

Does financial and macro policy explain household investment in gold?

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Abstract

Gold dominates household portfolios in India. This has been labelled as irrational behaviour by financially illiterate households. In this paper, we show that household preference towards gold is not irrational in the context of the Indian financial and macroeconomic environment which includes high inflation, financial repression, and capital controls. We use data from June 1999-March 2021 and find that (1) a depreciating currency has helped gold returns; (2) gold has consistently beaten inflation and provided real returns, (3) been a hedge and a weak safe-haven against the domestic equity market; (4) has outperformed fixed-deposits which have low interest rates; and (5) has allowed international diversification. If policy has to channel household savings to more productive uses, it has to confront the underlying issues in the macroeconomic environment which make gold a preferred investment choice.

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1 Introduction

India is one of the largest consumers of gold with 25% share in global aggregate demand. Gold plays a significant role in the portfolio of Indian households. Badarinza et al. (2017) find that on an average, gold constitutes 24% of household portfolios in India, the largest share after real estate. Among low-income household portfolios, the share of gold is higher (Ponnathpur & Dasgupta, 2020). More than two decades of reforms in capital and insurance markets have not been able to shake the Indian penchant for gold. This has led to concerns ranging from high import bills, to unproductive use of household savings (NITI Aayog, 2018; RBI, 2013). Governments have come up with several schemes such as the Gold Monetisation Scheme (GMS), 2015, the Sovereign Gold Bond (SGB) and Indian Gold Coin Scheme (IGCS) to divert household savings in gold to more productive uses.¹

Research has explained the choice of gold in various ways. From a finance perspective, gold is an important source of credit. Gold loans are used for consumption smoothing, often from the unorganised sector – because of ease of transactions and high loan-to-value ratios (LTV) (Sharma et al., 2017). Gold loans have been the instrument of choice to deal with periods of economic distress, such as the COVID 19 pandemic.² Gold is important for socio-cultural (as a matter of identity, or for dowry payments for example), and political (loans embed hierarchical relations) reasons (Bhalotra et al., 2020; Goedecke et al., 2018). Gold is often the instrument that is owned and operated by the women of the household, thus becoming the only asset that they have agency over, offering status and dignity within the family and society.

Most of the literature on household’s preference for gold in India has not paid adequate attention to the performance of gold as an asset class. International research suggests that gold has delivered near zero real returns (in USD) over a 100 year period (Siegel, 2014). It also points out that gold plays the role of a hedge or a “safe haven” for major European stock markets and the US but not for Australia, Canada, Japan and large emerging markets such as the BRIC countries (A.Batten et al., 2014; Baur & Lucey, 2010; Baur & McDermott, 2010; M.Lucey et al., 2017). Several papers have contributed to this question by more advanced methods of analysis, or by looking more deeply at specific countries.³

¹<https://dea.gov.in/gms2015>

²Nair, 2021 points out that outstanding loans against gold jewellery given by banks rose 82 per cent between March 2020 and 2021.

³For example, Hood and Malik (2013) find similar results for the US, even though they find that gold may not be the “best” hedge, while Gürgün and Ünalmiş (2014) find that a large number of economies in the the MSCI emerging markets index as well as nine other developing markets do exhibit hedge

This question is equally interesting in an emerging market setting, with its unique macroeconomic and financial policy environment. For example, India has had a problem of high and volatile inflation, a policy of financial repression, and capital controls that make it difficult to achieve international diversification. The price of gold is determined internationally and is not as deeply connected to the Indian economy. The INR-USD exchange rate plays an important role in determining the returns that domestic investors see on their gold holdings. Interventions on the exchange rate can have implications for returns that domestic investors see on gold.

In this context, there are important roles (other than collateral for credit) that gold can play: a) it can provide a “real” rate of return, b) it can be a hedge and a safe haven when markets are performing poorly⁴, and c) it can help with international diversification. If an asset possesses such properties then it becomes important for portfolio diversification, especially in times of stress (Chua et al., 1990). Studying how gold behaves as an asset class from a market perspective is important, as it ultimately shapes the economic value that households may derive out of gold. Kumar (2014) studies the 2004-2012 period in India and finds that stock-gold portfolios provide better diversification benefits than stock portfolios. If gold beats inflation or is indeed a hedge or a safe haven, then this might explain some of the preference of Indian households for gold.

