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Exploring the Viability of Gold Jewelry as a Diversifying and Safe-Haven Investment

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Exploring the Viability of Gold Jewelry as a Diversifying and Safe-Haven Investment

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Abstract

The purpose of this paper is to analyze the potential benefits of the inclusion of gold jewelry in a traditional investment portfolio. A popular commodity investment choice, gold has been lauded for its various diversification and safe-haven characteristics. Popular investment forms include paper gold, gold bars and gold coins. However, gold jewelry, although officially categorized as a retail purchase, is often bought with the intention of investment as well. This paper examines the diversification benefits of gold jewelry by measuring the performance of a portfolio in which gold jewelry is present, using multiple performance measures to determine its risk and reward characteristics. A qualitative analysis of gold jewelry demand trends during specified economic periods is conducted to determine if gold jewelry exhibits the characteristics of a safe-haven asset. The paper concludes with an overall analysis of the benefits gold jewelry may provide to a portfolio, along with any risks an investor should be aware of.

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1. Introduction

For centuries, gold has remained a popular investment for retail investors and central banks alike. From physical investments in bars and coins to trading gold exchange traded funds (ETFs) on stock markets, investments into the gold market take on multiple forms as investors vie for the best returns on the financially resilient commodity. While those who look to invest in the market do so primarily through ETFs and the purchase of bars and coins, there remain many people who purchase gold jewelry with the intention of investing in the physical form of the commodity. That is, the purchase of the jewelry is thought of as similar to an investment in gold bars or coins, as they all fall under the concept of investing in physical gold assets. However, gold jewelry has often been criticized as a poor investment within the gold market as the returns are corroded by additional labor, storing, and gemstone costs. This paper aims to understand the returns generated by purchasing gold jewelry as a form of gold investment and how it performs over the long run compared to other forms of gold investment and other asset classes.

2. Overview of Gold

The demand and appreciation of physical gold have deep historical roots, dating back to ancient civilizations. Many ancient peoples thought of the metal as god-like, linking the shiny yellow commodity to spirituality and power. Gold is also preferred to many other precious metals due to its chemical nature; it does not corrode or oxidize, unlike silver, copper, or iron, helping it maintain its spiritual connection to power and immortality. The respective rarity of gold compared to other metals also helps drive its demand, with people wanting to show their wealth by owning something so rare. While platinum is even more rare than gold, with less required upkeep and with hypoallergenic characteristics, it is less malleable and less scratch-resistant than gold. Gold also comes in a variety of colors, while platinum only comes in the traditional silver-white color. Gold is also more accessible to investors, while the price of platinum is often well outside the means of traditional investors, leading to higher demand for gold, making it more attractive to institutional investors and central banks as well.

In total, about 208,874 tonnes of gold have been mined throughout history, with the four main sources of gold demand being jewelry, investments, reserve assets, and technology. Jewelry demand accounts for 46% of global above-ground gold demand, with central banks and investments making up 20% and 26% respectively (World Gold Council, 2023). Unlike most other commodities, the majority of gold ever produced still remains today. Investors have been embracing alternatives to the traditional investments of equities and bonds, focusing on diversification through hedge funds, private equity funds, or commodities. Gold allocations, as a commodity, have also steadily been increasing as a result of this shift towards diversification, with global gold investment demand growing by an average of 15% per year since 2001, with the gold price increasing by approximately a factor of 7 over that time period. Various studies have concluded that allocating anywhere from 4% to 25% of a portfolio to gold increases risk-adjusted

returns. This diversification has also been indicated to be stronger through physical gold rather than paper gold.

The use of gold both in a portfolio and in general life has been hotly debated. Investors like Warren Buffet compare the price of gold to other economic bubbles and call the metal an ‘unproductive asset’, and academics like Professor Robert Triffin describe the love of gold as ‘an absurd wage of human resources’. They cite the metal has little commercial value and pays no dividend or income, and therefore cannot properly be valued beyond customer preference. On the flip side, investors like Ray Dalio call gold a ‘risk-reducing and return-enhancing portfolio diversifier’. Despite the differences in opinion that gold faces, the metal remains a well-sought-after commodity by central banks and retail investors alike, becoming an accepted asset as part of portfolios due to its many beneficial characteristics. The recent coronavirus outbreak in particular had many investors reevaluating the role of gold in a portfolio, as the metal has proven itself useful during tail risk events.

3. Paper Versus Physical Gold Investing

There are two ways through which one can purchase gold - either through paper or physical sources. Physical gold takes the form of accessories such as jewelry, gold bullion, and gold coins. These can be bought or sold through gold dealers on the markets, with jewelry being found in many different shopping centers. Gold bullion and coins are the primary sources of physical gold investments, with the gold being either 22k (91.67% gold) or 24k (99.9% gold) purity. Large possessions of gold bullion can be stored in gold accounts for storage and protection fees. The gold is stored in a vault by a recognized bullion dealer or depository, who cannot trade or lease the gold without permission from the owners. Gold jewelry is often laden with other metals and gems, so the purity can range from 10k (41.7% gold) to 24k. There are also gold accumulation plans that allow investors to put aside a fixed amount of money every month to buy gold every trading day in that month. The holder can decide to have the gold delivered as bullion or coins or sell the gold at any point. This is often used for jewelry purposes in countries like India, where a set amount of money continues to buy and deposit gold at a jeweler, who will wait until enough gold is accumulated to create a predetermined piece of jewelry.

Paper gold is an asset that reflects the price of gold but is not truly gold. There are many ways to invest in paper gold, including ETFs, bonds, gold funds, gold futures, and e-gold. ETFs are dematerialized gold instruments that are unit-linked to the price of physical gold, with each ETF unit representing 1 gram of physical gold on average. Gold funds work similarly as they aim to generate returns by investing in units of gold ETFs. They are targeted toward those that do not have a dematerialized account. Gold bonds are often government issued, valued in multiple of 1 gram of physical gold, with maturities of 8 years. E-gold is simply the trading of gold units through an exchange, with one unit of e-gold equal to 1 gram of gold. Gold ETFs, funds, and

e-gold all allow investors to invest in gold over long periods of time and request physical delivery of the gold when needed through the exchange. There is also the option to invest in gold mining stocks, however, the success of gold mining stocks is not based only on the price of gold, but the future success of the company, its capital structure, and more. Mining companies, therefore, tend to be more volatile than the actual gold price (Thakkar, 2013).

Gold ETFs were launched in 2003 and are the most common way of investing in paper gold, but have largely remained a lesser portion of the global gold market as many were either hesitant to invest or were unaware that this financial instrument existed. While gold ETFs did generate growth over the decade and a half since its launch due to different crises that turned investors towards the gold market, the coronavirus pandemic caused increased trust in the gold ETF market. The pandemic caused a shutdown of many businesses and physical locations, which meant many people could not purchase physical gold from shops. However, they were still able to trade gold ETFs, the holdings of which increased by 20.3 tonnes from 2019 to 2022 (Mishra, 2020). Paper gold can also be attractive as dematerialized accounts do not generally attract a wealth tax and investors only pay an income tax on gains, while physical gold holdings are liable to attract wealth taxes. Today, paper and physical gold have near identical rates, with minor tracking errors making up the difference.

When comparing the performance of paper and physical gold, Sunkara (2017) found that gold ETFs should be more attractive to investors as it exhibits less variability compared to physical gold, and investors tend to prefer investing in assets with low variance. However, even as knowledge about gold ETFs continues to expand, many investors continue to prefer investing in physical gold, deterred from ETFs due to the potential of a paper gold bubble. The argument for the existence of a paper gold bubble follows the idea that the gold price set by the derivatives market has destroyed the price of gold without involving actual gold, leading to a division between the price of paper and physical gold. It is strongly argued that if the paper gold bubble bursts, physical gold ownership is the only thing to protect against a systemic collapse of the financial system and the destruction of the fractionally reserved gold banking system. The fear of the paper gold bubble existing and its potential consequences leads to the demand for physical gold remaining strong throughout the world.

Physical gold can be bought through dealers both online and offline, as well as through local pawn shops and other smaller distributors. However, those who invest in paper gold also have the opportunity to gain physical gold by converting their shares into the equivalent weight of physical gold. One unit of a gold ETF is pegged to an equivalent value of gold, ranging from one-tenth to one gram of gold, so an investor is able to approach their fund house to withdraw the desired amount of gold. There is a minimum amount of gold ETF withdrawal necessary for the transaction to occur, usually about \$30,000 or ₹40 lakhs. There are also discrepancies within the type of gold ETF one is investing in - while many Indian gold ETFs allow for the conversion

to physical gold, US based gold ETFs vary. The SPDR gold ETFs, the most common gold ETFs in America, do not allow for the conversion to physical gold, while the VanEck® Merk® Gold Trust is the most used gold ETF for those who desire conversion in the future (VanEck). Gold ETF conversions can make it incredibly useful to investors who desire holding physical gold without having to pay for storage. While storage and insurance costs are already included in the ETF price, investors also avoid the mental strain of knowing their asset may be in danger. Investors are then able to exchange their ETF for physical gold when they feel the market is apt for them to convert the physical gold into jewelry. Through this process, gold ETF investors must pay for storage, insurance and transportation costs, as well as the labor and making costs, but the purchase of the gold itself was completed with the purchase of the ETF. If an investor was to buy an ETF at a time where the price of gold was low, and wait for the price to increase before converting to physical gold, they would be able to either convert the shares to physical gold, or continue investing in the shares to increase their portfolio returns. They could also decide to sell when the shares hit high prices, wait for the price to decrease, and use the cash to buy increased amounts of physical gold. Gold ETFs give investors great flexibility in their investment decisions, and that includes flexibility in determining what they do with physical gold as well.

4. Literature Review

4-1. Gold as a Safe Haven

A study conducted by Boubaker (2019) aimed to solidly characterize gold as a safe haven asset. A safe haven asset is defined as an asset that either retains or gains value during times of economic downturns. Gold is often thought of as a safe haven asset, often exhibiting positive returns while traditional asset classes fall. Boubaker initially uses a linear regression model and finds that while gold upholds its status as a safe haven, it does so only weakly. However, the long time period used as data led to the detection of nonlinearity and structural breaks, causing the study to switch to a regime-switching model, in which gold is found to serve as a strong hedge against crises, especially when the gold market is bullish. A study by Pullen (2014) further observes that in order to benefit from the safe haven characteristics of gold, one must have a position directly in physical gold or ETFs, without relying on gold stocks or mutual funds.

4-2. Gold as a Hedge

Gold has long been appreciated as a hedge against market downturns, protecting investors from worsening economic conditions. It is lauded as both a diversification strategy and a safe haven asset due to its peculiar linkage to other asset classes. Timothy Green, author of *The Ages of Gold*, states that unlike traditional paper-based assets, gold is no one's liability, so its value cannot be eroded due to a decline in the creditworthiness of its issuer. This gives it an inherent safe-haven quality not exhibited by stocks or bonds.

Asset diversification is best when the correlations of assets are weak, making it so an economic impact to one asset does not have such a strong impact on some other asset. However, the onset and spread of globalization has caused correlations between and within traditional asset classes to rise steadily over time (Idzorek, 2005). Worse, this correlation has been found to move towards 1 in times of economic distress, achieving the opposite goal of diversification. Since real assets, such as real estate and commodities, do not share the same driving price factors of financial assets, they make for valuable investments as they increase the diversification and decrease the correlation within a portfolio. Gold is a great example of such a commodity, as it serves as a hedge against both stocks and inflation, improving the variance and returns of a portfolio, while performing better than other similar commodities.

4-2-1. Gold as a Hedge Against the Stock Market

Stock markets and crises go hand-in-hand, so when the world faces a crisis, stock markets take a plunge, and vice versa. However, the gold market has an inverse association with the equity market, with a near zero positive correlation between equity and gold being observed (Fernando, 2017). During negative shocks in the stock market and other asset classes, gold increases in value. For example, during the 9/11 terrorist attacks on the World Trade Center, the price of gold increased and the covariance between the two markets was negative as investors continued to sell traditional assets as they believed them to be riskier assets (Taurasi, 2013). From 2000 to 2021, gold returns generally outperformed stock returns, with gold returns averaging 9.2% and stock returns averaging 7.39% over the time period, and always outperformed stock returns during extreme stock market shocks. The study by Fernando concluded that on average, the Sharpe ratio of an equity portfolio improves when gold is added to it, showing that the inclusion of gold improves the risk return characteristics of an equity portfolio.

The additional characteristic of easy liquidity also helps gold act as a diversifier against the stock market. Gold is able to be liquified very quickly at all hours a day. The average daily volume of gold cleared in the last decade by the world's most prominent precious metals market, the London Bullion Market Association (LBMA), was 625 tons, 20% of the world's average annual gold mine production of 3,300 tons. Essentially, total annual gold mine production is cleared by the LBMA about every 5.3 days, which shows the incredible liquidity capabilities of the metal. Due to the strong liquidity, large denominations of gold trading can occur at a narrow spread (Taurasi, 2013). Notably, gold's high liquidity capabilities remains true for the jewelry industry as well, especially in areas in which gold jewelry is highly treasured, such as Asia and the Middle East. These characteristics lead investors to flock to the gold market in financial crises. This strengthens gold's role as a hedge against the equity market, as well as a safe haven, especially during periods of high volatility on the stock market (Baur, 2013).

4-2-2. Gold as a Hedge Against Bonds

To understand the relationship between bonds and gold prices, it is useful to first understand the relationship between interest rates and gold prices. Gold prices and interest rates exhibit an inverse relationship due to the opportunity cost that comes with holding gold instead of coupon-yielding assets in times of high interest rates. Studies by Starr (2008) and Wang (2015) find that investment in gold is higher in places where real interest rates were negative, with a strong negative correlation between the change in interest rates and the price of gold. When interest rates are lower, people are encouraged to borrow more, so there is an increase in the money supply and a resulting increase in gold demand. When interest rates are higher, investors are dissatisfied with the non-coupon yielding gold and shift their attention to assets such as bonds. However, continued interest rate hikes, such as those observed during the coronavirus pandemic, puts increased financial strain on the financial systems, causing the demand for safe haven assets to grow (Chainani, 2022).

The information about the effect of interest rates on gold prices directly relates to the relationship between bond prices and gold prices. Bond prices and bond yields move in opposite directions, so higher interest rates would mean lower prices for bonds. This means that as interest rates rise, the price of a bond decreases, similar to gold, resulting in a strong positive correlation between bond prices and gold prices. This positive correlation makes it difficult for gold to act as a hedge against bond market losses. However, a study by Ghazali (2019) finds that while weak, gold can act as a hedge against bond market losses as well, primarily during times when both stock and bonds exhibit losses. This is further supported by studies conducted by Baur (2010), who concluded that gold is capable of acting as a weak safe haven asset to bonds.

