualized standard deviation	4.2%	4.7%	5.5%
Max. drawdown	-4.8%	-6.2%	-7.5%
Sharpe ratio	-0.77	-1.67	-2.23
Downside volatility	0.87%	0.87%	0.90%
Sortino ratio	-1.04	-0.98	-0.89
Diversification ratio	1.17	1.28	1.28
Historical value-at-risk (5%)	-1.7%	-2.1%	-2.2%
Conditional value-at-risk (5%)	-2.8%	-2.8%	-3.1%
Positive periods	62%	63%	61%

Source: Author's calculations.

Similar to Portfolio 1, the inclusion of gold did not effectively mitigate drawdowns in portfolio value across all three periods. In fact, portfolios with higher gold allocations experienced worse performance during the crises (Table 13).

TABLE 13: PERFORMANCE DURING RECENT CRISES

Asset	Base	Gold Allocation	
		10%	20%
Subprime crisis	-7.2%	-8.6%	-10.0%
Brexit	-2.7%	-3.2%	-3.7%
COVID-19 pandemic	-6.9%	-7.0%	-7.1%

Source: Author's calculations.

As suggested by the Markowitz optimization process, no allocation to gold is necessary to meet the criteria of maximizing the Sharpe ratio, minimizing variance, or minimizing cVaR. However, a gold weight of 9 percent is recommended to maximize diversification in the portfolio (Table 14). This suggests that adding a small allocation of gold can contribute to portfolio diversification without affecting risk-adjusted performance. Investors can consider this guideline when determining their gold allocation based on their diversification goals.

TABLE 14: GOLD WEIGHT IN THE PORTFOLIO TO ACHIEVE SPECIFIC CRITERIA

Criteria	Gold Weight
Maximum Sharpe ratio	0%
Minimum variance	0%
Minimum cVaR	0%
Maximum diversification	9%

Source: Author's calculations.

PENSION FUND/SWF/ENDOWMENT PORTFOLIO (PORTFOLIO 3)

The investors with higher risk tolerance and longer investment horizons, such as pension funds and SWFs that can afford to have risky assets in their portfolio, would typically invest more into domestic and foreign equities and various types of alternative asset classes (Table 15).

TABLE 15: PORTFOLIO 3 WITH GOLD ALLOCATION

Asset	Base	Gold Allocation	
		10%	20%
Gold	-	10%	20%
US Aggregate bonds	30%	30%	30%
US stocks	50%	45%	40%
EM stocks	15%	10%	10%
REITs	5%	5%	-

Source: Author's calculations.

The addition of gold to such investors' portfolios is more advantageous than the addition of gold to the portfolios of investors with shorter investment horizons and lower risk tolerance. The portfolios with higher gold allocations demonstrate mixed results. While the 10 percent gold allocation leads to a slightly better annualized return compared to the base portfolio, the 20 percent gold allocation shows a further decline. Risk-adjusted measures, such as the Sharpe ratio and Sortino ratio, also exhibit mixed outcomes, with the 10 percent gold allocation showing a slightly better Sharpe and Sortino ratio. The diversification ratio improves with higher gold allocations, suggesting increased diversification benefits. However, the historical and conditional value-at-risk values rise with higher gold allocations (Table 16).

TABLE 16: PERFORMANCE OF PORTFOLIO 3 WITH GOLD ALLOCATION (Q1 2000–Q1 2023)

Metric	Portfolio 3	Portfolio 3 (10% gold)	Portfolio 3 (20% gold)
Annualized return	-6.9%	-4.7%	-10.1%
Annualized standard deviation	5.1%	9.6%	8.9%
Max. drawdown	-4.7%	-8.5%	-8.5%
Sharpe ratio	-1.59	-0.61	-1.27
Downside volatility	1.15%	2.23%	1.93%
Sortino ratio	-0.71	-0.28	-0.32
Diversification ratio	1.64	1.34	1.43
Historical value-at-risk (5%)	-2.2%	-4.2%	-3.8%
Conditional value-at-risk (5%)	-3.5%	-6.6%	-5.8%
Positive periods	64%	65%	62%

Source: Author's calculations.

The inclusion of gold resulted in mixed outcomes for the portfolio drawdowns during the periods of recent market distress. During the Subprime Crisis, the portfolio with a 10 percent gold allocation experienced a significant decline of -20.3 percent, while the portfolio with a 20 percent gold allocation saw a slightly smaller decline of -18.7 percent. However, during Brexit, 20 percent gold allocation performed slightly better than the base portfolio, with smaller losses recorded. Amid the COVID-19 pandemic, neither gold allocation provided the desired level of protection, resulting in greater losses compared to the base portfolio. Overall, gold demonstrated very small potential as a risk mitigator during crises, although its effectiveness varied depending on the specific event and allocation (Table 17).

TABLE 17: PERFORMANCE DURING RECENT CRISES

Asset	Base	Gold Allocation	
		10%	20%
Subprime crisis	-10.0%	-20.3%	-18.7%
Brexit	-2.3%	-2.5%	-1.9%
COVID-19 pandemic	-9.0%	-13.5%	-12.6%

Source: Author's calculations.

According to the Markowitz optimization process, the allocation to gold should be 18 percent to maximize the Sharpe ratio. Conversely, if the objective is to minimize the portfolio's conditional value-at-risk (cVaR), a measure of extreme downside risk, the

recommended gold weight increases to 32 percent. This higher allocation to gold is intended to mitigate potential losses during adverse market conditions. On the other hand, for investors seeking maximum diversification benefits, a 10 percent investment in gold is advised. These recommendations provide guidance for investors to adjust their gold allocation based on their specific risk and return objectives (Table 18).

TABLE 18: GOLD WEIGHT IN THE PORTFOLIO TO ACHIEVE SPECIFIC CRITERIA

Criteria	Gold Weight
Maximum Sharpe ratio	18%
Minimum variance	0%
Minimum cVaR	32%
Maximum diversification	10%

Source: Author's calculations.

PROSPECTIVE ANALYSIS: INVESTIGATING ALTERNATIVE SCENARIOS

The design of macroeconomic scenarios depends on expectations about inflation, future interest rates, and fiscal and monetary measures. This section evaluates the expected performance of the stylized EM central bank portfolio (Portfolio 1) under three scenarios from Oxford Economics (OE) based on their Global Economic Model as updated November 30, 2022.

1. **Housing market crash:** Rising interest rates and unemployment cause a sharp drop in house prices, leading to a severe global recession. Residential investment and consumer spending decline as credit conditions tighten and investor sentiment worsens. Initially, central banks remain cautious with policy rates, resulting in minimal economic growth in 2023. The recovery in 2024 is slow but improves later due to looser monetary policy and some revival in housing and financial markets.

2. **High inflation regime:** The credibility of central banks is at risk due to high inflation. Despite efforts to raise interest rates, inflation expectations remain unanchored, leading to continued high costs and prices. Financial markets experience turmoil, with global monetary policy tightening, government bond yields rising, and stock prices falling. This leads to a stronger US dollar and a slowdown in the global economy, affecting households' disposable income. Economic growth is weak, with prolonged high inflation, inflation expectations, and policy rates.

3. **End of supply chain crisis:** Inflation eases and supply chains normalize faster than expected. China shifts away from a zero-COVID policy, aiding the process. Commodity market disruption is limited. Producer prices decrease, boosting sentiment. Equities

rise, bond yields fall, and currencies appreciate. Confidence improves, supporting demand recovery. Central banks remain cautious, keeping policy rates steady. Lower inflation allows for looser policy. The global economy grows 2.1 percent in 2023 and 3.8 percent in 2024.

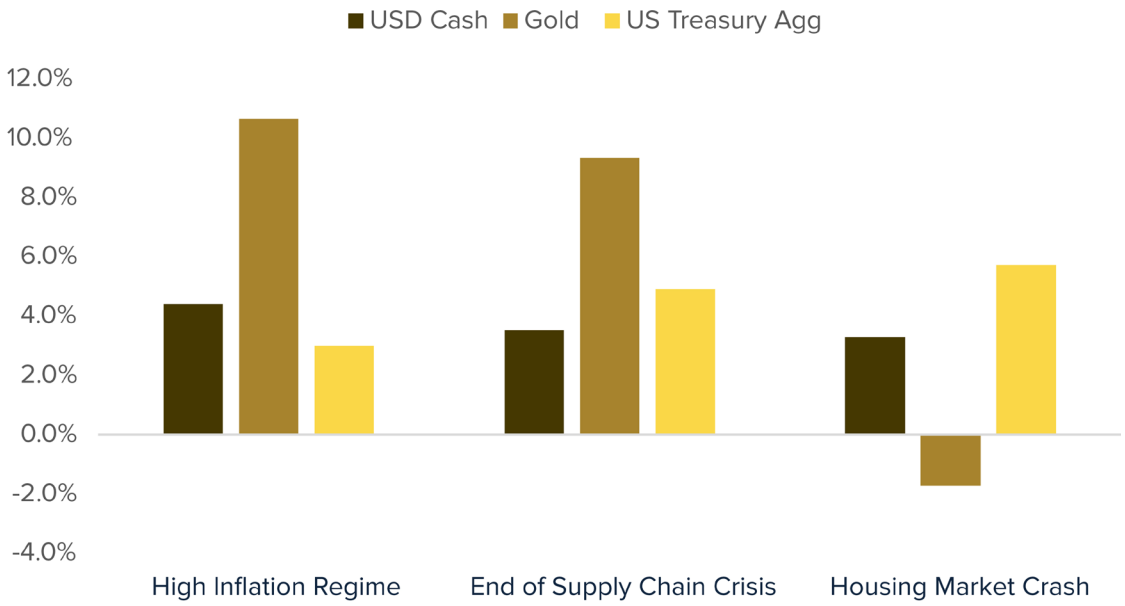
During a high inflation regime, USD cash may provide some protection against inflation, but gold tends to be considered a safe-haven investment. Gold's value often increases during inflationary periods, making it an attractive option. The US Treasury Aggregate, representing a portfolio of US government bonds, may offer a lower return compared to cash and gold in this scenario as increasing interest rates negatively impact most fixed-income assets (Figure 23).