In this paper, we evaluate the performance of gold as an asset class. We evaluate how gold performs vis-a-vis inflation, and vis-a-vis the Indian equity market. We find that over the last twenty two years, gold has beaten inflation in India, and has also been a hedge and a weak safe-haven in Indian markets.⁵ Our results would suggest a much larger weight in a household portfolio in India relative to what may be seen internationally. We conduct a simple Markowitz portfolio optimising exercise to study allocation between gold and NIFTY. The global minimum variance portfolio suggests a 63% weight to gold for target annual return of about 13%. As the target return increases, we see that the weight allocated to gold drops to about 3%. When one includes the SPX in the portfolio, the weight of gold drops to 46%, and NIFTY and SPX are at 31% and 22% respectively.

and safe-haven type properties. Bredin et al. (2015) analyse the same properties but for investors with short and long-run horizons and find that gold acts as a hedge for horizons upto a year, and acts as a safe haven during financial crisis. Beckmann et al. (2015) use the smooth transition regression (STR) technique and find that gold serves both as a hedge and a safe haven. Analysis from China suggests that gold is not a hedge for the market, but does act as a safe haven (Dee et al., 2013; Ming et al., 2020).

⁴An asset is a hedge when it is uncorrelated or negatively correlated with another asset or portfolio *on average*. A safe haven, on the other hand, is an asset that is uncorrelated or negatively correlated with another asset or portfolio *in times of market stress or turmoil*.

⁵Manuj, 2021 finds that gold has not served as a hedge or a safe haven for long-term investors the Indian stock markets.

This suggests that were international diversification more accessible, the weight of gold would be lower. The Sharpe's ratio, however, has wide confidence intervals owing to the very short time series of 22 years for which data is available. We also simulate portfolios with different weights and get broadly the same results.

While such an exercise has several limitations - in terms of limited time series data (only 22 years) and a relatively unsophisticated covariance matrix - it is a starting point to understand why households in India have continued to persist with gold investments. Besides features such as ease of access for purchase and sale, usefulness for credit, and social value, gold has also been able to provide a means to overcome the difficulties of a high inflation and financially repressed macroeconomic environment with capital controls. If policy has to divert household savings to more productive uses, it must confront the underlying issues in the macroeconomic environment which make gold a preferred investment choice.

The rest of the paper proceeds as follows. Section 2 sets gold in the context of the Indian financial markets. Section 3 presents the data used for the study, while the methods are presented in Section 4. Results are discussed in Section 5. Section 6 presents some robustness checks, while Section 7 concludes.

2 Gold in the context of Indian financial markets

Household saving will ultimately be a function of the financial environment within which the household operates. There is considerable uncertainty in India about the macroeconomic environment, unlike OECD countries such as the US, where historical data is available, and there is considerable policy maturity on issues such as inflation and macroeconomic stability (Shah, 2015). There are several factors about the macroeconomic and financial environment that specifically matter to households in making their financial saving decisions. These are as follows:

Inflation High inflation has been shown to discourage household saving (Ghosh & Nath, 2021). India adopted a formal inflation target of 4 per cent within a band of +/- 2 per cent in August 2016. Before this, high levels and volatility of inflation had been a persistent problem in India. The average inflation in the four years prior to inflation targeting was around 7.26% – this dropped to 4.19% after the adoption of the framework (Patnaik & Pandey, 2020). When there is such high and persistent inflation, households will naturally look for instruments which are able to, at the very least, beat inflation, even if not provide a complete hedge. The real value of

wealth diminishes rapidly in an inflationary environment, and assets that do not get affected by Indian inflation have an advantage.

Financial repression India has consistently followed a policy of “financial repression”. Central banks, insurance funds, pension funds are forced to lend to the government through policies such as the “Statutory Liquidity Ratio” or investment guidelines that force investment in specific asset classes. Financial repression has had significant costs on financial depth, that is, ratio of bank deposits to nominal GDP in India (Demetriades & Luintel, 1997). The policy of financial repression has led to an environment of low interest rates for government borrowing, and has prevented long-term yields from rising. This has led to an environment where fixed deposits, as well as insurance products provide low rates of return - often lower than the rate of inflation (Halan, 2017). Interest rates on fixed deposits have been low, and have been consistently falling over the 1999-2021 period from an interest of 9-10% to about 4%.⁶

Volatility in equity markets Emerging markets are generally more volatile than markets in OECD countries. The annualised 10 year standard deviation on the MSCI Emerging Markets Index was around 17%, while that of the MSCI World Index (based on large and mid cap representation across 23 Developed Markets (DM)) was around 13%.⁷ An asset that serves as a hedge assumes greater importance in emerging markets relative to developed markets.