4-2-3. Gold as a Hedge Against Currency Devaluations

Gold is also known to be protection against the depreciation in a currency's value. This holds especially true for the US dollar, where a stark inverse relationship exists between the two assets. This relationship can be explained by the notion that a weak dollar would allow one to buy more gold, so gold prices must rise when the US dollar weakens (Investopedia). The study by Wang (2015) studies the correlation between different currencies and the gold price, finding that there is a strong inverse relationship between gold and USD exchange rates, implying that gold can act as a safe haven against extreme USD rate movements. The inverse relationship between gold prices and dollar prices was studied by Seemuang (2013), and was found to be so strong that the authors claimed that percentage change in the US dollar index may be the best predictor of gold price movement. This hedging benefit serves as a potential explanation to the immense holdings of banks reserves, as it would serve to their benefit to protect their holdings during market turmoils, during which the USD tends to fall (Chainani, 2022).

In addition to currency, gold has exhibited correlations to the overall money supply. Gold price mirrors the growth of the money supply, the ever growing money supply helps increase gold

prices over time. For example, since 2016, the M2 money supply, which includes cash, checking deposits, small saving deposits, and money market mutual funds, has grown by 64%. In that time, gold prices increased by 66% (World Gold Council, 2022).

Due to the increasing prevalence of cryptocurrency in modern times, the idea that cryptocurrency, specifically Bitcoin, is comparable to gold is a highly believed one. A study done by Klein (2018) aims to understand the correlation between Bitcoin and gold. The study finds that while gold is confirmed to be a safe haven asset, Bitcoin is too volatile, and while the price of Bitcoin can increase during market turmoil, it can decrease just as easily. The asset is then more similar to stocks, in that volatility affects returns significantly, and is not risk-free as gold is. A study done by Baur (2021) confirms this result, finding a near zero correlation between the two assets, indicating that Bitcoin does not behave in the same aspect that gold does, and does not act as a safe haven, at least in the same sense that gold does.

4-2-4. Gold as a Hedge Against Inflation

Gold also works as a hedge against inflation. According to the WGC (2022), the average annual return of gold over the past 50 years measures 11%, outpacing the US and world CPIs over the same time period, which measure 3.94% and 10.4% respectively. Studies have shown that gold becomes increasingly attractive during times of high inflation due to its rising prices during these times, with a 1% increase in US inflation rates raising the long term price of gold by 1% (World Gold Council, 2010). The work of Professor Roy Jastram, author of *The Golden Constant*, shows that commodity prices tend to return to the same price in terms of ounces of gold, unlike manufactured goods which tend to increase over time because they reflect the rise in labor costs. A famous example derived by Professor Jastram shows that a loaf of bread remained the same price in terms of gold from 1560 to 1960. His work shows that gold functions as a strong and effective long-term hedge against inflation, and even as a short-term hedge against deflation, as gold keeps its store of value and purchasing power over time. However, it is noteworthy that this inflation hedge is not constant, and is most identifiable only in periods of very high inflation. The study by McCown uses the arbitrage pricing model and cointegration tests to determine if gold acts as a hedge against inflation. The arbitrage pricing model returns positive and statistically significant regression coefficients for the change in inflation risk factors, showing that gold is a good hedge against inflation on an annual basis. The study also uses the Johansen trace test and Johansen maximum eigenvalue test to test for cointegration between gold and the consumer price index (CPI). Both tests show strong evidence for the existence of one cointegrating equation relating the two variables, showing that the stochastic movements of the two are coordinated. Once again, the tests conclude that gold is a good hedge against inflation in the long run.

4-2-5. Gold Performance Compared to Other Precious Metals

Gold tends to differ from other precious metal commodities as well. During the 2008 financial crisis, the gold price increased by 6% while other precious metals fell, with the stock market falling around 40% (Shafiee, 2010). This difference between the performance of gold versus

other precious metals is examined in a study by Hillier. The study investigates the effects gold, silver, and platinum have on a portfolio, and how effective the diversification benefits of the metals are (Hillier, 2006). Hillier concludes that all three precious metals provided considerable diversification benefits in volatile equity markets, helping to reduce systematic risk.

4-2-6. Summary : Gold as a Hedge and Diversifier

Gold has a low correlation with many asset classes, strengthening its role as a diversifier. It works as a hedge against the stock market and inflation and has been proven to be a safe haven, especially in times of economic crises when many other asset classes are facing downturns. While it is important to remember that gold too can trend downwards and potentially be volatile, gold provides investors with the chance to protect their financials against potential downfalls in traditional asset markets. Its high liquidity also allows investors to meet liabilities quickly when other assets in their portfolio are too illiquid in the short term or are mispriced.

While gold has been shown to be extremely valuable in times of economic distress, it should be mentioned that gold can do well in times of economic expansion as well, especially in the jewelry and industrial sectors. In times of economic expansion, consumers have more wealth and income while companies and governments are looking to expand production and projects. This leads to increased demand for gold jewelry and industrial components, with the increased demand leading to higher prices.

4-3. Measures of Gold Performance and Volatility

4-3-1. Measuring the Coskewness and Cokurtosis of Gold

A study done by Taurasi (2013) calculated the level of coskewness and cokurtosis between gold and a diversified equity market portfolio. The study found that gold has positive coskewness with the market portfolio during both bear markets and times of market uncertainty and downturns, with gold's returns being significantly higher in times of high uncertainty. It does exhibit small negative coskewness during times of market upturns, as expected from a safe haven asset. The study done by Fernando confirms these findings, and adds that in contrast to gold, the equity market exhibits a negative coskewness, indicating increased potential for large downside losses. The metal also shows decreasing cokurtosis during times of market downturns, indicating that investing in gold could reduce the probability of generating extreme values, especially to the negative tail of the distribution, the effect of which is actually increased and becomes most beneficial during a market downturn.

4-3-2. Finding the Beta of Gold

The study by Taurasi (2013) also estimates the beta of gold, finding that the beta remains small across most market conditions and is negative in times of high market volatility, showing that gold bears almost no market risk. The beta of gold is further calculated in the study conducted by

McCown (2006). McCown concludes that an investment in gold bullion adds no systematic risk to an investor's portfolio through an estimate of the capital asset pricing model (CAPM) using an ordinary least squares regression (OLS). The OLS yields adjusted R-squared values close to zero, which indicates a beta statistically different from zero. He finds that this result is consistent with the gold returns for the period between 1970 and 2003, in which gold returns were slightly higher than the Treasury Bill rates. The study by Fernando does warn that although the beta of gold does remain near zero, its value is slowly increasing, likely due to the effect of the expansion of the gold ETF market. This could suggest increasing correlations between gold and equity in the future, which would undermine gold's diversification benefits. However, the likelihood of this occurring is low and not a cause for concern, and is rather just a point of warning for potential investors.

4-4. Gold, Cycles, and Sentiment

4-4-1. The Cyclical Nature of Gold

A study conducted by Laakso (2019) found that gold exhibited cycles daily, in the intermediate term, and over years. Daily cycles ranged between 30 to 45 days, sometimes stretching to 60 days. However, Laakso concluded that these cycles were too short and too inconsistent to make definite conclusions upon. Intermediate cycles for gold were determined to be approximately 6 months, or 24 weeks, long. However, this result once again does not hold much significance for the gold market. The multi-year cycle for gold was found to last 8 years, longer than the US stock market's cycle of 4 years or the 3-year cycle of commodities. The reasoning behind this was determined to be due to the characteristic of gold being a tail risk asset. Since gold is used to hedge tail risks, which are unlikely but not impossible, the need to hedge is not frequent, causing the multiyear gold cycle to extend farther than those for the stock market or other commodities.

Laakso also found that gold exhibited a clear ABC-type pattern. This wave is seen in other markets as well, but is particularly clear in the gold market. The wave can be decomposed into an A-wave, which is a growth in the price of a financial instrument, followed by a shorter B-wave decline, finishing with a C-wave growth that is often longer than the A-wave growth. The repetition of this wave in the gold market indicates that the price is likely to continue climbing over the long run, even if there happen to be periods of declining price.

4-4-2. The Effects of Sentiment

These cycles are the result of changing sentiments exhibited by gold investors. Gold is affected by a number of macroeconomic factors, including inflation, interest rates, and the ongoing of other financial markets, but is most affected by sentiments held by investors. A study done by Baur (2019) explores the impact of different variables on the price of gold, and finds that while macroeconomic factors indicate the changes in gold prices, expectations and uncertainty turn out to be much more important in explaining gold price movements. Investors flock to the gold

market in times of political and economic uncertainty, being the preferred asset in these crisis times due to its safe haven characteristic. However, even if macroeconomic indicators are all pointing towards economic instability or volatility, if investors remain optimistic about the overall economy and are under no pressure to find a safe haven investment, gold prices are unlikely to see significant movements in price.

4-5. Gold Supply and Demand

The spot price of gold is fixed by the London Bullion Market Association twice per day, known as the AM and PM fix prices. The goal of this price-fixing process is to reach a price for settling contracts within the London gold bullion market. The price fix can then be used as a benchmark to appropriately price other gold products across the world. The spot price is determined by the fundamental economic concept of supply and demand, with various factors making up each.

4-5-1. The Supply of Gold

The long-withstanding value of gold can be explained by its incredible scarcity, with the metal making up only about one 500,000,000th of the Earth's crust. Approximately 200,000 tonnes of gold have already been mined, with only an estimated 50,000 tonnes left to be mined. This incredibly small amount of available gold is what causes the metal to be incredibly expensive even without additional economic factors affecting it. This scarcity along with ongoing economics contributes to the current price of gold in the market.

The supply of gold has two factors: mining and recycling. Approximately 75% of gold demand is met through mine production, and the remaining 25% is met through gold recycling of jewelry, technological and industrial parts, and other scraps. Since the above-ground gold supply is much larger than the amount of gold mined annually, mining production variations have little effect on the value of gold.

The annual supply of gold from mining has been rising consistently throughout time, especially since 2009, but analysts have argued that gold mining may have reached a peak in gold production. There are two effects that occur as a result of peak production, being a reduction in the amount of gold reserves left economically viable to mine as well as developments in mining technology. The WGC estimates that only about 10% of global gold deposits have enough gold to be mined economically. Since the process of mining gold is so expensive, and with below-ground deposits shrinking, gold likely has hit a peak, and significantly less will be produced in the future. The extensive process required to mine gold also shows that mining output reacts slowly to sudden demand increases, making the supply of gold very inelastic. While higher gold prices can encourage more exploration to take place, the actual output of gold can take up to 20 years from the initiation of the site to enter the market.

There does remain hope for increased mining efficiency through robotic technology. Robots can reach underwater deposits and cost less than human workers, helping lower production costs. However, the cost of energy is likely to increase in the next two decades, and with mining being an energy dependent industry, the production costs of gold mining could dramatically increase. There is also the possibility that while current mining technology still has room for improvement, it will reach its maximum efficiency, at which point developments can no longer be made. At this point, it would likely become extremely difficult and expensive to mine deposits, leading to a potential halt in gold mining regardless of how much is left below-ground.

Rising mining costs, decreased exploration, and potentially higher energy costs make gold increasingly expensive to mine. These, combined with the lowering amount of gold left to mine, is likely to create upward pressure on gold prices, which would help turn currently uneconomical gold mines into economically mineable ones.

Recycled gold largely comes from jewelry and electronics, as well as scraps that are no longer needed in a large production process. Approximately 90% of recycled gold is sourced from jewelry, with more being recycled when the gold price is increasing or during a time of economic crisis. The other 10% is recycled largely from electronics recycling. Interestingly, a feature of gold is that gold jewelry and central bank reserves can move from the demand side to the supply side. This characterizes gold as a renewable resource, which could help contribute to a decrease in the demand for newly mined gold.

Jewelry recycling is positively correlated with gold prices, so as prices rise, more jewelry is recycled, increasing supply. During this situation, since the supply is increasing, prices fall. However, gold price and gold jewelry demand have exhibited a positive correlation since 2009. This means that while prices are rising, jewelry supply also rises, but so does jewelry demand. Gold jewelry demand tends to double gold recycling supply, so while the excess supply from recycling pulls the price down, it does not offset the increase in demand which increases the price. The result is a net positive growth in the gold price.

It is noteworthy to mention that author Schoenberger (2011) has extensively researched the central bank holdings of gold reserves, and has shown that gold scarcity has been enhanced through authority at various points in time. From burying gold in Egyptian tombs to holding large amounts of gold in central banks, centers of authority and governments are able to create artificial scarcity of gold, supporting the increase in the gold price and adding to the desire for many to hold parts of the precious metal. The WGC supports this idea, stating that since a few central banks hold so much of the world's total gold reserves, they have immense potential pricing power in the gold markets.

4-5-2. The Demand for Gold

A basic financial theory states that an increase in demand for a financial instrument increases the price of that instrument. A study conducted by Ghalayini (2020) concluded that for an increase of 1% in gold demand, the gold price rises by 0.53%. Professor Ray Jastram states that the continued demand and appeal for gold stems from two basic human desires - the need for security and the want of adornment.

The demand for gold jewelry tends to have an inverse correlation with the price of gold, so a fall in the price of gold causes demand to increase. A study by Batchelor (1995) found that the connection between jewelry demand and gold prices exhibited direct price elasticities ranging from 0.5 to 1.0. They also found that there was an increase in speculative gold jewelry buying ahead of anticipated price increases. However, these elasticities only apply in the short run, as in the long run, demand for gold jewelry tends to thrive regardless of the price.

Demand for gold investment has seen incredible growth, from being only 4% of overall gold demand in 2000 to 45% in 2009. This growth was spurred by the launch of gold-backed products such as gold ETFs. A study conducted by Selvaraj (2020) uses Kendall's coefficient of concordance to determine the factors that influence investors to invest in gold and finds that the safety, profitability, and future prospects of gold are the main factors that draw investors towards the metal. An increasing number of investors are seeing gold as a secured investment that provides liquidity, can be used as collateral, and can diversify a portfolio, increasing the demand for paper and physical gold (Thapa, 2020).

A study conducted by Immanuel (2022) aims to determine if the volume of gold consumption influences the price of gold. The study uses the Johansen cointegration test to determine if there exists a long-run relationship between gold prices and demand and whether the demand showed a significant impact on the price fix set by the LBMA. The results illustrate that the price fixed by the LBMA is influenced significantly by total gold demand, with Indian and Chinese consumption influencing the price the most.