When a supply chain crisis ends, interest rates for all three investments decrease. USD cash remains relatively stable, while gold retains its appeal as a stable investment during recovery periods. The US Treasury Agg may become more favorable as the crisis resolves, potentially offering higher returns.

In the case of a housing market crash, USD cash tends to hold its value and can be seen as a reliable option during market downturns. However, gold's value may decline during such crises, making it less favorable. The US Treasury Agg may become an attractive investment during a housing market crash, potentially offering higher returns compared to cash and gold.

It's important to note that these general behaviors are based on the hypothetical scenarios provided and may not necessarily reflect actual market conditions.

FIGURE 23: THREE-YEAR ANNUAL EXPECTED RETURNS



Source: Authors' calculations using World Bank Treasury's in-house developed software, Asset Allocation Workbench (AAWB), based on OE and WGC scenarios.

In the high inflation scenario, portfolios with higher gold allocations show the potential for increased returns. However, this comes with higher volatility and increased downside risk. As the gold allocation increases, the probability of negative returns decreases (Table 19).

TABLE 19: THREE-YEAR PORTFOLIO 1 PERFORMANCE

Portfolio	High Inflation Regime				End of Supply Chain Crisis				Housing Market Crash			
	Expected Return	Volatility	CVaR Return (95%)	Probability of Negative Returns	Expected Return	Volatility	CVaR Return (95%)	Probability of Negative Returns	Expected Return	Volatility	CVaR Return (95%)	Probability of Negative Returns
Portfolio 1	9.2%	4.3%	0.5%	1.7%	14.5%	4.8%	4.9%	0.1%	16.8%	5.0%	6.8%	0.1%
Portfolio 1 (10% gold)	11.2%	4.8%	1.8%	0.7%	15.7%	5.2%	5.5%	0.1%	14.3%	5.2%	4.1%	0.3%
Portfolio 1 (20% gold)	13.3%	6.7%	0.0%	1.8%	16.9%	7.1%	3.0%	0.5%	11.8%	6.8%	-1.6%	4.0%

Source: Authors' calculations using World Bank Treasury's in-house developed software, Asset Allocation Workbench (AAWB), based on OE and WGC scenarios.

During the end of a supply chain crisis, portfolios with varying gold allocations demonstrate higher expected returns compared to the base portfolio. However, the higher gold allocations also lead to increased volatility and risk, albeit with a low probability of negative returns.

In the housing market crash scenario, the base portfolio without gold allocation shows a high expected return and low probability of negative returns. However, portfolios with higher gold allocations experience lower expected returns, increased volatility, and higher CVaR values. The probability of negative returns also varies across portfolios.

Overall, adding gold to the portfolio has the potential to enhance returns in specific scenarios, but it comes with increased volatility and risk. The trade-off between returns, risk, and the probability of negative returns should be carefully considered based on individual investment goals and risk tolerance.

III. PORTFOLIO MANAGEMENT

STANDARDS

Gold standards are formed at the major global trading centers, where most institutional investors trade. The London OTC market, the COMEX US Futures market, and the Shanghai Gold Exchange (SGE) account for more than 90 percent of gold's wholesale trading volumes (see Table 3).

Investors in the London OTC market trade 400 troy ounce "Good Delivery" bars (LGD) housed in the vaults of London Precious Metals Clearing Limited (LPMCL) members and the Bank of England. The London OTC market, being the world's largest trading center, establishes the LBMA (London Bullion Market Association) Gold Price twice daily as the global reference standard for gold (see Table 20).

Most of the gold trades at COMEX, the second largest gold market, concentrate on the nearest active futures contract, which is primarily cash settled and strongly linked to physical gold via the exchange for physical (EFP) market. The usual COMEX bars allowed for physical settlement are 100 oz, 1 kilo, and, most recently, London Good Delivery bars from exchange-approved refiners.

Gold is imported into the Chinese domestic market by 13 licensed banks, including HSBC, ICBC, and the Bank of China. All "standard gold" bullion imported by the 13 banks must be cast by an LBMA or SGE approved refinery in bars or ingots of 50 gr, 100 gr, 1 kg, 3 kg, or 12.5 kg, with a fineness of 9999, 9995, 999, or 995, before it can be traded through the SGE system. The bars can be used to settle futures contracts on the Shanghai Futures Exchange (SHFE).

The following are required of refiners seeking accreditation from the **Good Delivery List:**

1. To have **existed** for at **least five years** and undertaken active gold **production** for **not less than three years.**
2. To produce a minimum of **10 tonnes** of gold per annum.
3. To have tangible net worth of at least **£15 million.**
4. To produce gold bars weighing between 350 and 430 fine troy ounces (oz) and with a **fineness** (minimum quantity of gold in the bar) of **99.5%.**
5. To satisfy the **Due Diligence** tests and implement **LBMA's Responsible Sourcing Programme** requiring refiners to demonstrate their efforts to combat money laundering, terrorist financing, and human rights abuses and to respect the environment globally.

TABLE 20: THE GOLD STANDARDS REQUIRED BY MAJOR TRADING HUBS

Contract	London OTC Market	COMEX Futures Market	SGE and SHFE
Deliverable Product	400 oz gold bar; 1 kg bar	100 oz gold bars; 1 kg bar; 400 oz bar	50 g, 100 g, 1 kg, 3 kg, or 12.5 kg gold bars
Mininum fineness	99.5%	99.5%, 99.99%	99.5%, 99.9%, 99.95% and 99.99%
Brands	Bars from LGD brands	Exchange approved brands	"Standard bars"
Facilities location	London	New York, Delaware	Shanghai

Source: CME Group, LBMA, SGE.

TRADING

As a trading commodity, gold can be traded through various channels, including exchanges, physical dealers, and over-the-counter (OTC) markets. On exchanges such as the COMEX and the Shanghai Gold Exchange (SGE), gold futures contracts and spot contracts are traded by investors and industry players. Physical dealers, such as jewelry shops and bullion dealers, offer physical gold in the form of bars, coins, and jewelry for purchase by retail customers. OTC markets, on the other hand, are decentralized and allow for customized transactions between buyers and sellers, with prices negotiated based on current market conditions.

In the London OTC market, the largest gold market by volume, gold is traded via bilateral agreements with bullion banks for Loco London Unallocated gold (Loco London refers to gold bullion that is physically held in London vaults to underpin the trading activity in this market). Spot trades are typically priced in USD/oz on a T+2 settlement basis. This price is commonly used as a benchmark for the gold price and gold prices in other markets, which are typically quoted on a discount/premium over the Loco London gold spot price.

Trading is typically conducted via electronic platforms provided by bullion banks or trading platforms such as Bloomberg, Refinitiv, and others. For example, trading on Bloomberg or Refinitiv is executed via chat, where traders interact directly with the bullion bank (see "Example of an unallocated gold buying deal with a bullion bank on spot basis"); through the dealer-to-client automated electronic trading system (FXTG, FXall), where gold trading takes place in standardized sizes (usually 1,000 oz) based on automatic quotes from the bullion banks; or in semi-automated trade execution systems (RFQ), where traders ask for quotes via a specialized interface from one or more bullion banks.

The most common ways of buying gold are through purchases in OTC market, from local production, or through ETFs. Gold is traded in the **OTC market** in standard bars produced by refiners on the London Gold Delivery (LGD) list. Gold can be purchased through the bullion bank in allocated or unallocated form.

According to **IMF (BMP 6) reserve reporting requirements,** gold can be held on an allocated or unallocated basis.

An allocated account is backed by a specific bar of the precious metal, so that the investor would not see a simple credit on their account but instead a weight list of bars, plates, or ingots showing the unique characteristics of the metal. This form is analogous to a safe deposit box, with the account operator simply acting as custodian.

An unallocated account is analogous to a currency/checking account held with a bank for a currency and reflects a debit or credit over an account rather than a specific bar. According to LBMA, over 90% of the gold traded in OTC markets clear via unallocated accounts.

Owners of the accounts must pay a maintenance fee for their unallocated account or a storage fee for their allocated account. Charges vary between account operators.

In both allocated and unallocated accounts, the metal itself is traded, with the designations *allocated* and *unallocated* referring only to the post-trading settlement mechanism. An important consideration for unallocated gold is that the account owner is exposed to the custodian's creditworthiness, while allocated accounts are free from credit risk. Nevertheless, neither form is free from political risk unless the allocated gold is held in the domicile country.