Capital controls One way to hedge a portfolio is to diversify across different markets. However, this has been difficult in India, owing to a complex framework of restrictions on the current and capital account till the year 2000. In 2000, the current account was made fully convertible, and a modified framework for capital controls was put in place (Patnaik & Shah, 2012). There continue to be restrictions, which differ depending on the type of investor, and the assets in question. Individuals are only permitted to take a specific amount of dollars out of the country every year. In February 2004, the RBI introduced the Liberalised Remittance Scheme (LRS) which allows residents to remit upto US\$25,000 per year for capital or current account transactions. By May, 2015 the limit was increased to US\$250,000. These rules allow individuals to open foreign bank accounts, purchase property, make investments in foreign capital markets upto the specified amount.⁸

Currency interventions India moved away from the tight USD peg to a basket peg

⁶See <https://www.capitalmind.in/2020/09/chart-of-the-day-bank-fd-rates-from-1976/>

⁷See <https://www.msci.com/documents/10199/149ed7bc-316e-4b4c-8ea4-43fcb5bd6523>

⁸See <https://www.mondaq.com/india/fund-management-reits/996088/the-liberalised-remittance-scheme-lrs>

involving several currencies with greater flexibility in 2004 (Zeileis et al., 2010). However, the Reserve Bank of India (RBI) has continued to intervene in the currency markets. Patnaik and Sengupta, 2021 study RBI interventions and find that when there has been pressure on the rupee to appreciate, the RBI has responded by intervening in the forex market and buying dollars. When, in the aftermath of the 2008 global financial crisis, there was pressure on the rupee to depreciate, the RBI allowed the rupee to fluctuate in this period. Indian investors, therefore, benefit from a larger depreciation of the rupee for those assets where the price is determined in international markets.

High inflation levels and volatility, low interest rates on account of financial repression, inability to invest in international markets until very recently, depreciation of the rupee have a bearing on the choices that are available to households. Financial repression changes the risk-return trade-off between fixed deposits and gold. Similarly in an environment where individuals are restricted from investing in overseas markets, gold offers a way for doing international diversification. These become important considerations as we evaluate the performance of gold vis-a-vis the Indian equity market.

3 Data

India is neither a major gold producer,⁹ nor a top trading center.¹⁰ However, it has a steady appetite for gold. Since the price of gold is determined by the marginal demand and supply driven by global macroeconomic conditions, the price of gold is, therefore, also not determined in India. For the purpose of our analysis, we source gold prices from the London market. Our reference series is the Gold Fixing Price 10:30 A.M. (London time) in the London Bullion Market, based in U.S. Dollars (See Figure 1). The unit of reference is one fine troy ounce (999.9 gm gold in 1000gm gold bar)¹¹ This data is downloaded from St Louis Fed website (Series: GOLDAMGBD228NLBM).¹²

There are two other price series that are important to mention. The first is the physical gold price series in the domestic market (Mumbai) in India. This is based on a survey of gold prices quoted every day in Mumbai. This series is slightly different from the London series as India imposes import duties on gold imports creating a wedge between the two prices (see Figure 1). Physical gold prices also include transactions cost (storage cost,