Multiple studies have concluded that global demand for gold is greater than global mining output. The WGC reported that in 2020, total gold supply was 4,633 tons, while total demand was 3,759 tons. However, this included gold recycling, without which supply reaches only 3,401 tons, leading to a demand-supply deficit of 358 tons based solely on mining production. With such a shortage of gold, the price of gold is forced to increase in order to spur additional interest in supplying more gold while making sure the existing demand is priced high enough to both cover costs and ensure continued interest in it. Since gold has a finite supply based on the amount left on Earth, it is likely that future gold prices will continue to increase as everyone rallies to have a piece of the rare metal.

5. Gold Jewelry

5-1. Gold : The West and the East

Gold is prevalent globally, with deep cultural and religious ties in various parts of the world. Ancient gold jewelry and ornaments have been found all across the world, dating back centuries. Gold coins were used as currency beginning in 550 BC, and paper currency was backed by gold until the end of the gold standard in 1971. Historical records show that ancient civilizations thought of the metal as being linked to the divine, a concept not entirely undone today. Ancient Incas thought of gold as the sweat of the sun, while ancient Egyptians believed that the skin of gods was made of gold, contributing to the belief of needing to send pharaohs to the afterlife covered in gold. Asian countries also have deep-standing traditions revolving around gold, explaining the ease of access residents of these countries have to gold jewelry and other accessories. China and India are two prominent examples of countries with immense cultural significance placed on gold, with gold jewelry demand in these markets making up approximately 61% of global jewelry demand (Baltrusaitis, 2022). China has a tradition of gifting newborns with small gold necklaces and bracelets, while India's most prominent religion, Hinduism, promotes a goddess of wealth often depicted with golden skin and a hand ejecting golden coins. Gold also often serves as a status symbol in these countries, signifying the wealth, power, and prosperity of families.

The WGC defines gold jewelry as all carat jewelry made from raw gold, including gem-set jewelry. It excludes jewelry of other metals plated with gold, coins and bars used as jewelry, second-hand jewelry unless remelted and sold for cash, and purchases funded by trading existing jewelry. The top countries that consume the highest amount of gold jewelry include India, China, the United States, the United Arab Emirates, and Indonesia in that order, with India and China consuming almost half of the world's gold jewelry demand.

There is a difference to be noted between physical gold bullion and jewelry, in that the former is typically sold by the ounce while karat jewelry is sold by the gram. In order to calculate the cost of gold in a piece of jewelry, ounces need to be converted to grams. 1 troy ounce is equal to 31.1 grams. An understanding of the different purities of gold must also be reached. The highest purity of gold is 24k, wherein 24 out of 24 parts of the gold is pure gold. When a piece of gold is said to be 14k gold, this indicates that it is 14 parts gold and 10 parts other metals, so 58% of it is gold. Pure gold is very soft, and can bend extremely easily. Due to the need for jewelry to be durable, it is unlikely that jewelry will be made in 24k gold, and rather will be made in 18-22k gold, especially in Eastern countries. Western countries tend to purchase 14k gold more often (Fried, 2023). The price of gold in jewelry closely mirrors the price fixed by the LBMA. 24k gold jewelry is very similar to the fixed price, while other purities use the percentage of gold content to determine its price. For example, at a price fix of \$1000 per oz, 22k gold, which is 92% pure gold, will have a price of \$920 per oz.

The West and the East recognize gold differently. While the West, including the United States, Canada, Europe, and Australia, has limited gold-related discussion both in society and within central banks, the East tends to talk about gold often. For example, while former Federal Reserve chairman Ben Bernanke has stated that he does not understand gold and merely stores it due to long-standing traditions, the head of the Central Bank of the Russian Federation Elvira Nabiullina has said that gold purchases by the Central Bank help diversify Russia's wealth. It should be noted that despite this statement, the United States continues to own the largest amount of gold in the world, holding over 24% of the world's central bank gold reserves. Other Western countries also hold much of the world's gold reserves, but countries like China, India, and Russia have all been increasing their holdings as their economies continue to develop rapidly. The difference between how the West and the East treat gold is reflected in their transactions related to gold jewelry as well.

While most of those in the United States and many other developed nations do not place such cultural significance on gold jewelry, the purchase of the commodity remains prevalent, with the United States, United Kingdom, and Italy all being part of the top 10 countries with the highest consumption of gold jewelry. Gold gifts are generally given during larger ceremonies, such as weddings. However, despite this, there remains a large difference in how gold jewelry is treated between developed and developing countries.

In developed countries, gold demand is driven largely by hedging variables, and gold demand rises with per capita income. In developing countries, demand is higher when income falls or is volatile and does not systematically rise with per capita income, reflective of the notion that developing countries view gold investment as precautionary savings. Many developing countries have the need to build up easily liquefiable wealth to be used in potentially adverse shocks, leading to increased demand for gold jewelry, as it can be easily sold to cover consumption needs. This is why in many developing countries, high-carat jewelry is viewed not just as an accessory, but also as an investment that can be easily liquified.

The difference in the treatment of gold jewelry between developed and developing is further exemplified by the ease with which gold jewelry is sold in the different types of countries. Developing countries generally sell jewelry high in carats and with minimal labor and artistic markups over the value of the gold, while developed nations sell only a small amount of high-carat jewelry and markups tend to be much higher as fewer people view it as an investment.

A major benefit to holding gold jewelry over other gold assets is the additional benefits that gold jewelry provides. For one, jewelry can be worn, giving it the feature of adornment and utility, something other gold assets do not exhibit. Additionally, gold has a convenience value in production. A producer of gold jewelry holds gold in order to avoid stockouts, receiving a higher

convenience yield, which is a premium of holding an actual possession instead of a piece of paper or a contract (McCown, 2006). This can be especially useful in a time of uncertainty.

5-2. Gold Jewelry Making

In order to understand the returns on gold jewelry and how they differ in developed and developing countries, or between Western and Eastern countries, the United States and India will be used as proxies to represent the respective categories. The United States is a global superpower with strong financial markets, economy, and political environment. They have a large amount of gold jewelry consumption, making the tracking of gold jewelry transactions easier to measure. India is a rising economy that has many of the same aforementioned qualities of the United States along with a great consumption of gold jewelry, again helping to measure the value of gold jewelry transactions. While this is a great simplification of the role gold jewelry holds in different countries, it will help shape the potential that gold jewelry has in an investment portfolio in the two different categories of countries.

Another thing to note is that many pieces of gold jewelry are inlaid with a variety of gemstones, each of which have their own valuations. Rather than having a fixed price internationally like gold does, gemstones are valued individually based on a set criteria known as the 4Cs - cut, color, clarity, and carat. Since the diversity of gemstone types and value is great, it can be difficult to understand gold jewelry returns when gemstones are included. As such, this paper will assume that any gold jewelry being bought and sold does not have additional gemstones attached to it.

Prior to 1973, US citizens were not able to purchase gold except in the form of jewelry. After 1973, while citizens were allowed to trade gold coins and bars, many likely felt uncomfortable doing so, as physical gold transactions remained low. Gold ETFs were introduced to the American market in 2003, which allowed both institutional and retail investors to enter the gold market without having to possess and protect the physical metal. However, even with the introduction of ETFs, most gold purchases in the Western world are isolated to jewelry transactions, most of which are sold at or below 18k purity. There is also an increase in jewelry branded as gold but contains 40% or less gold content. This is in stark contrast to Eastern countries, particularly Asian countries, in which gold is often sold at 22k to 24k, often laden with other gemstones as well. Women in particular choose to make gold jewelry investments because it tends to be easier and more flexible, and because it can be used both as an investment and to support their appearance. In many countries where women are unable to invest on their own, gold jewelry was the only way for them to have some financial security. Today, the United States makes up 23% of the global gold jewelry market, valued at \$61.8 billion (Classy Women's Guide, 2023).

Indian jewelry is widely recognized to be intricate and complex, with custom designs being made with top craftsmanship. Jewelry is one of the fastest-growing industries in the country, with the Indian economy benefiting greatly from it as the industry makes up approximately 7% of the country's GDP (Amutha, 2021). Gold is present in 80% of the jewelry market, both found alone as well as studded with additional gemstones. The Indian government has designated the jewelry industry as a focus sector due to the potential to promote exports and add value to the Indian economy. This is important as increased gold exports within India, which has been identified as a major influencing country on the LBMA fix prices, could turn the country from a price taker to a price maker, resulting in increased gold prices and returns.

Jewelry manufacturing involves complex designing, precise stone setting, polishing, filling, and grinding among other steps to turn gold bullion into an exquisite piece of jewelry. During this process, some production errors can occur, which can result in scraps of gold being discarded, causing the quantity of the raw gold to be reduced slightly compared to the original weight measurement (Kaspin, 2021). Manufacturers are not always aware of the loss of gold that occurs during production, and even if they are, there is often no action taken to prevent the losses. While the loss of gold is found and the gold weightage is updated before selling in higher-end stores, lower-end stores found in gold-heavy countries are unlikely to update the information. This causes a discrepancy to appear when the buyer wants to resell the jewelry, as they were told the gold was of a weight higher than it actually is, and therefore expect more money from reselling it.

5-3. Buying and Selling Gold Jewelry

There are different ways for consumers to buy gold jewelry. The most common is to simply buy pre-made accessories from distributors. In the United States, there are over 21,300 jewelry stores, including global brands that fulfill orders both in the US and elsewhere (Dun & Bradstreet First Research, 2023). While it is unclear how many of these sell gold jewelry alongside other metals and stones, with gold being an extremely popular precious metal, it can be assumed that a large portion of these stores sell gold jewelry. The stores also include branches of Indian stores, concentrated in areas with a high Indian population. These stores are to be included in the demand and supply for the United States, as they largely are not indicative of Indian market forces despite being headquartered there. In India, gold jewelry stores are commonplace, and the characteristics of the market are easier to measure due to the high prevalence of the metal. India is home to between 300-350 thousand jewelry stores, including international, national, and regional chains as well as smaller local distributors (Goldhub, 2022).

Besides pre-made accessories, many consumers choose to make custom gold pieces. This involves melting down physical gold into custom designs. The physical gold is often sourced from the final customer themselves instead of from the manufacturer. In this situation, the price of the gold itself is associated with the original physical gold, with the markups and labor costs

being the price of creating the new piece. The markup is applied from the manufacturer straight to the final customer, as there is likely no middle distributor. Depending on the source through which one manufactures the piece, labor costs and markups may increase based on ongoing market forces.

Selling gold jewelry also differs from area to area and has to deal with artisanal markups as well. Western countries often have evaluators that determine the price of a piece of gold, factoring in the spot price, purity and condition of the gold, and the artisan premium that comes across in the image of the accessory. Eastern countries are similar, but the concept of haggling is much more prominent in Eastern countries than in Western ones. It is possible that a piece of gold would sell for higher in an Eastern country with intense haggling than it would in a Western one. For the sake of this paper, haggling will not be taken into account.

The gold selling market has both an online and offline market as well, with offline buyers in particular likely able to produce cash quickly. Gold jewelry is often melted after being bought, and the seller should expect to be paid about 70% to 80% of the melt value. Melt value is equivalent to the spot price of the gold purity, multiplied by the weight of the gold brought in. It can clearly be seen from this that if the buyer is looking to melt incoming gold, selling when the price of gold is high is optimal. It is also important to look at the artisanal markup when selling gold. The buyers of second-hand gold in Western and Eastern gold jewelry evaluate markups differently. Western buyers often do not pay much attention to the originality or labor that was used to produce an accessory, so there is little to no extra money given to pieces based on their originality. This is largely because most gold jewelry in the United States is sold to be melted. However, in India, where gold is often resold, the artisanal markup is important to take into consideration. Therefore, buyers in India will pay more based on the intricacy and originality of the piece. These factors play an important role in determining when the best time is to sell gold jewelry. Those in a country that does not pay much attention to artistic markup would fare better by waiting for incredibly high gold prices, while those in Eastern countries could still see a sizable return on their investment even if the price of gold is not so high.

Overall, the different forms of buying gold jewelry has advantages and disadvantages. Buying premade gold accessories allows one to buy when gold prices are low, but they may face much higher artisan markups. Custom made jewelry from existing gold stashes allows one to buy physical gold whenever they would like and simply pay for the labor costs, but they must find a trustworthy jeweler within their budget. Artisan markups are a large force that investors must contend with as they can significantly impact the level of returns on their investment.

One of the major obstacles to buying and selling jewelry is the artistic markup that accompanies it. This markup can be frustrating, as it causes the buyer to purchase for higher than the spot price of gold, which may cause them to sell it for a lesser profit. The artistic markup on a piece

of jewelry can vary based on location and how the gold was sourced. Developed countries also exhibit much higher artisan markups than developing countries, consistent with the lower interest in the metal's store of wealth value (Starr, 2008). With pre-made gold jewelry, the markup is first applied from the manufacturer to the distributor, then from the distributor to the final customer. In the US, final customers can expect to see incredibly high markups on their accessories, ranging from a price increase of 100% to 700% on the price of the gold. In India, these markups are even more varied, but are often lower. Large chains and smaller stores alike will not apply very high markup costs, charging between 25% to 100% on the price of gold, with the majority falling between 30-50%. These percentages are not finite, as each company applies very different markups on their jewelry and it is difficult and insignificant to find an average or median value. For custom made jewelry, the markup is only applied from the manufacturer to the final customer. This means that artisan markup is significantly less, ranging between 50% to 150% in the US and between 25% to 100% in India. During heightened times of inflation, pre-made jewelry markups increase due to the increased price of the source gold. However, custom jewelry does not see incredible jumps in price, and rather sees a slight upward adjustment intended for the company to create a larger profit margin during the difficult inflationary period.

6. Determining the Portfolio Returns and Value of Gold Jewelry

Before beginning the calculations regarding the return on gold, it should be noted that transactions of gold jewelry are incredibly complex and rely on many different factors, many of which cannot be accounted for. For example, as mentioned before, haggling is prominent in many Eastern countries and can significantly influence the selling price of a piece of gold. The following calculations will heavily and liberally use assumptions to fill in gray areas while simplifying the transaction process.

6-1. Breaking Even on Original Investment

During the transactional process, there are different buyers and sellers, with buyers turning into sellers and vice versa. For the sake of simplicity, only pre-made jewelry will be focused on as it is the most common source of gold jewelry demand and supply and has higher price returns and therefore higher potential for investment returns compared to custom made jewelry. The process for the transaction of pre-made jewelry starts with a customer buying from a store. The customer then sells to a different buyer. That buyer then sells to another person. To keep each individual in the process clear, each entity will be given a specific term. 'Store' will refer to the original store which initially sells the piece. 'Customer' will refer to the first buyer of the piece and the one choosing to sell it afterwards. 'Seller' will refer to the person buying the jewelry from the customer and selling it to someone else.