After the custodian accounts are set up, gold can be purchased from a bullion bank in the OTC market. Like a foreign exchange transaction, the procedure for purchasing gold does not require signing or conducting any special legal agreement. The buyer simply requests the bullion bank to quote to sell the desired amount of gold against the currency of choice (usually USD or EUR) on a spot basis (T+2). The gold is usually traded in smaller lots (e.g., 1,000 oz, 5,000 oz, or 10,000 oz), as larger orders can affect the spot price of the gold and delay efficient execution of the order by the bullion bank, depending on the liquidity at the time of trade.

GOLD TRADING THROUGH EXCHANGES

After the London market, the CME Group's COMEX derivatives exchange has become an increasingly important venue for driving price discovery. The market is tightly linked to physical markets, and a growing share of its volume is traded during Asian market hours. COMEX gold trading takes place through three types of futures contracts, which can be settled with cash or physically. The contract types are differentiated to accommodate gold complying with different standards: typical COMEX 100 oz bars, LGD 400 oz bars, and Chinese 1 kg bars. The trade in the exchange is executed with the assistance of accredited brokers who have direct access to COMEX trading platforms. The settlement of the trades is done using the deliverable gold (Table 21) from the approved brands, which includes more than 100 refiners across the world.

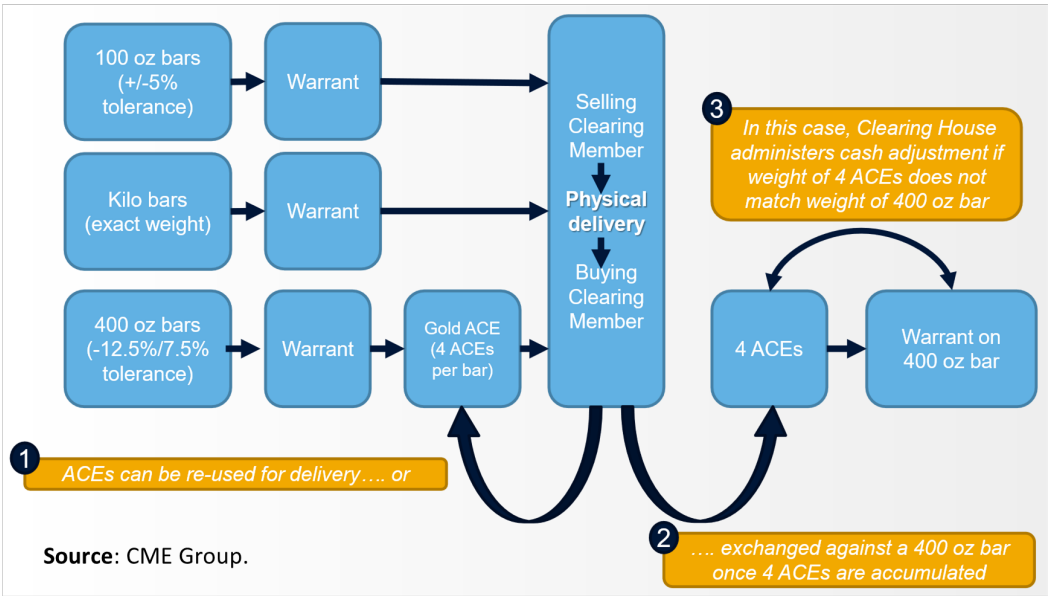
TABLE 21: CME GROUP—DELIVERABLE PRECIOUS METALS PRODUCTS

Contract	Gold Futures (GC)	Gold (Enhanced Delivery) (4GC)	Gold Kilo Futures (GCK)
Deliverable Product	100 oz gold bar; 1 kg bar	100 oz gold bars; 1 kg bar; 400 oz bar	1 kg gold bar
Number required per contract	1 x 100 oz bar or 3 x 1 kg bar	1 x 100 oz bar or 3 x 1 kg bar or 1 x Accumulated Certificate of Exchange (each 400 oz bar equivalent to 4 ACEs)	1 x 1 kg bar
Weight tolerance	±5%	12.5% lower and 7.5% higher than contract size (±5% tolerance applies to 100 oz gold bars)	N/A
Minimum fineness	995	995	9999
Brands	Exchange approved brands	Exchange approved brands	Exchange approved brands
Facilities location	New York, Delaware	New York, Delaware	Hong Kong

Source: CME Group.

Historically, LGD bars were ineligible for COMEX futures settlement; however, following logistics disruptions caused by COVID-19, Gold (Enhanced Delivery) (4GC) contracts were introduced in 2020 to accommodate gold from London vaults. The gold must be stored in one of the accredited warehouses, and the beneficiary owner is provided with the receipt (warrant), which can be converted into Accumulated Certificates of Exchanges (ACEs) at the rate of a 400 oz bar warrant equaling 4 ACEs. The ACEs are then used to settle the futures trades when they are physically settled (Figure 24). It takes three business days to complete the delivery process.

FIGURE 24: GOLD (ENHANCED DELIVERY) FUTURES–DELIVERY PROCESS



Source: CME Group.

This gives the participants—the seller, the buyer, their respective clearing firms, and the CME Clearing—time to make the necessary notifications and arrangements.

Because deliveries take place between clearing firms acting as agents for those having accounts with them, clearing firms play an important role in the delivery process. Contract deliveries are not made directly between account holders.

In addition to these primary trading centers, the global gold market is supported by a number of secondary markets: China (SGE & SHFE), Dubai, Hong Kong, India, Japan, and Singapore. These markets provide a variety of spot trading options or listed contracts, but they do not attract the same level of liquidity that the primary trading centers do.

Despite their lower liquidity, these secondary markets are critical to the global gold market. They meet local needs and serve as regional trading hubs.

GOLD INVESTMENTS AND LIQUIDITY MANAGEMENT

Gold can be invested in term **deposits** to earn a return. Normally, the tenor of the deposit must be long (e.g., six months or more) to generate a return sufficient to cover the storage costs of gold. Term deposits usually necessitate signing a legal agreement in the form of a nonstandardized Precious Metals Lending Agreement.

Example of the Loco London unallocated gold deposit deal with the bullion bank.

GOLD LENDER: Hi friends. Would like to deposit 10,000 oz Loco London gold to 6 month. Please quote your best.

BORROWER: Sure. 50bp. Basis Price 2015 USD/oz.

GOLD LENDER: Done

GOLD LENDER: To confirm I deposit XAU 10,000 oz at 50bp (bp - 2015 USD/oz). Tenor - Feb 5, 2022 - Aug 5, 2022.

At maturity my USD to our account with "XXX". My XAU to our account with "XXX".

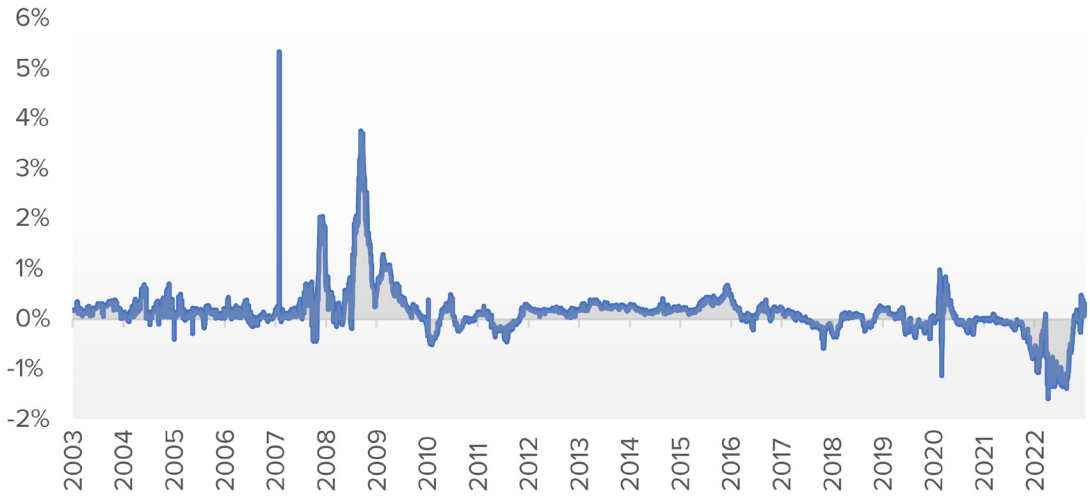
BORROWER: All agreed. Thank you.

The confirmation and settlement of the trade is similar to the unallocated gold trading/ settlement procedure (the deposit confirmation is done through SWIFT MT620 message).

At maturity, the depositor receives **10,000 oz** gold plus Interest **$50,375** ((10,000z*US$2015* 0.0050*180)/360).

Deposits can be made in the form of unallocated or allocated (physical) gold; however, there is an additional procedure for weighing the physical gold because the depositor may receive other LGD gold that differs in weight. Unless otherwise agreed upon during the transaction, interest is paid in US dollars. Investing gold into deposit introduces credit risk against the gold deposit holder which must be taken into account. Gold deposit rates (proxied by taking the difference between the USD Libor rate and the USD gold swap rate) float around zero during periods when the market is calm as the borrowing bank typically swaps the gold deposits into US dollars and loans out the US dollars to earn the spread between the rate on USD deposits/loan and the USD gold swap rate (Figure 25).