In order to determine the best time to buy and sell gold jewelry, it is first useful to set a break-even price at which the entire price of the jewelry would be returned. On the sell side, the price is determined by the melt value and the artisanal markup. The melt value of a piece of

jewelry has been determined as the spot price of the piece of gold, multiplied by the weight of the gold. The melt value of gold can then be represented as $MV = W_G SP_G$. In the United States, the return from selling gold jewelry often ends at the melt value, so a customer can expect to be paid between $0.70(MV)$ and $0.80(MV)$ for their gold jewelry. This paper will assume those in the United States can expect 75% of the melt value, arriving at an equation of $0.75(MV)$, or

$$\text{Price paid} = 0.75 \times [W_G SP_G] \quad (\text{Eq. 1})$$

While the United States does not pay much attention to artisanal markup, it is possible that a seller of gold would pay in excess of melt value based on the intricacy of a piece. Another equation can then be drafted to add on a potential artisanal markup value. Even if the markup was taken into consideration, it is unlikely that it would be anywhere near the original markup. Smaller stores were determined to apply a markup between 100% and 700%, so this paper will assume that customers can expect the seller to take into consideration a flat 30% markup value. That is, regardless of intricacy, if the worth of a piece is determined while considering artisanal markups, the markup amount will be 30%. Melt value will continue to play a role in the pricing of gold, that is, a customer can expect to be paid between 70% and 80% for the melt value of their jewelry, but with the markup now considered. Continuing with the assumptions made for melting gold, the new equation for customers selling in the United States is

$$\text{Price paid} = 0.75 \times [W_G SP_G] + 0.20[W_G SP_G] \quad (\text{Eq. 2})$$

In India, the percentage paid on the melt value of gold is likely to remain similar to that of the United States at an assumed 75%, however, the additional artistic markup is likely to enter even if the gold is simply melted down, and will also be higher than that of the United States. The considered markups are likely to be a flat 15%, slightly less than the lower bound of the likely range of Indian markups noted before. Therefore, the equation regarding the potential price return on gold jewelry can be represented as

$$\text{Price paid} = 0.75 \times [W_G SP_G] + 0.15[W_G SP_G] \quad (\text{Eq. 3})$$

However, if the gold was to be resold, the artistic markup would play a much bigger role in the price returned to the customer. The customer is looking to reap a profit even on the markup price they paid, and sellers are aware both that customers are unlikely to sell without seeing a return that considers the markup and that they too can markup the product significantly to sell it again. In this situation, the customer can expect to see about a 65% markup applied to the spot price in their return, slightly lower than the upper bound of the likely range of Indian markups noted before. The equation then becomes

$$\text{Price paid} = 0.75 \times [W_G SP_G] + 0.60[W_G SP_G] \quad (\text{Eq. 4})$$

These equations can now be used to determine how much a customer needs to be paid by the seller in order for them to break-even on the original price of their gold. During this calculation, it is necessary to keep in mind that one tends to buy when the market shows low prices and sell at higher prices.

For example, if a US customer bought an accessory priced at \$1,000 with a weight of 20 grams at a time when the market price was \$30 per gram, this indicates a markup price of \$400, or 66%. If the seller wishes to melt it, the customer can make 75% of the spot price times the weight back. This means that the customer must wait until the overall value of their gold reaches a price of about \$1,333.33, or \$66.67 per gram. At this price, which required a price appreciation of about 122% per gram, the customer would be breaking even with their original investment. Therefore, in order for a US customer to break even with their original investment, they would need to see a 122% increase in the spot price of gold. However, if the seller wished to resell the piece, a flat 20% markup would be added to the piece. Therefore, the customer would then only require the spot price to reach \$52.63, meaning that they need only a 75.4% appreciation in the spot price. In India, the same accessory meant for melting would require a spot price of \$55.55, and a spot price of \$37.04 for reselling, leading to required price appreciations of 58.7% and 23.5% respectively. Clearly, the Indian market requires a much lower price appreciation in order to see gold jewelry as a break even investment. Indians are therefore able to reap a better price return on their investment with a lower appreciation in spot price.

During the transactional process for custom-made jewelry, there is only the 'Customer' and the 'Seller', as the 'Store' would refer to where the customer originally got their bar of gold, Since gold bars have no markups, they are bought simply at the spot price. The customer then pays for labor costs to have the bar turned into jewelry. As mentioned above, during this process, there is the possibility that production causes higher gold scraps to be wasted. So while a bar of gold may be measured at 20 grams, the resulting piece may be slightly less. This is unlikely to affect the price greatly, especially if the going spot price is low and/or the amount of wasted material is low, but an increase in either of these factors would lead to incremental increases in the lowered amount of the price return.

Overall, these calculations give a baseline understanding of how one would determine the price at which they are able to make a profit off of their gold jewelry. In Western countries, a significant price appreciation in the spot price of gold is needed in order to see a profit, even if the seller offers to apply a flat fee with the intention of reselling the piece. In Eastern countries, the needed appreciation is much lower, which allows for greater profit to be reaped. The great value given to gold in the East has led to an incredibly large market there, the size of which allows for great investment value compared to the West. The higher demand for gold in the East

leads to better investment opportunities, which again leads to higher demand for gold, continuing the cycle of better price returns in the East on gold jewelry.

6-2. Historical Appreciations of Gold

Throughout history, there have been plenty of price appreciations that would enable a holder of gold jewelry to see greater than the break-even return on their investment. While the price can fluctuate greatly from year to year, the overall trend of gold prices continues to increase. Since gold accessories are often held for long periods of time, there is little doubt that gold pieces bought even a decade ago would have appreciated the necessary amount for a holder to see a significant return. The price appreciations for various arbitrarily chosen time periods are shown below, ranging from 10 to 20 years time spans from 1970 to 2020.

1970-1980	1610%	1980-1990	-38%	1990-2000	-27%	2000-2010	339%
1970-1990	967%	1980-2000	-55%	1990-2010	220%	2000-2020	535%

Correcting for purchasing power, assuming a base year of 1970, the price appreciations become :

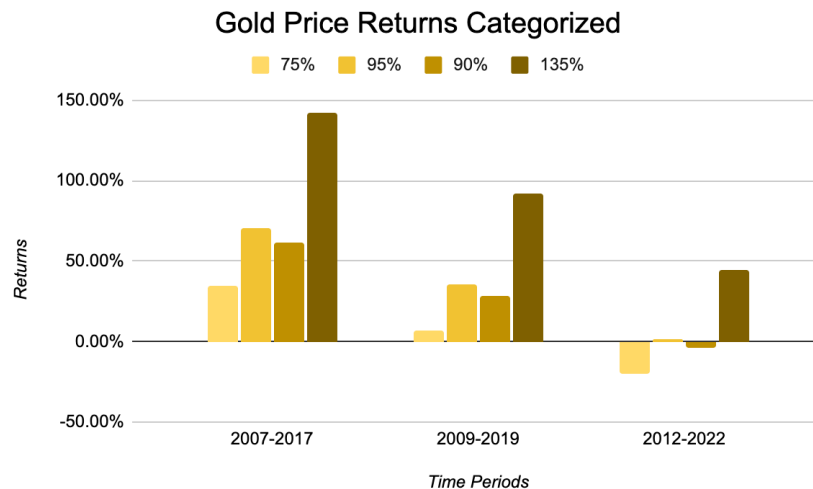
1970-1980	731%	1980-1990	-62%	1990-2000	-45%	2000-2010	242%
1970-1990	217%	1980-2000	-79%	1990-2010	88%	2000-2020	395%

The majority of these appreciations show incredible increases in the price of gold, sans the period from 1980 to 2000 which show decreases in the price. However, even these decreases are slight compared to the size of the growth of the appreciation periods. Considering many gold ornaments are kept for long periods of time, there is a large chance that the customer would be able to receive a sizable return on their investment. While the correction for purchasing power shows that the highest required break even point is not always reached, in contrast to nominal appreciation wherein each appreciation period exceeds the required appreciation, it is evident that many of the time periods do exceed the required largest appreciation of 122%. It can also be seen that the longer the holding period, the more likely a greater appreciation will be realized, so the sentimental nature of holding gold jewelry for longer periods additionally helps its value. In order to determine the returns of gold jewelry in particular, the returns over the period of 2007-2022 were used. This allows for consistency throughout this paper, as varying periods of time within this set will be used later. The gold returns were further adjusted to account for the return that would occur based on the amount a seller would pay the customer. For example, a seller in America with the intention of melting the accessory would pay 75% of the value of that accessory in the present time. The return is therefore calculated using the price of the accessory when it was bought and 75% of the price of the accessory at the time of selling. Each of the

categories were used in the calculations, with 75% and 95% returns representing the USA, and 90% and 135% returns representing India.

Using these gold return categories, the following price appreciations were found and graphed.

	USA		India	
	75%	95%	90%	135%
2007-2017	34.6519%	70.5591%	61.5823%	142.3735%
2009-2019	6.7820%	35.2572%	28.1384%	92.2077%
2012-2022	-19.6540%	1.7716%	-3.5848%	44.6228%



Looking at these price appreciations, it can be seen that gold returned at the 95% and 135% levels consistently saw price appreciations. However, those returned at 75% or 90% did not exhibit consistent positive returns, with smaller positive returns in 2009-2019 and negative returns being observed from 2012-2022. Therefore, in either the US or in India, selling gold with the purpose of melting would result in negative returns if bought in 2012 and sold in 2022. However, these calculations are heavily dependent on the initial year bought and the year sold. Differences in the years would bring about likely incredibly different results.

By looking simply at the price appreciation of gold, both nominal and real, it is quite clear that gold and gold jewelry can make for beneficial long-term investments. However, the true value and benefits of gold jewelry within an investment portfolio cannot be deduced from simple price appreciations.

6-3. Expected Return of Gold Jewelry

In order to get a better idea of the benefits and expected return gold jewelry has within a portfolio, the capital asset pricing model (CAPM) can be used. CAPM is a tool that helps estimate the expected return of an asset based on the riskiness of the market. Gold was previously found to exhibit characteristics of a zero-beta asset [McCown]. However, gold jewelry faces more potential risk sources, and is therefore likely to exhibit a more volatile beta.

6-3-1. Finding the Beta of Gold Jewelry

In order to find the beta of gold jewelry, the returns from this time period were used and the variances for each return type of gold were found. While a multitude of different assets make up the overall market of an economy, the stock market is often deemed an appropriate representation of how the economic conditions in a country are faring. Therefore, as the benchmark comparison, the two popular stock market indices within the US and India will be used, being the S&P 500 and NIFTY 50. The variances of these market indices were found as well, along with the covariances with the different gold return categories ([A1](#), [A2](#)). Using this information, the beta of each category was calculated.

	USA Beta		India Beta	
	75%	95%	90%	135%
2007-2017	-0.2009	-0.2544	-0.2283	-0.3424
2009-2019	-0.2108	-0.2670	-0.2111	-0.3167
2012-2022	-0.2685	-0.3401	-0.2374	-0.3561

The values found for the betas are in line with the knowledge that gold and stock markets perform opposite to each other. Gold was previously found to have the qualities of a zero beta asset, but as gold jewelry has excess risk and low returns compared to other forms of physical gold, the extra negativity of the beta for jewelry is in line with what is expected.

6-3-2. Applying the CAPM

With the beta for each time period having been found, it can be used in determining the expected value of gold jewelry through CAPM. The formula for CAPM is as follows.

$$ER_a = R_f + \beta_a(ER_m - R_f)$$

Plugging in the values found for the average annual returns of the S&P 500 and NIFTY and the risk free rates ([A3](#)) of the two countries, the equations find the following values.

	USA CAPM		India CAPM	
	75%	95%	90%	135%
2007-2017	1.42%	1.18%	5.81%	5.35%
2009-2019	0.69%	0.30%	6.24%	5.90%
2012-2022	0.65%	0.04%	6.05%	5.47%

The found values for expected return between the two countries are drastically different. While the USA exhibits low levels of expected return, India sees sizable levels of expected returns, surpassing the returns shown from the Indian bond market during the time. Considering the USA does not have a strong gold market, and that the risk free rate in India is quite high, these values are reasonable. The values clearly show that there is a much higher level of expected return from the investment in gold jewelry in India than in the USA. However, for both countries, the found returns are lower than those of the risk free rates, showing that the levels of return for gold are much more risky and express lesser returns than the risk free asset in each country.

There do remain limitations in using the CAPM. One of the most important limitations in respect to this paper is in the calculation of the asset's beta. The betas in this paper were found using the covariance of each category of gold jewelry with the stock market divided by the variance of the stock market. Not only is the stock market not an accurate representation of the entire investments market within a country, it is difficult to calculate the beta of an asset accurately. For speed and simplicity, the previously mentioned formula is used, utilized as a proxy rather than an all-encompassing fair value for the beta of an asset. There is also the concern that the linear relationship between risk and reward, or beta and individual asset returns, breaks down both in the long and the short term, making it a poor choice to accurately assess the risk and reward characteristics of an asset.

In order to better understand the role gold jewelry can play in a portfolio, another widely used tool will be utilized, being the Sharpe ratio.

6-4. Sharpe Ratios

To determine the value and returns gold jewelry would have within a portfolio based on its level of risk, the Sharpe ratio will be applied to a hybrid portfolio containing the most basic stocks and bonds an investor can hold. Gold jewelry will be added to the portfolio to determine if its addition helps grow the returns of a basic hybrid portfolio in both countries over a set time

period. A simple buy-and-hold strategy will be used, wherein the portfolio is bought at the beginning of the set time period and sold at the end.

One of the most popular indices in the United States is the S&P 500, which tracks the stock performance of the 500 largest publicly traded companies in the US. While there is no exact Indian equivalent, the NIFTY 50 represents the weighted average of the largest 50 publicly traded Indian companies. Both countries also have bond indices, with one of the most common in the US being the Bloomberg Aggregate Bond Index, measuring the performance of investment-grade bonds in the United States, and one of the most common in India being the S&P BSE India bond index (SPBINCOT). Additionally, a common technique for designing hybrid portfolios involves designating 60% of the portfolio to stocks and 40% to bonds. Using this distribution, variations will be made to determine if the inclusion of gold jewelry improves the Sharpe ratio of the portfolio and to what extent should gold jewelry be weighted.

Gold jewelry is often bought with the intention of being sold after a long period of time, if ever. For this reason, time periods of 10 years were chosen as they would be able to encompass different fluctuations in the spot price and represent an adequate amount of time passing while providing enough sample periods within the found data sets. Beginning 2007, this gives overlapping time ranges of 2007-2017, 2009-2019, and 2012-2022.

For each of the time periods, the annualized returns and covariances of the stock and bond markets for each location were found and used to construct portfolios using the commonly held 60/40 hybrid method (A2). The following portfolio returns, standard deviations, and Sharpe ratios for each of the years were then found and listed below, along with the Sharpe formula.

$$\text{Sharpe ratio} : (R_p - R_f) / \sigma_p$$

	USA			India		
	Portfolio Return	Standard Deviation	Sharpe Ratio	Portfolio Return	Standard Deviation	Sharpe Ratio
2007-2017	0.0589	0.0813	0.4375	0.0988	0.0846	0.3697
2009-2019	0.0704	0.0812	0.6030	0.0962	0.0850	0.3174
2012-2022	0.0776	0.0824	0.5845	0.1065	0.0847	0.4081

The goal of the inclusion of an extra asset would be to increase the value of the Sharpe ratio. The inclusion and resulting higher ratio with gold jewelry in particular would indicate that the added

asset, gold jewelry, moves unaffected by already included assets and increases the diversification of the portfolio.

In order to determine the effects of gold jewelry in the portfolio, more portfolios will be constructed building off the existing 60/40 portfolios for the US and India. These new portfolios will be divided 59/39/2, 57/38/5, and 55/35/10 between stocks, bonds, and gold jewelry respectively. Additionally, an important factor to consider is the fact that most holders of gold jewelry do not receive the value of the ongoing spot price as their return on investment. Instead, the seller dictates the amount returned to the customer. Previously, these returns were assumed to be 75% and 95% in the USA and 90% and 135% in India based on if a seller chose to melt or resell the jewelry, respectively. Taking this into account, the annualized returns and standard deviations of each percentage, as well as their covariances to the aforementioned stock and bonds markets were found (A2).

The following Sharpe ratios were found for each of the portfolio splits.

59/39/2						
USA						
Gold - 75%			Gold - 95%			
	Portfolio Return	Standard Deviation	Sharpe Ratio	Portfolio Return	Standard Deviation	Sharpe Ratio
2007-2017	0.0539	0.0736	0.4157	0.0573	0.0796	0.4268
2009-2019	0.0648	0.0795	0.5461	0.0690	0.0795	0.5995
2012-2022	0.0715	0.0806	0.5218	0.0756	0.0805	0.5731
India						
Gold - 90%			Gold - 135%			
	Portfolio Return	Standard Deviation	Sharpe Ratio	Portfolio Return	Standard Deviation	Sharpe Ratio
2007-2017	0.0963	0.0825	0.3487	0.1060	0.0821	0.4682
2009-2019	0.0932	0.0829	0.2895	0.1027	0.0826	0.4052
2012-2022	0.1027	0.0825	0.3734	0.1119	0.0822	0.4865

57/38/5						
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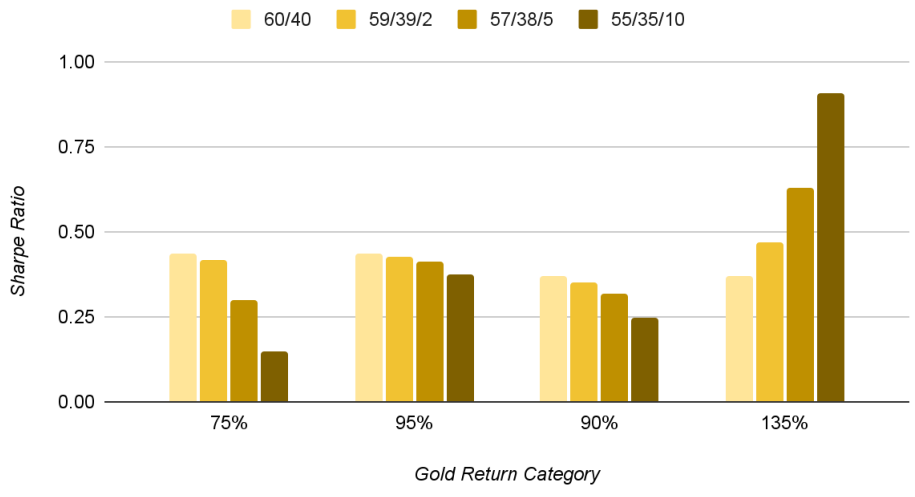
USA						
Gold - 75%			Gold - 95%			
Portfolio Return	Standard Deviation	Sharpe Ratio	Portfolio Return	Standard Deviation	Sharpe Ratio	
2007-2017	0.0464	0.0767	0.3005	0.0548	0.0766	0.4109
2009-2019	0.0563	0.0765	0.4559	0.0668	0.0764	0.5995
2012-2022	0.0619	0.0773	0.4193	0.0721	0.0772	0.5523
India						
Gold - 90%			Gold - 135%			
Portfolio Return	Standard Deviation	Sharpe Ratio	Portfolio Return	Standard Deviation	Sharpe Ratio	
2007-2017	0.0923	0.0787	0.3158	0.1166	0.0780	0.6295
2009-2019	0.0887	0.0792	0.2462	0.1124	0.0786	0.5494
2012-2022	0.0969	0.0787	0.3183	0.1199	0.0780	0.6146

55/35/10						
USA						
Gold - 75%			Gold - 95%			
Portfolio Return	Standard Deviation	Sharpe Ratio	Portfolio Return	Standard Deviation	Sharpe Ratio	
2007-2017	0.0341	0.0736	0.1461	0.0509	0.0737	0.3751
2009-2019	0.0427	0.0734	0.2903	0.0637	0.0733	0.5995
2012-2022	0.0472	0.0740	0.2388	0.0675	0.0738	0.5150
India						
Gold - 90%			Gold - 135%			
Portfolio Return	Standard Deviation	Sharpe Ratio	Portfolio Return	Standard Deviation	Sharpe Ratio	
2007-2017	0.0861	0.0748	0.2491	0.1346	0.0741	0.9066
2009-2019	0.0813	0.0755	0.1609	0.1707	0.0759	1.3362

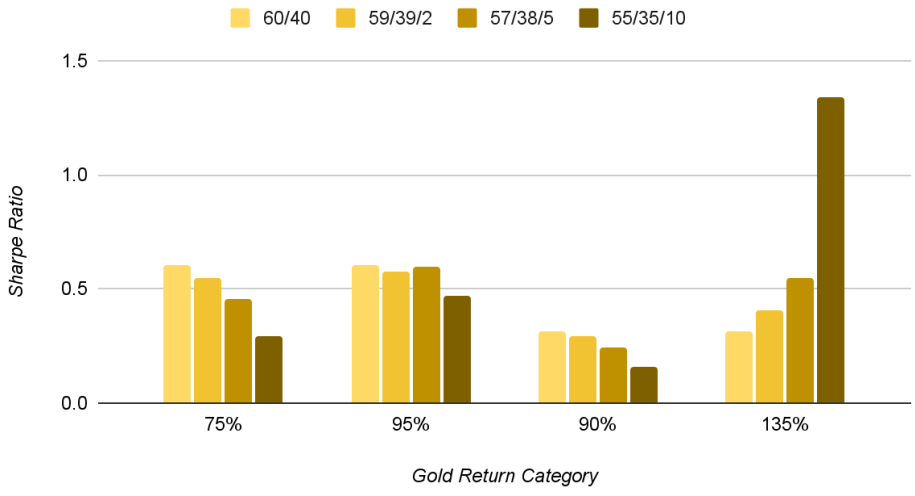
2012-2022

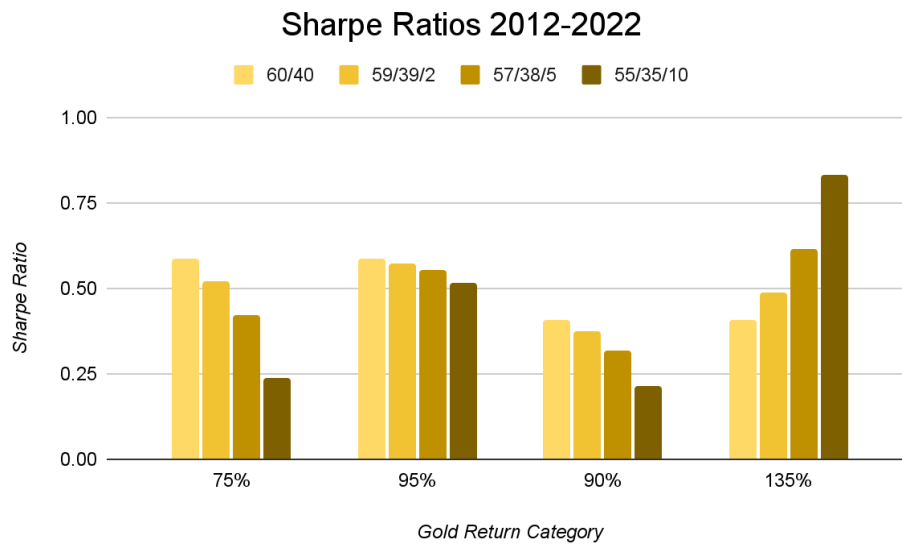
0.0878	0.0749	0.2121	0.1336	0.0743	0.8302
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Sharpe Ratios 2007-2017



Sharpe Ratios 2009-2019





Comparing the Sharpe ratios of the hybrid stock and bond portfolios with the portfolios that include gold jewelry, the majority of gold-including portfolios do not surpass the Sharpe ratio found with the simple hybrid stock and bond portfolios. As the amount of gold within the portfolio increased, the Sharpe ratio decreased. A notable exception are the portfolios that include gold jewelry that would see a return of 135% of the ongoing spot price. Each of the portfolios with this level of return from gold jewelry saw incredible increases in the Sharpe ratio especially as the weights of gold jewelry increased, indicating that the inclusion of such jewelry that appreciates a great amount would prove incredibly beneficial to a portfolio, however, portfolios possessing gold that has returns below 135% of the current spot price would not see such a benefit to their risk and reward characteristics. It should be noted that some of the gold-including portfolios had similar Sharpe ratios to the original portfolios, so a difference in weighting or in the percentage value of the return on gold jewelry could cause the Sharpe ratio to increase beyond the ratio of the hybrid stock and bond portfolio.

6-4-1. Optimal Weight Allocations to Maximize Sharpe Ratio

Since it has been found that the predetermined portfolio weightings would not generate an increase in the Sharpe ratio of a hybrid portfolio, with the exception of portfolios that included gold jewelry that returned 135%, this paper attempted to find the optimal weights of each asset under the given return values. That is, calculations were performed to determine the optimal weight of each asset within the portfolio that would maximize the resulting Sharpe ratio. In order to do so, each of the assets per country were grouped together for each time period. That is, rather than dividing the gold return categories for each country, hypothetical investors would be able to invest in either category within their country during each time period. These calculations resulted in the following allocations.

USA					
	Gold - 75%	Gold - 95%	SPX	BAGG	Sharpe Ratio
2007-2017	0	0	0.2012	0.7988	0.6067
2009-2019	0	0	0.2776	0.7224	0.6934
2012-2022	0	0	1	0	0.6204

India					
	Gold - 90%	Gold - 135%	NIFTY	SPBINCOT	Sharpe Ratio
2007-2017	0	0.2156	0.1635	0.6209	2.6767
2009-2019	0	0.1934	0.1511	0.6556	2.4569
2012-2022	0	0.1749	0.1642	0.6610	2.0767

It is clear that in order to maximize the Sharpe ratio, no allocation must be given to each of the 75%, 90% and 95% gold return investments. However, significant portions of the portfolio was allocated to the 135% gold return investment. This raises the possibility that other return values, lower than 135% but higher than 95%, could result in significant increases to a portfolio's risk and reward characteristics as well. Interestingly, the period from 2012-2022 in the United States shows that in order to maximize the Sharpe ratio of the portfolio, no investment must be given to anything but the S&P 500 stock index. As the stock market and gold returns perform opposite of one another, it does make sense that the resulting allocation here has no gold with the intensity of allocation towards stocks.

The Sharpe ratio also has its limitations. As mentioned before, gold exhibits a positive coskewness with the market and shows decreasing kurtosis in times of market downturns. The returns for gold jewelry found during this period also showed some positive coskewness, shown in the periods from 2009-2019 and 2012-2022. The returns also showed overall low levels of kurtosis, with the lowest levels in the 2007-2017 time period. Seeing as this period is characterized by the 2008 recession, this is in line with the characteristics of gold, where the kurtosis falls during a market downturn. However, the Sharpe ratio does not take into account the skewness or kurtosis of an asset and assumes that returns are normally distributed, decreasing the accuracy and reliability of its use (A1). Additionally, the Sharpe ratio is a good measure of volatility, but cannot distinguish between upside and downside losses. Therefore, it would penalize large and sporadic increases in an asset's returns even if downsides to that asset were

small. However, despite these limitations, the Sharpe ratio continues to provide useful information about the risk and reward characteristics of an asset.

6-5. Treynor Measures

A similar measure that can be used to determine the value gold holds within a portfolio is the Treynor measure. While the Sharpe ratio compares the return of a portfolio against its risk, the Treynor ratio measures how much excess return is generated per unit of risk in a portfolio. The Sharpe ratio therefore uses portfolio standard deviation as a measure of portfolio risk, while the Treynor measure uses the beta of the portfolio as the measure of risk.

Known as the reward-to-volatility ratio, a higher Treynor value indicates that a portfolio has performed better than others based on the level of risk each portfolio possessed. The Treynor value shows the amount of excess return earned over the return that could have been earned by investing in a risk-free asset.