FIGURE 25: HISTORICAL 6-MONTH GOLD DEPOSIT RATE

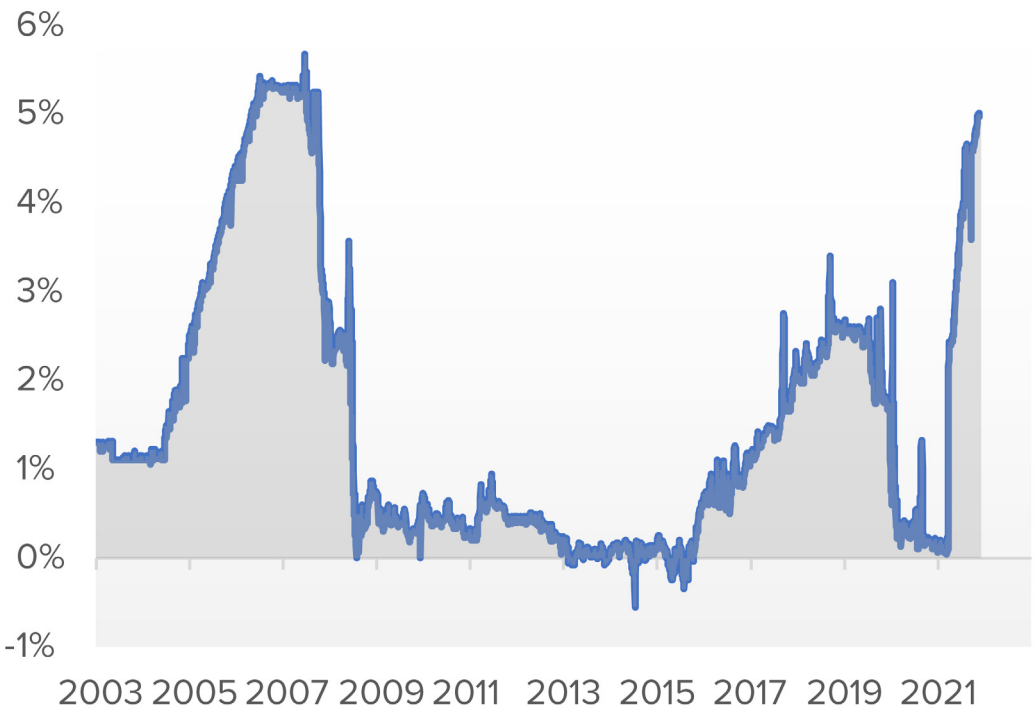


Source: Author calculations based on Bloomberg data.

Gold swaps can also be used to raise liquidity when it is needed. Because the lending is collateralized by gold, interest rates can be cheaper. Gold swaps are traded with a predetermined amount of gold converted into currency with the commitment to reverse the transaction. The gold borrower typically pays a fixed fee expressed in percent per year.

Demand for gold swaps is especially strong during times of financial stress in markets, when institutions try to leverage their relatively illiquid gold holdings to obtain liquid cash to cover their positions, pushing swap rates higher (Figure 26). Gold swaps, like derivative products, are governed by conventional derivatives master agreements and require participants to sign the International Swaps and Derivatives Association (ISDA) agreement.

FIGURE 26: HISTORICAL 1-MONTH USD-GOLD SWAP RATE



Source: Author's calculations based on Bloomberg data.

GOLD HEDGING

The gold positions can be hedged with the use of derivative instruments such as forwards, futures, and options (Table 22).

Forwards and futures, agreements to buy or sell gold at a predetermined price on a specified date in the future, are the least expensive way to hedge future gold price fluctuations. Practically free hedging strategies, these instruments do not allow flexibility, and counterparties are obliged to make good on sell/buy agreements on the predetermined price and date.

Gold can be hedged using forward contracts in the OTC market through the bullion banks. Being a fully tailor-made product, forwards allow customization of the hedge parameters to meet investors' preference. One drawback of using the forward contract to hedge gold exposure is that it requires counterparties in the OTC transaction to sign a ISDA agreement.

Example of the Loco London unallocated gold—USD swap deal with the bullion bank.

GOLD LENDER: Hi friends. Would like to swap 10,000 oz Loco London gold to USD for 1 month. Please quoate your best.

BORROWER: Sure. 180bp at basis price 2015 USD/oz please.

GOLD LENDER: Done

GOLD LENDER: to confirm I swap XAU USD 10,000 oz at 180bp (bp - 2015 USD/oz). Tenor - Feb 5, 2022 - March 5, 2022.

At maturity my XAU to our account with "XXX".

BORROWER: All agreed. Thank you.

Hereby the gold has been sold to the borrower at 2015 USD/oz on Feb 5, 2022, with the obligation to buy it back at the forward rate of 2018.02 = (((2015*1.8%*30)/360) + 2015) on Mar 5, 2022.

The lender of the gold thus receives US$20,150,000 to use for one month. In one month, the lender must reverse the transaction by buying the gold back for US$20,180,200 (implied USD lending cost is US$30,200).

The confirmation of the swap trades are sent using form MT399 or MT699 (free format) SWIFT messages at T+0.

The settlement of the trade is the same as for the unallocated gold settlement procedure.

Gold futures are traded on the COMEX division of the New York Mercantile Exchange (NYMEX), with a standard contract size of 100 troy ounces and two smaller contracts of 50 and 10 troy ounces. The exchange specifies the delivery of gold to exchange-approved vaults, although these terms are subject to change by the exchange. It is imperative to have an approved futures trading account to partake in gold futures trading.

TABLE 22: COMPARISON OF GOLD DERIVATIVE CONTRACTS

	Forward	Futures	Options
Nature	Customized	Standardized	Customized (OTC), Standardized (Exchange)
Venue	OTC	Exchanges	OTC of Exchange
Size	Flexible	100, 50, or 10 oz per contract	Flexible through OTC, 100 oz per contract via Exchange
Cost	Free	Free	Market premium
Liquidity	Less liquid	High liquid	Less liquid
Counterparty risk	Risky	Negligible	Risky (OTC), negligible (Exchange)
Settlement	Physical	Cash or physical	Cash or physical
Margin	None	Required	None (OTC), required (Exchange)
Mark-to-market (MTM)	No MTM	MTM on daily basis	No MTM (OTC), MTM on daily basis (Exchange)

Source: LBMA, COMEX.

Options hedging comes at a substantial cost depending on the implied volatility of the gold price; however, it provides the right, but not the obligation, to sell/buy gold at the agreed price to the long side of the deal. Divergences exist between the two primary gold options, which are based on the most liquid gold futures contracts globally at the Shanghai Futures Exchange (SHFE) and the COMEX. Although sharing some similarities, the SHFE's gold option is classified as European style, while the gold options offered at the COMEX are classified as American style (Table 23).

Investors cannot trade Exchange-traded futures or options contracts directly with the exchange; trades are conducted through the accredited broker providing the investors' with market access.

TABLE 23: COMPARISON OF MAIN GOLD OPTION

Specifications	COMEX	SHFE
Contract Unit	100 troy ounces	1000 g
Minimum Price Fluctuation	US$0.1 per troy ounce	0.02 yuan/g
Price Quotation	US$/troy ounce	yuan/g
Trading Hours	Sunday-Friday 6:00pm - 5:00pm [5:00pm - 4:00pm CT) with a 60-minute break each day beginning at 5:00pm (4:00pm CT)	China Standard Time: 9:00am - 11:30am, 1:30pm - 3:00pm on trading days
Listed Contracts	Monthly contracts listed for 20 consecutive months and any June in December in the nearest 72 months.	Next three consecutive months and even months in the nearest thirteen months
Termination of Trading	Trading terminates at 12:30pm CT on the 4th last business day of the month prior to the contract month	Trading terminates at 3:00pm on the 5th last business day of the month prior to the underlying future's spot month
Position Limits	Spot month: 3000 lots	The month prior to spot month: long/short: 2700 lots
	Other months: 6000 lots	Other months: long/short: 9000 lots
Price Limit	option, no, futures, yes	the limit-up and limit-down of underlying futures in yuan
Strike Price Listing Procedures	Minimum 40 strikes at $5.00 per troy ounce strike increment, then 10 strikes at $10.00, then 8 strikes at $25.00 depending on stike price levels. Dynamic strikes at $5.00 per troy ounce strike increment above and below the highest and lowest pre-listed strikes.	Strike prices range between 1.5 times underlying future's last settlement and 0.5 times underlying future's last settlement in steps of 2 yuan/g, 4 yuan/g and 8 yuan/g depending on the strike prices
Exercise Style	American	European
Settlement Method	Deliverable	Deliverable
Underlying	Gold Futures	Gold Futures

Source: Jia 2020.

Hedging gold exposure is especially attractive during financial crises, as by entering the gold forward, the institution allows the counterparty to use the liquidity for additional time based on the tenor of the contract. Gold forward rates closely follow the gold-USD swap rate, as essentially the institution entering the forward agreement is similar to the party on the short side of a swap contract (Figure 26).

For example, a central bank selling gold at the spot price of 2015 USD/oz could have entered a one-month forward contract with a forward premium of approximately 5 percent. This means that the central bank must deliver the gold to the buyer in one month, and the buyer must purchase the gold at the forward price of 2023.4 USD/oz for a premium of 8.4 USD/oz. Although the seller of gold is fixing its downside at a forward price, entering this forward contract foregoes the upside potential.