The betas for gold were calculated above for each time period and return category. Since the rest of the portfolio is to be invested in stock and bond markets, the betas for these will continue to be 1. Using the previously found information, the Treynor measures for the different portfolios are shown below along with the Treynor formula.

$$\text{Treynor ratio} : (R_p - R_f) / \beta_p$$

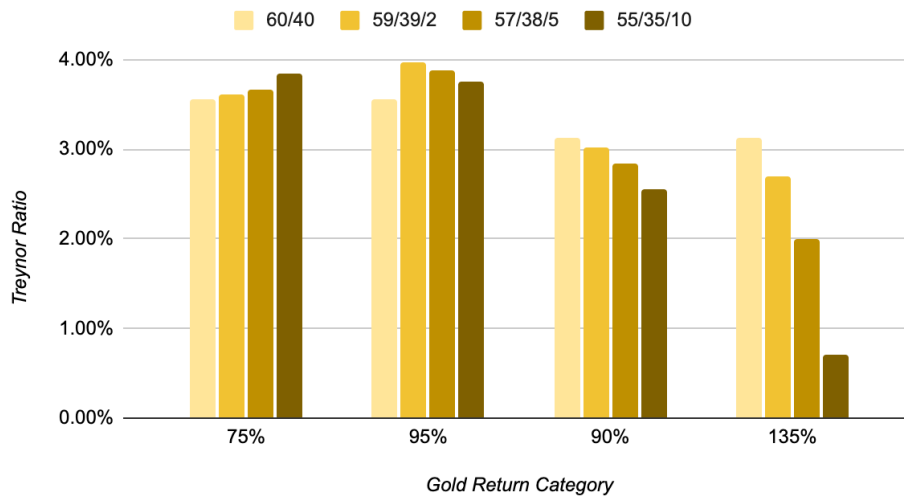
60/40		
	USA	India
2007-2017	3.5580%	3.1280%
2009-2019	4.8960%	2.6980%
2012-2022	4.8140%	3.4560%

59/39/2				
	Gold - 75%	Gold - 95%	Gold - 90%	Gold - 135%
2007-2017	3.6087%	3.9705%	3.0233%	2.6962%
2009-2019	4.9747%	6.7173%	2.5936%	2.3030%
2012-2022	4.9294%	7.7888%	3.3732%	3.0332%

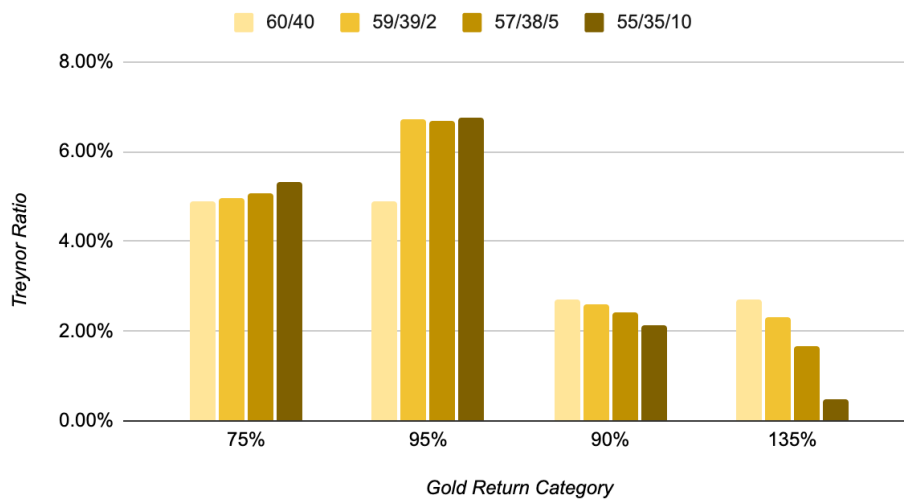
	57/38/5			
	Gold - 75%	Gold - 95%	Gold - 90%	Gold - 135%
2007-2017	3.6769%	3.8793%	2.8431%	1.9889%
2009-2019	5.0740%	6.6887%	2.4201%	1.6618%
2012-2022	5.0645%	7.7626%	3.2226%	2.4212%

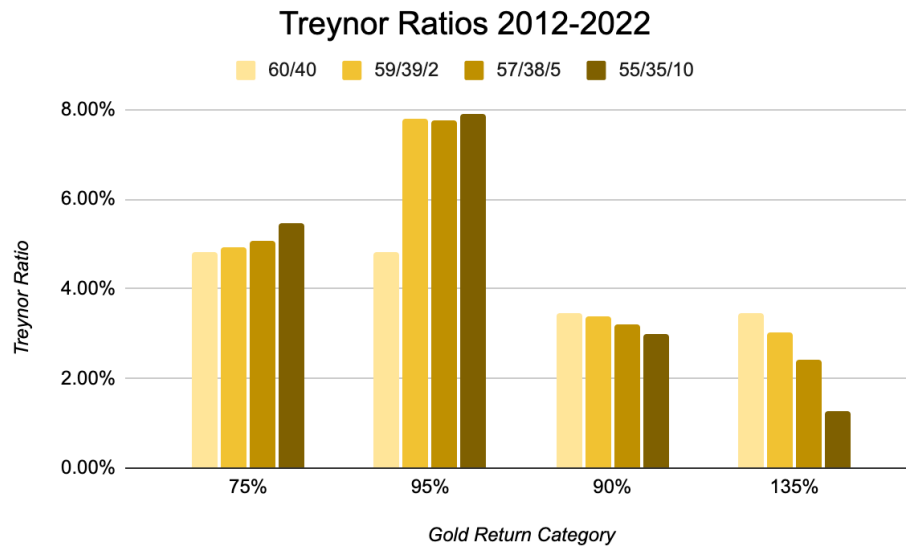
	55/35/10			
	Gold - 75%	Gold - 95%	Gold - 90%	Gold - 135%
2007-2017	3.8391%	3.7582%	2.5459%	0.7012%
2009-2019	5.3329%	6.7397%	2.1185%	0.4833%
2012-2022	5.4583%	7.9100%	2.9951%	1.2635%

Treynor Ratios 2007-2017



Treynor Ratios 2009-2019





In the US, the Treynor measure generally increases with an increase in the amount of gold in the portfolio, with an exception for 95% gold returns in 2009-2019. In India however, an increase in the amount of gold in the portfolio is met with a decrease in the Treynor measure. This conclusion can be traced to the values of the betas found. For the US, the betas became more negative both across time periods and across gold returns categories. This meant that with more time and more gold within the portfolio, the overall portfolio would have a lower beta. This would support the Treynor measure, increasing the value as there is a lower beta, so more excess return can be generated for each unit of overall market risk. However, in the case of India, while the betas do increase across gold return categories, there is more fluctuation between the time periods, making the value of gold within the portfolio less attractive. Additionally, India has a much higher risk free rate compared to the US. Therefore, for each additional unit of a portfolio being dedicated to gold, there is less excess return compared to investing in a risk free asset.

6-5-1. Optimal Weight Allocations to Maximize Treynor Ratio

Similar to the optimal weights found in order to maximize the Sharpe ratio during each period of time, the same technique was used to determine which weights would maximize the Treynor ratio for each period of time. Once again, rather than dividing the gold return categories for each country, potential investors would be able to invest in either category within their country during each time period.

		USA				
		Gold - 75%	Gold - 95%	SPX	BAGG	Treynor Ratio
2007-2017		0	0.7175	0.2825	0	0.1253

2009-2019	0	0	1.0000	0	0.0688
2012-2022	0	0	1.0000	0	0.0855

India					
	Gold - 90%	Gold - 135%	NIFTY	SPBINCOT	Treynor Ratio
2007-2017	0	0.6705	0.3295	0	2.7325
2009-2019	0	0.6835	0.3165	0	2.4981
2012-2022	0	0.6637	0.3363	0	2.1697

The optimal Treynor values found indicate that usually a combination of stocks and gold make for the optimal portfolio. In America, only one of the periods called for the inclusion of gold in the 95% return category, being 2007-2017. However, India called for gold, specifically in the 135% return category, to be included in all the time periods. India also saw incredible Treynor values, being well above 200%. Since the weight of gold was higher than the weight of stocks in each of these portfolios, it can be concluded that for India, weighting a large percentage of the portfolio with gold of returns 135% would result in a large amount of excess return over the risk-free rate. It can also be seen that the measure did not indicate for any amount of the portfolio to be weighted towards the bond market. Since the measure tries to determine the amount over the risk free rate that excess returns would be generated, it leads to the natural conclusion that including the risk-free asset benchmark in the portfolio would not generate excess returns. While the chosen bond markets are not risk-free, they represent large portions of the bond markets that are generally regarded as limited risk. Therefore, the lack of weighting towards these markets stems from the relative risk-free nature of the underlying market.

Notably, some of the conclusions found for the Sharpe ratios and the Treynor ratios are different. In particular, while the Sharpe ratio optimization called for no gold to be included in the 2007-2017 portfolio in America, the Treynor optimization included a large weighting of 95% return gold in the same time period. Additionally, in both countries, the Sharpe ratio called for heavy weightings to the bond market. However, the Treynor ratio included no weighting towards the bond market. The discrepancy between the two ratios comes from what the two are measuring. While the Sharpe ratio looks to maximize returns for a given level of risk measured by standard deviation, the Treynor ratio looks to maximize returns above a risk free asset using beta as a measure of risk. So while the Sharpe ratio sees the low standard deviation of the bond market as a positive attribute, the Treynor ratio looks at the low levels of gold betas to maximize the returns over the risk-free rate.

The Treynor measure has its own limitations. The most relevant limitation is the fact that it uses beta to determine its value. Beta can be difficult to measure, even with assets with plenty of information and data to gain a close estimate of its potential beta. With gold jewelry, the beta is much harder to measure and is dependent on many factors that are not readily available or difficult to make assumptions about. With the Treynor measure being so heavily dependent on the beta and gold and gold jewelry being difficult to determine a beta from, it leads to the measure being difficult to apply properly to gold jewelry.

6-6. Jensen's Alpha

Another popular method of evaluating a portfolio's performance is by using Jensen's alpha. Jensen's alpha, also known as alpha, is a measure of the average return of a portfolio as predicted by the CAPM, given the asset's beta and the average market return. In order to determine the market's average return, each country's hybrid portfolio of 60% stocks and 40% bonds for each time period were used as benchmarks. The formula used is listed below.

$$\alpha_a = R_p - (R_f + \beta_a(R_m - R_f))$$

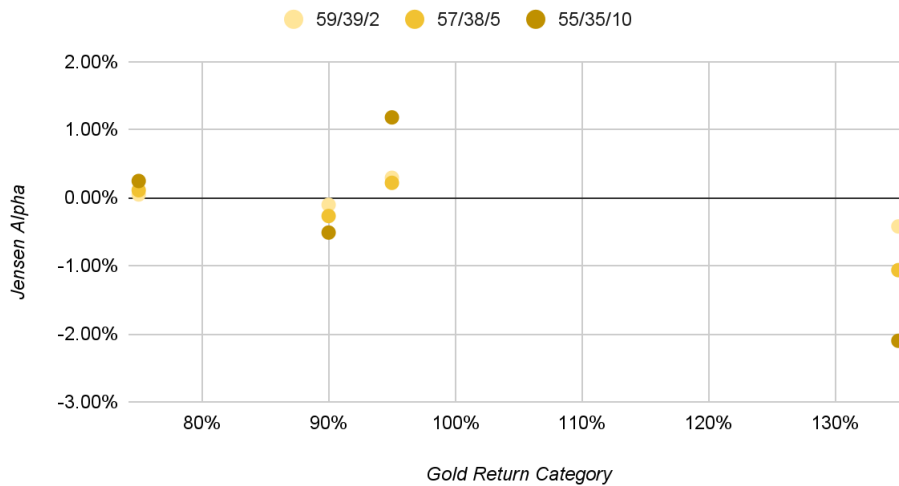
With that in place, the found alphas are listed below.

59/39/2				
USA Alpha		India Alpha		
75%	95%	90%	135%	
2007-2017	0.0475%	0.2927%	-0.1041%	-0.4222%
2009-2019	0.0729%	1.2957%	-0.1038%	-0.3866%
2012-2022	0.0729%	1.2957%	-0.0847%	-0.4153%

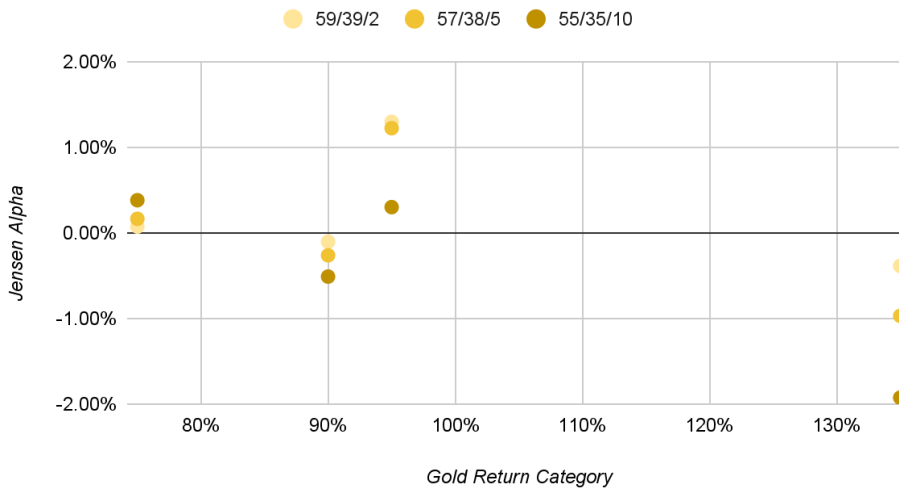
57/38/5				
USA Alpha		India Alpha		
75%	95%	90%	135%	
2007-2017	0.1099%	0.2181%	-0.2693%	-1.0646%
2009-2019	0.1635%	1.2217%	-0.2629%	-0.9698%
2012-2022	0.2383%	2.0165%	-0.2227%	-0.9684%

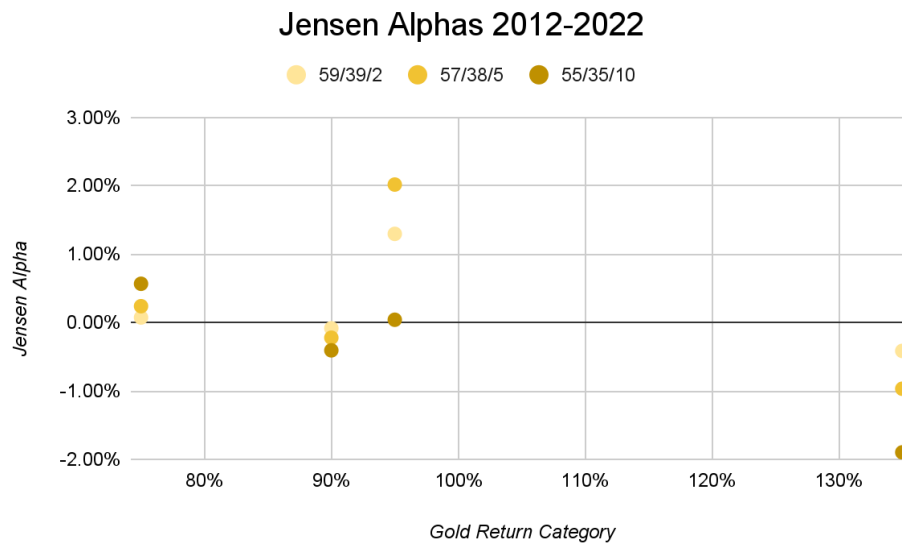
55/35/10				
USA Alpha		India Alpha		
75%	95%	90%	135%	
2007-2017	0.2456%	1.1800%	-0.5124%	-2.1028%
2009-2019	0.3805%	0.3000%	-0.5111%	-1.9249%
2012-2022	0.5660%	0.0400%	-0.4074%	-1.8986%

Jensen Alphas 2007-2017



Jensen Alphas 2009-2019





Across the board, the shown alphas are generally quite small, ranging between absolute values of 0 to 2%. The United States does see a positive alpha across the board, with a significant 2.02% alpha from 2012-2022 when gold of 95% return is weighted at 5%. Other time periods and gold weights see a positive value, indicating that each of the gold weights helps increase the return of the portfolio compared to the hybrid portfolio. However, in India, all of the alphas are shown to be negative, indicating that the portfolios performed worse than a simple 60/40 hybrid portfolio. So while including gold in the portfolio might make for a better risk profile and a healthy return, it would still perform worse than a simple hybrid portfolio in the country.

It is useful to mention that the CAPM and Jensen's alpha resulted in different results. The CAPM found the expected rate of return of the asset compared to the expected stock market returns of each individual country. However, the calculation for Jensen's alpha used the realized returns for gold jewelry within a portfolio consisting of the jewelry, stocks, and bonds, and compared to a hybrid portfolio of stocks and bonds. The difference between the factors included within the calculations make the factors used in the CAPM calculations and the alpha calculations different, and the two should not be compared to each other.

While the Jensen alpha is useful in determining the excess return that a portfolio generates compared to the market portfolio, it has its limitations. For one, it uses the CAPM strategy which only factors in market risk and systematic risk. While this can be useful, it does not factor in unsystematic risk and the different obstacles facing each individual asset class. However, it does provide an incredibly useful tool to determine the use and strength of a portfolio compared to simply investing in the overall market portfolio.

6-7. Assumptions Warnings

The calculations made within this paper were founded based on many different assumptions to give a general idea of the potential returns and other characteristics of gold jewelry investment. In reality, the values surrounding the purchase and subsequent transactions of gold jewelry are near impossible to accurately determine. This is due both to the lack of concrete information and data surrounding gold jewelry transactions, extreme differences within any one location regarding the creation, sale, and resale of the accessory, and other qualitative information unable to be quantitatively found. These confounding variables include rates at individual stores, haggling opportunities and even sentiment, all of which contribute to the return characteristics of gold jewelry. This causes the found characteristics in this paper to be based on values that may not apply to a real life situation. There is also the additional concern of accurately representing and predicting the markets, as ongoing market conditions can change rapidly and drastically, making the returns from transactions of physical property more difficult to estimate. Lastly, while the United States and India were used as proxy countries in the paper to represent the Western and Asian markets, the two are not and cannot be perfect matches to the entire sector for which they represent. Each of the sectors are made of a variety of countries, each with their own market conditions, economic developments, sentiments, etc. The calculations and found values were heavily dependent on the performance of each country's stock and bond markets, including the country's ongoing risk-free rates, which can differ drastically between countries. The proxies were primarily used for the sake of simplicity, rather than to accurately represent their respective geographic sectors. Additionally, the gold jewelry assumptions made were based on an entirely gold piece of accessory. In reality, many gold pieces are intertwined with gemstones, each with their own price trends and returns that can greatly affect the investment value of a piece. While gold was kept free of gemstones for this paper in the name of simplicity, gemstones can potentially support or inhibit the return potential of a gold accessory.

7. Safe Haven Asset - Gold Jewelry Demand Trends

While the safe haven property of gold has been thoroughly explored by prior research, more recent data will be used to determine the potential of gold and gold jewelry as a safe haven asset. This analysis will focus on the Great Recession of 2008 with a timeline of 2007-2009, oil price volatility of 2014 with a timeline of 2012-2016, and the COVID-19 pandemic of 2020 with a timeline of 2019-2022. The information and timeline was found through various press releases from the World Gold Council.

7-1. The Great Recession

In 2008, the United States underwent the Great Recession following a series of vulnerabilities within the financial system, including the subprime mortgage crisis. The situation caused a great amount of people who became unemployed or experienced severe economic hardship. Based on the aforementioned qualities of gold, gold demand should have increased during this time, and it has been proven that it indeed did. The subprime mortgage crisis, the defining attribute of the

Great Depression, began late 2007 and lasted through June 2009, with 2008 in particular being the worst-hit year. In May 2007, worldwide gold demand had increased 4% and gold jewelry demand had increased 17% compared to the relatively weak 2006 Q1 levels (World Gold Council, 2007). Strong economic growth was pushing for continued increases in gold demand, but not to unrealistic expectations. However, as the subprime crisis started to come to light in November 2007, safe haven investors spurred record inflows into gold, with demand increasing 30% from the previous year (World Gold Council, 2007). This demand was fuelled primarily by investors rather than jewelry investors, with gold ETFs being demanded the most. Jewelry actually fared worse, with US jewelry demand falling 13% due to the fear of a potential economic downturn coupled with high gold prices. However, high- and mid-market demand for gold jewelry remained steadily rising. Other countries saw continuously growing jewelry demand, including Russia (World Gold Council, 2008). By January 2008, the subprime mortgage crisis had made itself known to all investors and individuals. Continued dollar weakness, inflationary fears, and unstable financial conditions all contributed to the gold price reaching a new dollar record at the time, reaching \$865.85 per ounce (World Gold Council, 2008). As gold jewelry derives its prices from the gold price, it can be concluded that gold jewelry prices also increased. Jewelry demand was a significant factor in the rise of the gold price, with strong Asian gold jewelry demand in particular contributing to the rise. However, by this time, it was predicted that jewelry demand would unlikely be strong during the remainder of Q1 2008. In March 2008, gold broke the \$1000 per ounce level, with investors taking a 'flight to quality' in a number of the world's key gold markets (World Gold Council, 2008). Throughout this, gold jewelry demand behaved differently in different markets. In India, a 47% decline in demanded jewelry tonnes was reported, and in the US, a 30% decrease. However, China and Egypt saw 2% and 8% increases in jewelry demand respectively. The increases in jewelry demand in China and Egypt are representative of the positive attitude and buying intentions of consumers, showing that even during economic hardships and high gold prices, gold demand remains robust and gold jewelry demand can also rise (World Gold Council, 2008). However, overall, gold jewelry demand saw a 24% decline from 2008-2009, picking up again only in Q4 of 2009 due to an increase in investors seeking diversification and wealth preservation (World Gold Council, 2009). Overall, during the subprime mortgage crisis, investment in gold was incredibly strong, reinforcing the idea of gold as a safe haven asset. However, gold jewelry demand was more nuanced. Many countries saw massive declines in gold jewelry purchases as individuals were unable to purchase luxury items with lessened financial capabilities. Some countries did see increases in gold jewelry purchases, but on the whole, major gold markets saw hits in jewelry demand during this period. Despite this decrease in demand, a survey conducted in 2008 also showed that gold jewelry maintained its global position as the most popular item chosen by a woman spending her discretionary income on herself. Even during the crisis, surveyed women largely chose gold jewelry as a long lasting and valuable purchase. So while demand for gold jewelry during the crisis lessened, the idea of gold jewelry being used as a safe haven asset solidified. This is supported by a progressively rapid recovery in the levels of worldwide gold

jewelry demand in 2010 (World Gold Council, 2009). The small growth in demand for gold jewelry during this time and the increased demand for it once individuals were in a more economically sound position provides the idea that gold jewelry can also function as a safe haven asset.

7-2. Oil Crisis

2012 was a period of strong economic growth, with central banks around the world driving gold demand. Q4 2012 saw records both for the gold price and gold demand volume, being \$1,721.8 per ounce and \$236.4 billion respectively (World Gold Council, 2012). Demand for gold jewelry was strong, and had been so for approximately 2 years at this point. This trend continued into 2013, with consumer demand for jewelry increasingly growing throughout the quarters (World Gold Council, 2013). Those surveyed in Asia at this time reportedly felt confident that the price of gold would increase in the next 5 years, leading to increased premiums paid for jewelry. 2013 in particular was a strong year for gold and gold jewelry, with key gold markets buying more into the metal and Chinese and Indian individuals increasing their holdings of jewelry (World Gold Council, 2013). While India continued seeing high jewelry demand in 2014, China saw an ease off of the metal, digesting the high demand from the previous year (World Gold Council, 2014). However, as the year continued on, economic conditions became unfavorable for gold. This period was characterized by the plunge in oil prices from mid-2014 to 2016. The price of oil declined 70% during this time (World Gold Council, 2014). Additionally, the US dollar gained incredibly during this time, becoming the dollar's fastest rise in the past 40 years (World Gold Council, 2014). The dollar's strength was due to the strong American economy in comparison to other countries, many of whom were implementing stimulus policies to revive their economies. Gold and oil are both commodities and generally tend to trend together. When oil prices plunged, gold prices also started to fall slightly. Combined with the presence of a strong dollar, another factor decreasing the price of gold, gold demand fell in 2014. This translated to gold jewelry as well, with jewelry not seeing significant increases in demand in the later half of 2014 (World Gold Council, 2015). However, in 2015, gold and gold jewelry both saw demand become steady again, seeing a healthy progression of demand back to normal levels, all while the oil industry was still struggling. Gold jewelry demand was varying, with a 10% drop in China, likely fueled by the continuation of the digestion of 2012 highs, and a 22% increase in India (World Gold Council, 2015). Neither of these changes seem representative of the ongoing macroeconomic factors, and rather show a progression of the countries returning to their normal gold jewelry buying patterns. In this situation, gold does not seem to have acted as a safe haven asset, but was not disregarded either. While declining oil prices and a strong dollar would make for a situation where the price and demand of gold should have fallen dramatically, it did not, indicating that investors still had faith in the metal to continue investing in it. Indeed, some gold investment vehicles such as ETFs and central bank holdings saw some growth during this period, with investments in gold increasing 4% in Q1 2015 (World Gold Council, 2015). Still, the growth itself was not significant enough to characterize the investment as a definite safe haven.

However, the overall faith investors continue to have in the asset indicates that investors harbor positive sentiment towards the asset, and can characterize it as a safe haven in their rationales when buying into the metal. The demand for gold jewelry rose in some countries, showing a progression back to normal buying patterns despite the ongoing macroeconomic conditions, giving it some characteristics of a safe haven asset, being that investors continued to buy into it despite ongoing financial conditions. Overall, gold itself remained a popular investment choice for many investors during this time despite some lows, continuing to give the metal a safe haven characteristic.

7-3. Coronavirus Pandemic

The period from 2019 to 2022 was defined by the coronavirus pandemic. Occurring primarily during 2020, the coronavirus pandemic resulted in many individuals experiencing layoffs and having a reduced income. The period also faced high inflation which was met with high interest rates. Prior to the onset of the disease in 2019, gold demand remained healthily stable and growing (World Gold Council, 2019). Q1 2019 saw a growth in global gold demand, growing 7% in a year to 1,503.3 trillion, with demand for gold jewelry also increasing (World Gold Council, 2019). This trend continued in Q2 of 2019 as well, with jewelry in particular seeing a 12% increase from its previous year's level. Q4 2019 did see a drop off in jewelry demand, but this was largely due to the elevated price, as investors waited for the price to level out. But with the onset of the COVID-19 pandemic in 2020, investors rushed to gold as a safe haven investment, increasing the volume of demand and price of gold (World Gold Council, 2020). Investment vehicles were heavily bought, with ETF inflows leading to a global record of the holdings at 3,185 trillion. However, consumer-focused gold sectors such as jewelry faced a sharp weakening, with demand for the products hitting a record low of 325.8 trillion. This was led by the series of lockdown measures administered by countries, causing the purchase and sale of the jewelry near impossible. This trend continued through the first half of 2022, with all forms of physical gold sales dropping, including jewelry, coins and bars, and technological and industrial gold. The growth in investment gold caused the price of gold to reach historic highs in many currencies, proving to be too much for many jewelry buyers. By the year end, jewelry demand had declined to a new annual year-over-year low, although Q4 2020 did see improvements compared to record lows from Q2 2020 (World Gold Council, 2021). A study conducted during the aftermath of the pandemic saw that for every 1% increase in inflation, Indian gold demand increased by 2.6% (World Gold Council, 2021). While this study focused on gold demand in the form of investments, the study did find that in general, jewelry demand is more influenced by long-term drivers while demand in bars and coins tend to respond more sharply to short-term factors, including taxes and inflation. This supports the idea that investors would not turn to jewelry during this time, and would rather resort to gold investment vehicles. By Q3 of 2021, gold jewelry had begun to increase again, especially compared to pandemic times, improving 33% year-on-year (World Gold Council, 2022). This improved significantly again by Q1 2022, with annual consumer demand for jewelry rebounding to match 2019's pre-pandemic levels of

2,124 trillion (World Gold Council, 2022). Jewelry reached its highest level in nearly a decade in key gold markets, including China and India, benefitting from the countries' regaining economic strength (World Gold Council, 2023). The demand for gold and gold jewelry continued to rebound throughout the year, remaining resilient and poised for greater demand in the upcoming quarters.

7-4. Gold Jewelry as a Safe Haven Asset

Looking at the performance of gold demand throughout the various financial crises and significant situations over the past 20 years, it is clear that gold continues to keep its characteristic as a safe haven asset. Investors flock to the metal in times of economic downturns, putting their faith in the fact that it is likely to rise in value during the downturn, as well as keep its value for the future. However, gold jewelry performs differently, with economic downturns often resulting in individuals having less income to spend on luxuries. Therefore, spending on gold jewelry is likely to decrease during these times as individuals simply are unable to spend large amounts on gold jewelry. This marks a large difference in the purpose of gold jewelry versus gold as an investment. While investment gold becomes a prime purchase during economic downturns, gold jewelry is meant to be worn as luxury adornment alongside being an investment. During an economic downturn, buying jewelry can wait, as one can purchase it for adornment following the downturn, emphasizing its wearability rather than its investment purpose. With this said however, gold jewelry does remain on the minds of many investors during economic downturns. Once an economic downturn has begun to cool down and many regain some discretionary income, gold jewelry demand begins to rise again, as has been seen in each of the noted economic situations. Sentiment surrounding the usage and value of gold jewelry as well as the faith many have that the metal will once again rise in value cause many to continue purchasing the jewelry even at the beginning of the aftermath of an economic downturn. In general, while gold jewelry is not a direct safe haven asset, as investors do not flock to it in times of immediate economic downturn, it does harbor some characteristics of being one. Investors do flock to it when economic conditions are unstable or unfavorable, even if they do so after the immediate crisis is over, giving gold jewelry some features of a safe haven asset.

hybrid portfolio in the country. Overall, the three measures came to varying conclusions, a combination of which could be used to justify the inclusion or exclusion of gold from a portfolio in either country.

8. Risks of Investing in Gold and Gold Jewelry

There are some factors that prove as risks to the gold and gold jewelry industry and therefore serve as risks to purchasing the asset. From an individual investor's perspective there is the overwhelming risk that the price of gold falls in the time the investment is held. This is a risk underlying the purchase of any asset, but the risk of holding the asset is largely ironed out the longer the investment is held, as is seen from the appreciations shown above. There is also the factor of market sentiment to contend with. Investment in gold tends to increase during times of

market downturns, with fear-based decision making driving the investment trends. When markets are shaky, investors turn to safe haven assets to keep their investments more stable, but this urgency and fear causes them to overlook due diligence, which may hurt their investments in the future. Gold jewelry and other physical ornaments also suffer from storage and safety risks. The metal must be kept in secure safes or lockers in order to decrease the risk of theft, which can add additional costs to the investor. The risk is also never eliminated, adding a level of worry and concern for the investor.