The central bank can retain the upside potential and hedge the dowside risk of the gold price by buying the one-month put option with the strike price of 2023.4 USD/oz. Put options can be purchased in the OTC market from bullion banks (under customized contracts) or exchanges such as COMEX (using standardized contracts) via brokers. Each option contract is worth 100 ounces of gold. If an option costs US$15, the amount paid for the option is US$15 x 100 = US$1500. Purchasing a gold futures contract that allows the purchaser to buy 100 ounces of gold requires a maintanance margin of US$8,300, while purchasing physical gold necessitates a full cash outlay for each ounce purchased.

For example, on March 31, 2023, the LBMA PM Fixing for gold was 1979.70 USD/oz. If the central bank wants to hedge its downside, it can buy a put option at the closing price of 22.40 USD/oz per troy ounce of gold. This means that the total cost of the put option to hedge the position on 10,000 oz will be US$224,000 (10,000*$22.40).

Several option strategies, such as zero cost collars, barrier options, binary options, and others, involve combining a long/short position in puts/calls and lowering the cost of hedging by changing the risk profile.

IV. OPERATIONAL ASPECT OF GOLD TRADING

BUYING GOLD THROUGH LOCAL PRODUCTION

Purchases of local gold production have a distinct advantage in that, because the gold is purchased for the local currency, the procedure can help build up foreign reserves.

Central banks can set up local gold buying programs in several ways. The most common procedure is to give the country's central bank a "priority right" or "right of first refusal" to purchase local production. (Some countries like Ethiopia, Ghana, Kazakhstan, the Kyrgyz Republic, Türkiye, and Uzbekistan use this approach.) An alternative method is for the central bank to set up a special gold buying program or form direct agreements to purchase the metal from local artisanal and small-scale miners (e.g., the ASGM program) or commercial banks (as in Bolivia, Ecuador, Mongolia, the Philippines, the Russian Federation, and Zambia).

The central banks publish the official gold purchase prices and usually include a discount for logistics costs, trading (bid-ask spread), and quality, if the metal is not of LGD standard.

Since most locally produced gold comes in nonstandardized form, the central banks engage in quality swap programs to upgrade their holdings to LGD standard. This is accomplished with the help of LGD refiners, with both the Bank for International Settlements (BIS) and bullion banks providing intermediary services.

The Central Bank of Philippines is uniquely positioned, as it has run its own LGD refiner since 1974, allowing the bank to upgrade the gold it purchases from local small-scale miners to international standards. A decision to set up the LBMA-accredited refiner must be considered carefully, as the association imposes strict requirements related to gold quality and production levels on potential candidates.

Notably, the absence of LBMA compliance does not mean that the gold owned by a central bank will be untradable in international markets, since some bullion banks can purchase gold of certain minimum fineness, albeit on discount. The LBMA accreditation merely ensures the liquidity of the gold holdings by deeming them acceptable for settlement in world's biggest trading venues, such as the London Bullion Market, COMEX, and SGE.

Box 1: Central Bank of Ecuador’s ASGM Program

The Central Bank of Ecuador (BCE) began its gold purchase program in 2012, and it has emerged as an increasingly promising strategy helping to formalize the ASGM industry while also growing the developing country's international reserves.

The program aims to formalize and support small-scale mining operations while bolstering the country's international reserves. By establishing collection centers in strategic locations, the central bank facilitates direct gold sales from artisanal miners.

By cutting out intermediaries, the program ensures that miners receive fair prices for their gold. This has had a positive impact on their livelihoods. Individuals or entities interested in trading gold must meet specific requirements, including having a registered mining license, remaining up-to-date with their tax obligations, and avoiding involvement in crimes such as money laundering or narcotics trafficking. They must also register and obtain authorization as an Economic Agent with the BCE. The gold purchase procedure involves determining the fine gold content through the density method, receiving molten bars meeting certain criteria, and making payment through direct transfer to the seller's registered bank account. The BCE has an antibribery policy in place, prohibiting actions such as offering gifts to gain undue advantage or accepting gifts that could create conflicts of interest (World Gold Council 2021).

The central bank's commitment to environmental and social responsibility is evident in the program's design. It adheres to stringent standards, ensuring that gold purchases comply with sustainability practices. Additionally, the bank provides technical assistance and training programs to improve mining practices, enhancing the sector's long-term sustainability.

Although the initiative only benefits individual miners, it also has macroeconomic implications. The acquisition program has contributed to Ecuador's international reserves, increasing their value by approximately $1.4 billion. The gold purchase program has helped the BCE obtain around eight tonnes of nonmonetary gold over the past decade. This enabled the central bank to add around 2.5 tonnes of internationally certified gold bars to its international reserves last year, boosting its coffers by $158 million. The addition of monetary gold helped Ecuador’s international reserves to grow to $9.35 billion as of January 20, 2023 (Jeffery et al. 2023).

Furthermore, the program has successfully formalized the artisanal mining sector. Previously operating in the informal economy, these miners are now part of a regulated and transparent market, bringing them under the purview of government regulations and improving overall industry transparency.

CUSTODY OPTIONS

Gold holdings can be custodied in allocated form at home or in many official institutions offering the service—such as the Bank of England (BOE), the BIS, Banque de France (BdF), and the Federal Reserve Bank of New York (FRBNY)—or in unallocated form with the bullion banks and logistics companies offering vaulting service (Tables 24 and 25). Some bullion banks in the London Bullion Market offer unallocated accounts (HSBC Bank Plc, ICBC Standard Bank Plc, UBS, and JP Morgan Chase); these banks are clearing members of London Precious Metals Clearing Limited (LPMCL).

The important consideration in choosing the type of gold custody is the fee. The bullion banks usually have no charges for unallocated accounts, while the allocated storage fees can be at least 1.5 percent per annum. However, there are handling fees to move the physical gold into both types of custody accounts, usually charged on a per bar basis. Notably, gold custody in an unallocated account with a bullion bank exposes the owner to the account provider's credit risk, whereas allocated accounts are not exposed to credit risk because they are typically held with central banks of developed countries. Political risks must be considered in either case, because gold accounts can be frozen.

TABLE 24: COMPARISON OF MAJOR GOLD CUSTODIES

Custodian	Bank of England	Bank of France	New York FED	BIS
Clients	Governments, official institutions, commerical banks, and firms	Governments, official institutions, and commerical banks	Governments and official institutions	Governments and official institutions
Gold type	Allocated LGD bars	Allocated LGD bars	Allocated accounts	Unallocated Loco London, Berne, and New York accounts
Location	London	Paris	New York	Berne
Extra services		Gold purchases and sales, outright forwards, deposits, gold swaps		Gold trading, gold quality upgrade, location exchange

Source: BOE, Banque de France, NY FED, and BIS.

TABLE 25: VAULTING LOCATION OF CENTRAL BANK GOLD RESERVES

		Vaulting Location (% of Total Holdings)						
	Tonnes	Domestic	BoE	NY Fed	SNB	BoC	BdF	BIS
United States	8,133.5	100%						
Germany	3,359.1	50.9%	12.4%	36.8%				
Italy	2,451.8	44.9%	5.8%	43.3%	6.1%			
France	2,436.3				Undisclosed			
Russian Federation	2,292.3	100.0%						
China	1,948.3				Undisclosed			
Switzerland	1,040.0	70.0%	20.0%			10.0%		
Japan	846.0				Undisclosed			
India	703.7	42.0%						
Netherlands	612.5	31.0%	18.0%	31.0%		20.0%		
ECB	504.8	Stored across several locations; breakdown undisclosed.						
Taiwan	423.6				Undisclosed			
Kazakhstan	385.9				Undisclosed			
Portugal	382.6	45.1%	48.7%	1.0%				5.2%
Uzbekistan	358.0				Undisclosed			
Saudi Arabia	323.1				Undisclosed			
United Kingdom	310.3	100.0%						
Lebanon	286.8				Undisclosed			
Spain	281.6				Undisclosed			

Source: World Gold Council, 2022.

LOGISTICS CONSIDERATIONS

Logistics and insurance for gold are usually accomplished by only a few of the largest logistics companies possessing the required capabilities to secure the transport of high-value cargo. Among them are Brinks, Loomis, Malca-Amit, and G4S, who offer full suites of solutions for secure transport, insurance, and vaulting of physical gold.

Physical gold is transported and insured in accordance with the international terms of sale (Incoterms) agreed upon with the logistics company. Free on board (FOB) or delivery at place (DAP) are common terms of sale. The former implies that, once the gold is loaded onto the transport vehicle at the point of departure, the seller's right to the gold is transferred to the buyer and insured by the logistics company during the journey to the buyer's vault.

With DAP, the seller organizes the transportation of gold directly to the buyer's port, where the right to the metal is transferred. The cost of transportation and logistics is usually charged in dollars per ounce and varies by around 5 to 15 cents per fine ounce, depending on the amount of gold shipped, terms of the sale, type of insurance, the use of a special courier to accompany the cargo, and other conditions. Location swap fees can also be charged when gold is delivered to a port other than London (usually Zurich).

An alternative way to organize the transport of the gold is through bullion banks, which act as buyers of the physical gold and organize the logistics and insurance. The benefit of this approach for the gold seller is that bullion banks sometimes offer premiums on top of the spot price to buy physical LGD-quality gold. The size of the premium is determined by the demand for physical gold in major gold-buying countries, such as India and China.