Within the industry, there is the aforementioned risk of increasing mining efficiency. Increases in mining efficiency would increase the supply of gold, driving the prices of gold down. However, while these increases are possible, there is also the possibility of development having reached its peak, at which point mining technology is unable to become any more efficient. There is also the simple fact that gold is a scarce resource, so despite increases in mining technology, there is only so much gold that can ever be mined. Additionally, a strong US dollar would lead to devaluation in the price of gold. Gold is a hedge against the USD, so an increase in the strength of the USD would lead to decreases in the price of gold. The future of the USD is greatly debated, with some analysts predicting greater strength in the short term, while others see weakening. However, in the long term, all analysts generally agree that the USD is likely to decrease in value over the long term, perhaps in the upcoming 20 years (Laakso, 2019). A weakening in the USD would lead to a jump in the price of gold. The future of the USD is yet to be determined, but if the analyst prediction of great weakening manifests itself, gold could see major increases in price.

There are many different risks facing individual gold investors and the gold industry as a whole, both in the short term and long. However, these risks are either ones small and common enough to continue justifying the price of gold, or ones that are unlikely to significantly decrease the price of gold. Gold has retained its value as a precious and scarce commodity throughout time, and is unlikely to lose those characteristics in the future.

9. Conclusion

Gold has been an integral part of history, spanning millennia of fascination over the shiny yellow metal. Its various forms have been used as jewelry, accessories, and coating, among a variety of other uses. Modern times have seen paper gold rise as an investment vehicle, with investors hoping to track the price of gold and reap the benefits without investing into the physical form of it. But using gold jewelry as a potential investment has spanned time much longer than investments into paper gold. Women in particular have benefited from the use of gold jewelry as a store of value, using it when they themselves were unable to have financial independence in any other manner. Today, the same theory behind the store of value of gold and gold jewelry continues, expanding it into an investment realm as well, with the price of jewelry often increasing greatly over time. This gives many the ability to trade in their jewelry and gain a

much higher price return than what they had originally paid for it. In times of economic distress, when the price of gold increases, this can be particularly useful.

This paper aimed to explore the use of gold jewelry within a traditional investment portfolio. While commodities like gold are often included in a traditional portfolio, with the risk and return characteristics of such an inclusion being well researched and explained, the characteristics of gold jewelry had yet to be researched in such a manner.

By simply viewing the price of gold, it is clear that the metal rises in value over time. This creates a strong incentive for investors to buy into the asset to take advantage of the rising returns. Gold jewelry becomes an attractive form of investment as it serves not just as a potential source of returns but can be used as adornment. However, it is important to know that gold jewelry does not have the same levels of returns as gold itself due to the various factors that go into making the jewelry as well as selling it. Jewelry comes with labor and design costs, and selling it requires knowledge of the environment's attitude towards gold as well as the end use of the sold jewelry. This makes the returns from gold jewelry diverge from the returns found from gold bars and coins or from investments in paper gold.

The difference of attitudes between Western and Eastern countries towards gold makes for great differences between the returns from gold jewelry. In Western countries, where the emphasis on gold is not strong, returns on gold jewelry are equally not strong, with pawn shops not taking into account the artisan markups on an original piece of jewelry and thereby disregarding a large portion of the original cost of gold. This results in a much tighter potential return amount. Conversely, in Eastern countries where the emphasis on gold is strong, many pawn shops will take into consideration the artisan markup on a piece of jewelry, factoring it into the return potential of the asset. It is entirely possible to make more than the current spot price of gold in an Eastern country due to this emphasis on the artisan value of jewelry.

A simple historical appreciation of the value of gold jewelry showed that regardless of country, selling the gold jewelry with the purpose of reselling would result in some return on the asset. Gold jewelry with a final purpose of melting, while it did not result in all positive returns, did consistently show some positive return, especially in the first two time periods. Therefore, just as a sole investment, buying gold jewelry is likely to gain an investor some return. The CAPM takes this further, showing that gold jewelry does have some positive return. However, this return is quite risky and is lower than that of simply investing in the risk free asset of the country.

Looking solely at the optimal weightings of different assets in each of the portfolio measurements calculated, different conclusions can be drawn. When utilizing the Sharpe ratio, the optimal weight calculations indicated that no gold return category except for 135% was to be kept in the portfolio. The calculation resulted in none of the other gold return categories

exhibiting optimal return characteristics for the level of risk they each possessed. As the level of weight increased for the gold jewelry, only the 135% gold had increases in the Sharpe ratio while the others showed lower Sharpe ratios as the weight of gold in the portfolio increased. Shifting to the Treynor measure, slightly different conclusions were made. Since the Treynor measure shows how much excess return per unit of risk is generated, it uses portfolio beta instead of portfolio standard deviation. Looking at the optimal weights of gold jewelry using the Treynor measure, once again, the 135% gold return category showed the most significant weightings. However, the 95% gold return category also showed some weighting in the 2007-2017 time period, and was a significant amount as well. While the Sharpe ratio showed no indication that any other gold return category should be included, the 95% gold category having some weightage for the Treynor measure shows that gold can produce some excess return for each individual unit of risk possessed. For both the Sharpe and Treynor measures, India showed much higher potential ending values, attributed to the higher emphasis on gold in the country. However, the Jensen alpha resulted in a much different conclusion than the Sharpe and Treynor measures. All of the US values were positive, showing that the inclusion of gold in the portfolio would increase the return of the portfolio compared to the hybrid value. However, the alpha values in India were all negative indicating that the portfolios performed worse than a simple hybrid portfolio in the country. Overall, the three measures came to varying conclusions, a combination of which could be used to justify the inclusion or exclusion of gold from a portfolio in either country.

A qualitative analysis of the role of gold jewelry as a safe haven asset was also undertaken. It has been proven before that gold acts as a safe haven asset, and the question arose of whether simple gold's characteristics would apply to gold jewelry as well. Using information from the World Gold Council to create a timeline of gold jewelry demand, significant time periods were chosen to determine if gold jewelry spending increased or decreased during those times. The analysis used the 2008 recession, 2014 oil price volatility and the 2020 coronavirus pandemic as significant economic events that could indicate whether or not gold jewelry acted as a safe haven asset. The analysis found that the usage of gold jewelry as a safe haven is not strong in an immediate sense, but does harbor safe haven characteristics following a period of some economic revival. It is likely that while investors flock to investment gold during economic downturns, consumers find physical gold characteristics interesting during this time. They are then likely to follow through on this interest following some economic revival when they possess more money with which to buy the jewelry. The underlying idea would be that the jewelry would function as a safe store of value during a potential future economic downturn, and consumers would guard against that potential future by buying gold jewelry now.

After using quantitative and qualitative data to understand the return from gold jewelry, it can be seen that jewelry does have some diversifying and safe haven characteristics. While the latter is much stronger than the former, including the proper weightage of an appropriate gold return category into a portfolio can have positive diversifying properties to the portfolio as well.

This paper came to an ambiguous conclusion, being that gold jewelry has both positive and negative attributes related to its inclusion in a traditional portfolio. While its prices do often increase over time, giving it great price return value, it is subject to markups and fees, causing the jewelry to underperform the market. Optimal calculations found that there was little benefit for most people who decided to hold gold jewelry as an investment asset. While there were large differences found between the West and East through the proxy countries USA and India, with India seeing particularly better usage of investment gold jewelry, both countries often showed that gold jewelry did not have great investment benefits.

While this paper does conclude that gold jewelry within an investment portfolio is unlikely to bring great value in terms of its risk and reward characteristics, it is important to remember that the usage of gold jewelry as an investment strategy differs greatly from the usage of other assets as an investment, including other commodities and alternative assets. For one, even as jewelry is bought with the intention of investment, it still serves other purposes such as adornment and a symbol of status. Therefore, the return on investment is not as important of a characteristic as is the beauty, making, and quality of the piece. Consumers are less concerned about the specific investment risks associated with the jewelry as they are with the other purposes the jewelry serves. The main investment aspect to jewelry then solely becomes the price return one can gain after some years or during an economic downturn. Additionally, the investment and holding strategies of gold jewelry differ greatly from the holding strategies of other investments. While other strategies involve constant transactions and can easily be measured in short time spans, gold jewelry cannot. That is, the returns of equities and bonds can be measured on a daily or on an even more frequent basis as their transactions happen often. Techniques in high-frequency trading means that these transactions can happen in seconds, with investors entering and exiting multiple positions quickly. However, gold jewelry is often held for long periods of time, and may never be sold, especially in the case of ancestral heirlooms. It is much more difficult then to measure the return characteristics of the jewelry, as its transactional history cannot be normalized to emulate a traditional asset's transactional history without losing many of the features and objectives of investing in gold jewelry. Therefore, while this paper does attempt to give more quantitative data surrounding the use of gold jewelry in a traditional portfolio, the reality remains that gold jewelry's investment strategies diverge too greatly from the investment strategies of traditional assets to properly include gold jewelry in a traditional investment portfolio.

There is no doubt that gold will continue to hold a strong presence in the lives of many around the world. Its beauty along with its scarcity makes for great interest surrounding the metal. Investment in jewelry is also likely to continue as it has, with the return on its price being a strong motivator to buy into the asset. Beyond investment however, gold jewelry continues to serve purposes such as adornment and status symbols, making it difficult to perceive a world in which the metal ever falls out of favor in the eyes of consumers.

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11. Appendix

A1. Variances of SPX and NIFTY

	Variances	
	SPX	NIFTY
2007-2017	0.0181	0.0226
2009-2019	0.0180	0.0228
2012-2022	0.0190	0.0226

A2. Annual Returns, Standard Deviations, and Covariance Matrices

	S&P 500		NIFTY 50		Bloomberg Agg		SPBINCOT	
	Return	St. Dev	Return	St. Dev	Return	St. Dev	Return	St. Dev
2007-2017	6.8359%	0.1345	10.8475%	0.1505	4.4593%	0.0451	8.4238%	0.0329
2009-2019	9.0208%	0.1341	10.1256%	0.1510	4.0592%	0.0443	8.8478%	0.0336
2012-2022	11.5000%	0.1378	12.0114%	0.1503	2.1552%	0.0458	8.6002%	0.0331

	Gold - 75%		Gold - 95%		Gold - 90%		Gold - 135%	
	Return	St. Dev	Return	St. Dev	Return	St. Dev	Return	St. Dev
2007-2017	-19.1732%	0.0991	2.3806%	0.1255	-3.0078%	0.1189	45.4883%	0.1784
2009-2019	-21.1214%	0.1009	-0.0870%	0.1279	-5.3456%	0.1211	41.9816%	0.1817
2012-2022	-23.6471%	0.1086	-3.2863%	0.1376	-8.3765%	0.1304	37.4352%	0.1956

Annual Co-Var Matrix 2007-2017

	G75	G95	G90	G135	SPX	BAGG	NIFTY	SPBINCOT
G75	0.0098	0.0124	0.0118	0.0177	-0.0036	0.0026	-0.0043	-0.0001
G95	0.0124	0.0158	0.0149	0.0224	-0.0046	0.0033	-0.0055	-0.0002
G90	0.0118	0.0149	0.0141	0.0212	-0.0044	0.0031	-0.0052	-0.0002
G135	0.0177	0.0224	0.0212	0.0318	-0.0065	0.0047	-0.0078	-0.0002
SPX	-0.0036	-0.0046	-0.0044	-0.0065	0.0181	-0.0006	0.0140	-0.0013

BAGG	0.0026	0.0033	0.0031	0.0047	-0.0006	0.0020	-0.0012	0.0007
NIFTY	-0.0043	-0.0055	-0.0052	-0.0078	0.0140	-0.0012	0.0226	-0.0023
SPBINCOT	-0.0001	-0.0002	-0.0002	-0.0002	-0.0013	0.0007	-0.0023	0.0011

Annual Co-Var Matrix 2009-2019

	G75	G95	G90	G135	SPX	BAGG	NIFTY	SPBINCOT
G75	0.0102	0.0129	0.0122	0.0183	-0.0038	0.0025	-0.0040	-0.0003
G95	0.0129	0.0163	0.0155	0.0232	-0.0048	0.0031	-0.0051	-0.0004
G90	0.0122	0.0155	0.0147	0.0220	-0.0045	0.0030	-0.0048	-0.0003
G135	0.0183	0.0232	0.0220	0.0330	-0.0068	0.0045	-0.0072	-0.0005
SPX	-0.0038	-0.0048	-0.0045	-0.0068	0.0180	-0.0004	0.0137	-0.0012
BAGG	0.0025	0.0031	0.0030	0.0045	-0.0004	0.0020	-0.0012	0.0007
NIFTY	-0.0040	-0.0051	-0.0048	-0.0072	0.0137	-0.0012	0.0228	-0.0024
SPBINCOT	-0.0003	-0.0004	-0.0003	-0.0005	-0.0012	0.0007	-0.0024	0.0011

Annual Co-Var Matrix 2012-2022

	G75	G95	G90	G135	SPX	BAGG	NIFTY	SPBINCOT
G75	0.0118	0.0150	0.0142	0.0212	-0.0051	0.0032	-0.0045	-0.0004
G95	0.0150	0.0189	0.0179	0.0269	-0.0065	0.0040	-0.0057	-0.0005
G90	0.0142	0.0179	0.0170	0.0255	-0.0061	0.0038	-0.0054	-0.0005
G135	0.0212	0.0269	0.0255	0.0382	-0.0092	0.0057	-0.0080	-0.0007
SPX	-0.0051	-0.0065	-0.0061	-0.0092	0.0190	-0.0009	0.0140	-0.0010
BAGG	0.0032	0.0040	0.0038	0.0057	-0.0009	0.0021	-0.0011	0.0006
NIFTY	-0.0045	-0.0057	-0.0054	-0.0080	0.0140	-0.0011	0.0226	-0.0023
SPBINCOT	-0.0004	-0.0005	-0.0005	-0.0007	-0.0010	0.0006	-0.0023	0.0011

*Standard deviations and covariances are not written as percentages for the sake of simplicity

A3. Risk Free Rates : Ending Rate

Risk Free Rates		
	USA	India
2017	2.33%	6.75%
2019	2.14%	6.92%
2022	2.95%	7.19%

A4. Skewness and Kurtosis

	Skewness	Kurtosis
2007-2017	-0.0831	-1.2954
2009-2019	0.14361	0.5355
2012-2022	0.5925	1.2364