For example, the spot price of gold on February 20, 2023, was around $1,841/oz, $2,069/oz on the MCI India, and $1,862/oz on the Shanghai Gold Exchange (SGE). This allows the bullion bank that purchased the LGD gold to earn a premium by refining it into kilobars accepted in the India and China exchanges and selling it in those markets.

Example of the physical gold shipment deal with the bullion bank on FOB basis.

SELLER: Hi friends. Please quote your best to ship 10 metric tonnes of XAU Loco London on FOB "Port name" basis on March 20, 2023, against our unallocated account with "Custodian name" with insurance. We will require 1 courier to accompany this shipment.

BUYER: Hello friends. Sure, we can take it at 10 cents/oz (cost).

SELLER: Agreed. Here are the details of the shipment:

Gross weight: 9,998,462.80 gram, 321,402.251 oz.

Fine weight: 9,997,256.10 gram, 321,286.988 oz.

810 Bars, 16 pallets.

For good order's sake we will pay you $32,128.70 (10 cents * 321,286.988) on March 20, 2023. Agreed?

BUYER: All agreed. Thank you very much for the deal. Ciao!

According to the terms of the deal, the buyer (a bullion bank) will organize transportation for the gold from the seller's port (usually an airport) to its own vault and credit the unallocated account of the seller with an amount equal to the fine weight of gold bought from the seller. Notably, if the seller offered a premium for this deal (for example +10c/oz), the buyer would have received the equivalent dollar amount ($32,128.70).

GOLD ACCOUNTING FRAMEWORK

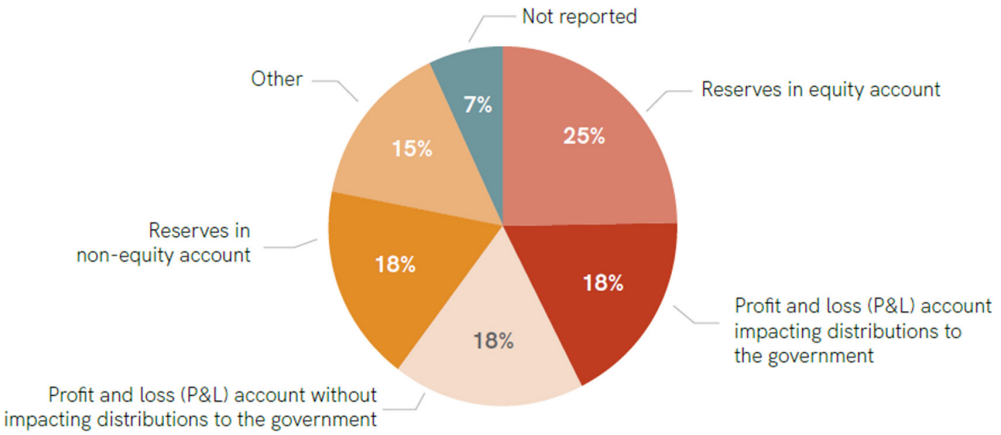
Established accounting practices for gold are scarce due to its limited adoption as an asset by various entities. One reason for this limited adoption is that most central banks are required to follow International Financial Reporting Standards (IFRS), which do not provide adequate guidance on how gold should be treated (Schwarz et al. 2015). As a result, central banks have implemented various measures for managing their gold reserves, typically involving differentiation between monetary gold and nonmonetary gold. The former is considered as part of foreign reserves and may be valued by some central banks at market prices, while others use its cost as the basis for valuation. Nonmonetary gold, on the other hand, is typically valued either at its cost or at the lower of cost and net realizable value (Bholat and Darbyshire 2016).

Therefore most central banks refer to IMF's BOP and IIP manual (BPM6) for guidance (Sullivan 2022). According to IFRS, gold bullion is treated as a commodity rather than a financial asset, and all foreign exchange revaluation gains and losses on monetary items must be reported through profit and loss. As a result, the IFRS 9 and IAS 32 rules do not apply to gold because financial loss arises from a contractual arrangement, which gold does not have. Gold does not qualify as an investment property under IAS 40 because investment property is either land or a building or its components. According to the World Gold Council, this treatment is appropriate for jewelers and manufacturers, but central banks use their gold to raise foreign exchange liquidity (for example, during times of national crisis) and require a fair value assessment of the resources at their disposal (World Gold Council 2021b). Central banks within the Eurosystem receive guidance on the treatment of gold from the European System of Central Banks (ESCB).

Accounting practices vary considerably among public institutions. The most common approach to reporting returns on gold has been to account for unrealized gains and losses as reserves, either in equity or a nonequity account (43 percent). For 36 percent of institutions, the mark-to-market valuation of gold affected the profit and loss account. Notably, few institutions (18 percent) include unrealized gains and losses on gold when calculating distributions to their governments (Figure 27).

In the absence of clear guidance, seven accounting treatments for gold have emerged (World Gold Council 2016). This fragmentation has led central banks to devise creative ways to use their vast gold reserves to manipulate earnings (Box 2).

FIGURE 27: ACCOUNTING PRACTICES FOR UNREALIZED GAINS AND LOSSES ON GOLD



N=85.

Source: Third RAMP survey on the Reserve Management Practices of Central Banks.

In 2018, at the request of several central banks, the WGC issued guidance on accounting for gold for monetary authorities; this guidance, which also covers other forms of gold, aims to achieve consistency across various institutions in accounting for all forms of gold holdings. The framework, already adopted by some WGC member central banks, treats gold as a financial instrument denominated in local currency.

Prepared with reference to the IASB's accounting frameworks, the guidance provides a framework for accounting for gold consistent with current financial reporting standards and IMF's BoP reporting. The WGC considers both presentation in the balance sheet and the income statement, as well as the treatment of unrealized revaluations.

The guidance divides gold into three categories: monetary gold, nonmonetary gold, and antique gold. Monetary gold is initially measured at fair value, with subsequent measurements based on the cost of delivering gold to market. Nonmonetary gold is measured as a commodity under IFRS rules. Antique gold can be measured using the monetary authority's art accounting policy.

The gold is revalued in a way similar that applied to currency. The unrealized gains are disclosed through Other Comprehensive Income (OCI) or equivalent and allocated to special gold unrealized revaluation reserve in equity. The unrealized losses are losses reported in OCI and deplete the revaluation reserve until it reaches zero. Losses in excess of this amount are reported through Profit and Loss (P&L). Realized gains and losses are reported directly through P&L and help to reverse realized gains and losses from the revaluation reserve.

Other monetary gold transactions involving derivatives and other gold instruments, such as swaps, location swaps, deposits, and others, are treated in accordance with the IFRS.

The guidance is simply a best practice recommendation with no legal mandate attached. It only applies to monetary gold and cannot be used by monetary authorities who employ fully historic cost accounting.

Box 2: Revaluation Account to Cover Losses: Curaçao and Saint Martin

The central bank of Curaçao and Saint Martin (CBCS) used its gold revaluation account (GRA) to offset losses in 2021. The CBCS sold and immediately bought back some of its gold reserves. A GRA is an account that records unrealized gains (or losses) of gold assets and usually part of the equity. The CBCS started making losses in 2020 and 2021. They held 420,395 fine troy ounces of gold and equity of Netherlands Antillean guilder (NAf) 1,341 million, of which NAf 1,275 million was GRA. This made it tempting to use some of the GRA to cover losses.

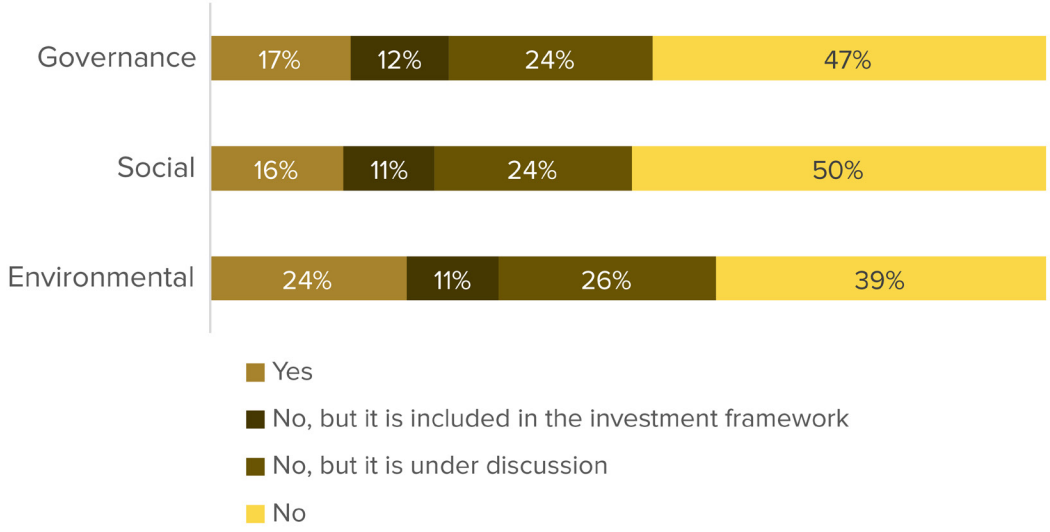
In CBCS's 2021 transaction, the bank sold and immediately bought back 2,945 ounces of gold to turn an unrealized gain into a realized gain. The value of the gold traded was NAf 9.55 million, and CBCS's total gold holdings did not change. CBCS dampened losses by using a small portion of its GRA, thus keeping a healthy capital position.

One reason GRAs are prohibited from being used to absorb losses is because, once fully run down, a declining gold price will cause GRAs to become negative, damaging the central bank's equity. For central banks that bought their gold during Bretton Woods at $35 dollars an ounce, this risk is immaterial. Central banks may also choose to support the gold price to avoid seeing it fall.

V. SUSTAINABLE INVESTING IN GOLD

As the energy transition starts to pick up pace, decarbonization is quickly becoming a key focus for many institutional investors. Reserve managers, in particular, are participating in this trend, although the rate of adoption of ESG investing is still low (fourth RAMP Survey 2023): twenty-four percent of respondents consider ESG to be part of their reserve management mandate. The low rate of ESG adoption in reserve portfolios is due to central banks' focus on high-quality, fixed-income assets, where the availability of ESG instruments and strategies is limited (see Bouyé, Klingebiel, and Ruiz Gil 2021). Notably, environmental factors dominate governance and social factors as more reserve managers implement or consider implementing ESG into their investment policy (Figure 28).

FIGURE 28: INCLUSION OF ESG FACTORS IN THE INVESTMENT POLICY



Source: Fourth RAMP survey on the Reserve Management Practices of Central Banks (preliminary results).
Note: N=119.

It is important to note that physical gold extraction, by definition, cannot have a positive environmental impact. Furthermore, there is no internationally accepted method for assessing the carbon footprint of gold.

Gold mining is known to have a significant impact on anthropogenic climate change due to the use of fossil fuels, primarily diesel, resulting in considerable greenhouse gas emissions (Mudd 2007). Various studies have confirmed that the greenhouse gas emission (GHG) intensity associated with gold production is substantially higher compared to that of other metals (Baur and Oll 2019). However, when considering global production on an aggregate level, gold proves to be more environmentally friendly than other metals.

This is due to its greater value and lower annual mining output in comparison to metals such as silver, copper, iron ore, and aluminum (Hagelüken and Meskers 2010). Additionally, compared to other nonrenewable resources, gold possesses the quality of durability to a unique degree.

The gold industry's annual carbon footprint is roughly 0.3 percent of global emissions (World Gold Council 2022). Some empirical estimates put the median level of GHG associated with the extraction of one metric tonne of gold at 20.3 tons (Ghia, Lindeman, and Zhang 2021), 16.9 tons (Hagelüken and Meskers 2010), 17.6 tons (Norgate and Haque 2012), and 15.4 tons (Baur and Oll 2019). The estimates show that gold holdings lead to 36 percent less CO2 emissions than S&P500 holdings (Baur and Oll 2019).

According to Baur and Oll (2019), adding gold to a diversified equity portfolio not only improves the risk-return relationship but also contributes to the portfolio's sustainability by reducing carbon emissions over time. This applies to both the S&P500 and carbon-efficient versions of it. Even if carbon emissions are attributed to physical gold holdings, the impact on carbon performance is positive, since emissions from companies are continuous, while gold mining is a one-time event with nonrecurring emissions.

To regulate production processes at the level of mining and refining, the gold industry adheres to a number of stringent standards and frameworks with the goal reducing the environmental impacts and risks associated with gold production.

On the mining side, the World Gold Council (WGC) launched Responsible Gold Mining Principles (RGMP) in 2019, which includes all WGC members, who currently account for nearly 60 percent of annual large-scale gold production. RGMP consists of 51 principles that examine all material ESG factors related to gold mining. It covers topics such as water management, climate change, gender diversity, anti-bribery, and community engagement, among others, to provide a comprehensive picture of the material risks and opportunities shaping modern gold mining and its broader impacts.

On the refinery side, the LBMA's Responsible Gold Guidance (RGG) was developed in close compliance with OECD Due Diligence Guidance and introduced in 2012 (and updated in 2019 and 2021). The guidance includes global measures to combat money laundering, terrorist financing, and human rights violations.

Furthermore, the RGG was designed to recognize the growing importance of strong environmental, social, and governance (ESG) responsibilities. Because most GHG emissions in gold production come primarily from generating and consuming electricity, once these energy sources are switched from fossil fuels to renewable energy sources, emission levels decrease. According to a Wood Mackenzie study of 31 major gold mining companies published by the World Gold Council, the emissions intensity of power used in gold production is estimated to fall by 35 percent by 2030. Given the rate of the energy transition and the nature of industry decarbonization opportunities, gold mining could reach net-zero emissions by 2050, in line with Paris Agreement targets (World Gold Council and Urgentem 2021).

Some of the initiatives put forward to improve the gold ESG score within investment portfolios suggest investing in gold exploration companies as an alternative to investing in mined gold. These companies only explore for and secure in-ground gold resources without mining or causing significant environmental damage. Despite the uncertainty regarding the amount and quality of the in-ground gold, this form of "green gold" correlates strongly with traditional gold bullion (Baur, Trench, and Ulrich 2021).

No further emissions are associated with gold once it is in the hands of investors in the form of refined bars. The debate over refined gold is that old (pre-2012) gold bars of unknown origin that may have a criminal or violent history may be remelted into new ones. Those remelted bars may end up in the vaults of gold-backed investment product issuers who claim to be ESG compliant, a practice known as "greenwashing." According to Bates (2021), unlike other recycling practices, gold recycling does not contribute to reducing waste and does not support responsible mining that enhances livelihoods. Human rights groups caution that unverified recycled gold can be susceptible to mislabeling and money laundering.

Various programs are in place to certify the origin and/or ESG characteristics of gold, resulting in a premium between 1.7 percent and 10 percent over the market price of gold. Expert interviews reveal unanimous agreement among industry professionals regarding the significant value of provenance data for gold. There is a demand for such data, with market participants indicating their willingness to pay a provenance premium estimated to be between 0 percent and 2 percent (Gruber and Montemurro 2021).

Gold is not a natural draw for ESG investors due to the high environmental cost of extracting gold from the ground, but the metal is a valuable financial asset, and producers are large employers in developing countries, supporting long-term socioeconomic development through job creation, tax revenue, and investment in local communities. In 2020, the WGC estimated that its members contributed nearly US$38 billion to the GDP of the countries in which they operate.

ETFs and similar products that issue shares backed by bullion are one of the most popular ways to invest in ESG compliant gold. According to the most recent Reuters survey, the majority of the largest gold ETFs prefer bars made after 2012, when LBMA RGG rules went into effect, and some even prefer bars produced after 2019, when rules became even stricter (Table 26). Some smaller funds, such as the Swiss banking group Raiffeisen and the Swiss wealth management firm de Pury Pictet Turrettini, hold traceable metal from large and artisanal mines. The industry is shifting toward holding more gold, which is known to appeal to ESG-driven investors.

TABLE 26: TOP 10 ETF FUNDS BY GOLD HOLDINGS

Fund Brands	Country of Listing	Focus on Post-2012 Bars	Focus on Post-2019 Bars
SPDR Gold Shares	US	-	-
iShares Gold Trust	US	-	-
Invesco Physical Gold ETC	UK	Yes	-
Xetra-Gold	Germany	-	-
iShares Physical Gold ETC	UK	Yes	-
ZKB Gold ETF ‡	Switzerland	Yes	-
Sprott Physical Gold Trust	US	Yes	-
SPDR Gold MiniShares Trust	US	-	-
WisdomTree Physical Gold	UK	Yes	Yes
Amundi Physical Gold ETC	France	-	Yes

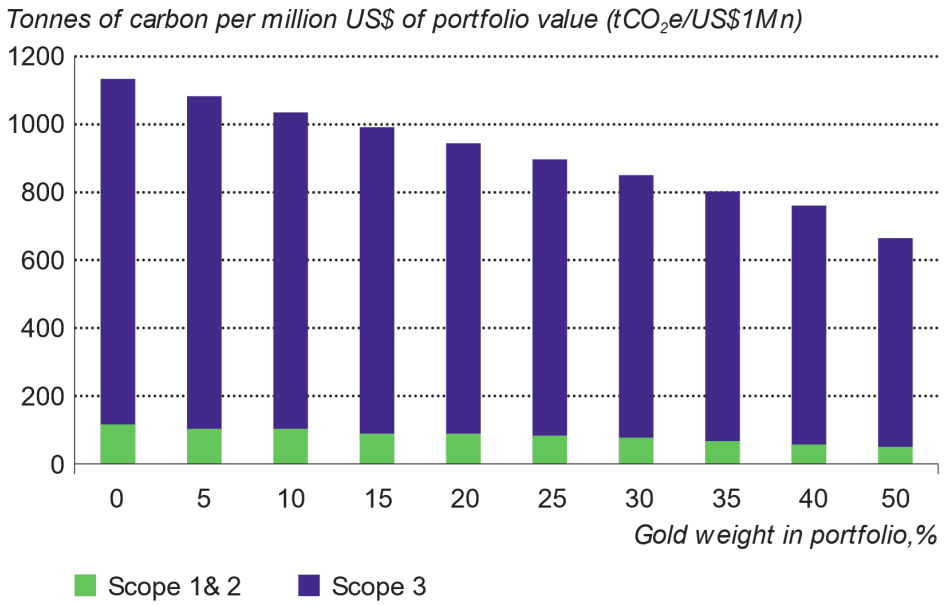
Source: Hobson 2022 (Reuters), World Gold Council, 2023, ETF prospectus data.

GOLD: DECARBONIZING INVESTMENT PORTFOLIOS

Quantifying the climate transition impact in a portfolio of investing in gold is critical for investors attempting to assess and respond to the risks and opportunities posed by climate change. According to the most recent research by WGC and specialist climate risk consultancy Urgentem, increased gold allocations have a significant impact on an overall portfolio's carbon footprint and emissions intensity. A 10 percent gold allocation (along with corresponding reductions in other asset holdings) reduced the emissions intensity of a portfolio of 70 percent equities and 30 percent bonds by 7 percent; a 20 percent gold allocation reduced it by 17 percent (World Gold Council and Urgentem 2021) (Figure 29).

The increased allocations to gold have led to notable corresponding reductions on the carbon footprint and emissions intensity of the market value of the overall portfolio. A long-term perspective is also required to determine how portfolio holdings of gold will contribute to long-term climate scenarios and targets.

FIGURE 29: GOLD ALLOCATION AND CARBON INTENSITY OF PORTFOLIO



Source: Urgentem and WGC, 2021.

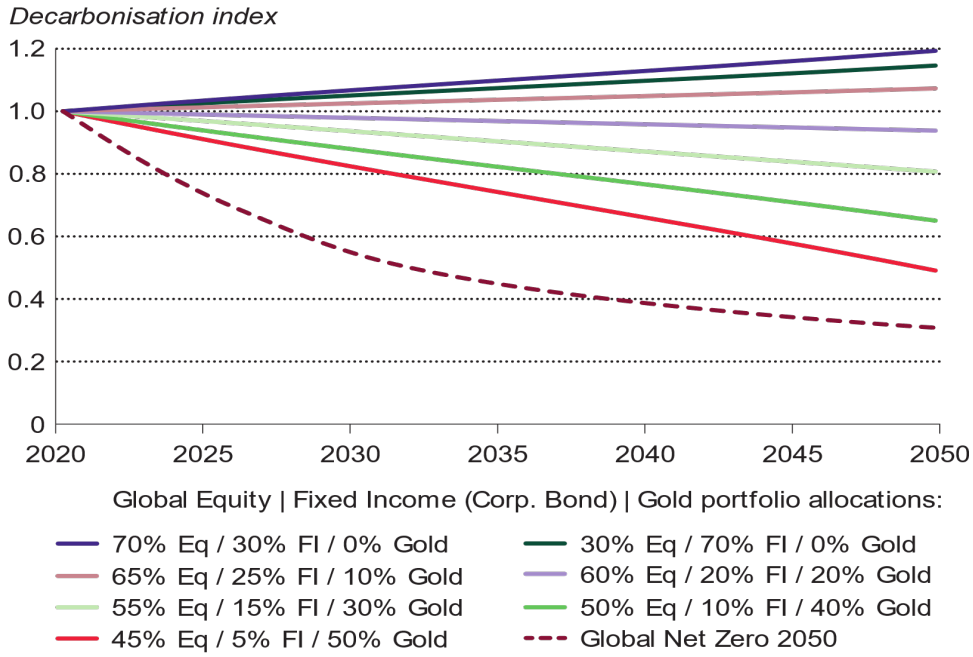
Additionally, carbon emissions associated with holding physical gold are minimal, and even the concept of "embedded" emissions becomes less challenging given gold's promising pathway to decarbonization. This means that holding gold over the long term will likely lower the carbon footprint of an investment portfolio over time.

Decarbonization pathways are calculated using a bottom-up approach to determine the emissions trajectories of different portfolios. Portfolio emissions trajectories are then compared to global scenario pathways. This information can help investors understand how their portfolios are likely to perform under different climate scenarios.

Analysis of different portfolio compositions (bonds and equities) and of how increased allocations to gold can positively impact efforts to more closely align a portfolio's carbon trajectory with the global goal of net zero shows that no portfolio comprised of these assets, given what is known about their current or projected future carbon profiles, wholly aligns to a Net Zero 2050 carbon target. Nonetheless, allocations to gold might have a positive impact on future alignment (Figure 30).

A "temperature rating," which seeks to quantify the temperature implications of investment holdings, is one forward-looking measure that can help asset managers understand the transition pathways of their investments toward net-zero GHG emissions by 2050. Although it is worth noting the ongoing debate about whether such metrics obscure important factors within a portfolio, foster complacency, or divert attention from real-world climate risks and impacts (Thinking Ahead Institute 2020), portfolio temperature metrics, when combined with a variety of other measures and detailed consideration of future decarbonization pathways, can provide a useful and concise indicator of potential exposure and progress.

FIGURE 30: GOLD ALLOCATIONAND PORTFOLIO DECARBONIZATION



Source: Urgentem, and WGC, 2021.

Urgentem findings suggest that gold may be useful in mitigating the climate impacts of investment holdings. The estimated temperature increase implied by portfolio holdings falls by more than 1°C when compared to portfolios without gold; a 20 percent gold weighting results in a temperature fall of 0.44°C (Figure 31).

FIGURE 31: GOLD ALLOCATION AND IMPLIED PORTFOLIO TEMPERATURE

Asset allocations and implied portfolio temperature, to 2100

% gold

Portfolio Weight Equities | Fixed Income (Corp. Bonds) | Gold	Portfolio Temp Increase, ℃ to 2100
70% Eq / 30% FI / 0% Gold	2.96
30% Eq / 70% FI / 0% Gold	2.85
65% Eq / 25% FI / 10% Gold	2.75
60% Eq / 20% FI / 20% Gold	2.53
55% Eq / 15% FI / 30% Gold	2.28
50% Eq / 10% FI / 40% Gold	2.01
45% Eq / 5% FI / 50% Gold	1.76

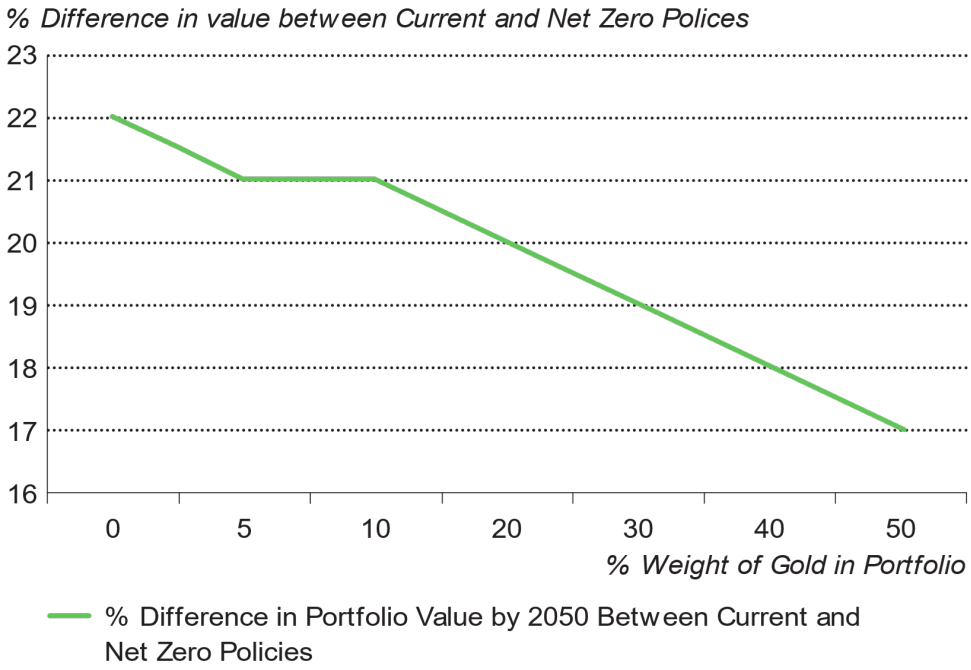
Portfolio temperature

Source: Urgentem, and WGC, 2021.

Decarbonization costs, expressed as a value per ton of carbon dioxide equivalent (tCO2e), can help investors analyze the potential impact of climate-focused policies and associated

business cost implications on their portfolios. Carbon pricing policies will have a negative impact on a portfolio value over time, especially in the Net Zero 2050 scenario. This is because the higher carbon price will constrain returns from both the equities and fixed income markets. However, gold can play a role in minimizing the negative impact of carbon pricing policies. The World Gold Council analysis showed that expected portfolio loss is minimized by increasing the weight of gold in a portfolio. Comparing a portfolio with no gold to one with a 50 percent allocation to gold, the loss of portfolio value is reduced by 5 percent (Figure 32).

FIGURE 32:



Source: Urgentem, and WGC, 2021.

Gold can be a climate-risk mitigating asset in an investment portfolio. Gold's role as a safe haven asset, risk hedge, and store of value during periods of market stress lends credence to analysis suggesting that gold's long-term returns may be more robust than those of many mainstream asset classes in the context of a range of climate scenarios and possible impacts.

It should be emphasized that the analysis presented here assumes that the gold mining industry will take substantial actions to decarbonize. If that does not happen, and little progress is made in reducing the use of fossil fuels in on-site operations or in lowering emissions from high-emission mines, the potential of gold holdings to reduce an investment portfolio's carbon footprint would be significantly reduced.

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