⁹India has a share of 0.05% in global gold production

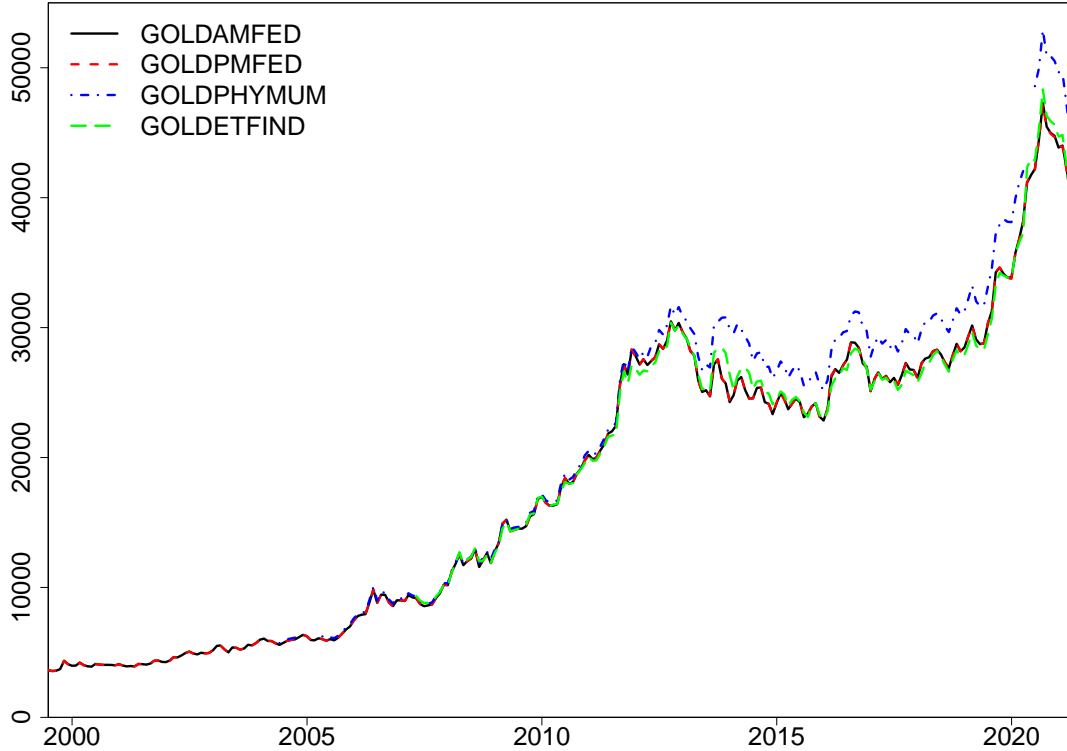
¹⁰The top trading centers of gold that comprise more than 90% of global trading volumes are the UK, US and China

¹¹1 troy ounce = 31.1034768 grams

¹²<https://fred.stlouisfed.org/series/GOLDAMGBD228NLBM>

Figure 1 Gold prices

Gold reference prices at the London Bullion Market Association (LBMA) are quoted in USD per Troy Ounce for 99.5% purity every day at 10:30AM and 3:00PM. To convert LBMA prices to Indian rupees (INR), we multiply the LBMA AM/PM prices with St Louis FED's INR/USD exchange rate. GOLDAMFED and GOLDPMFED shows the evolution of LBMA 10:30AM and 3:00PM prices. Physical gold prices (GOLDPHYMUM) in Mumbai is quoted per 10 grams for 24 carat purity (available from May 2004). This is survey data sourced from CMIE. Gold ETF in India (GOLDETFIND) are quoted per gram for 99.5% purity. This data is sourced from National Stock Exchange (NSE). For gold ETF, we consider the closing price of UTI Gold Exchange Traded Fund (GOLDSHARE), which is the oldest running gold ETF series in India (available from March 2007).



cess, nominal tax, etc.), so this is not directly comparable to other gold price indices.

The second is the data from Gold ETFs that trade on the National Stock Exchange. Gold ETFs were only introduced in the late 2000s, and historical price data is therefore not available. However, we do find that for the period that ETFs have been available, ETF prices close track the LBMA AM series used in this paper. For the purpose of the paper we use the London prices. For a detailed discussion about various gold price series and our choice, refer to Appendix A.

The domestic equity market is represented by the Nifty 50, a market index introduced by the National Stock Exchange (NSE) in India on 22 April 1996. It is a free float market capitalisation weighted index which showcases the top 50 equity stocks traded in the stock exchange, and has emerged as the most important benchmark in Indian financial

Table 1: Summary statistics

The table provides a description of all the data series used in the analysis. LBM stands for the London Bullion Market. All data except CPI is available at daily frequency. CPI data is available at monthly frequency.

Variable	Description	Start-date	End-date	Min	Mean	Median	Max	Unit
Global gold prices								
GOLDAMFED	Gold Fixing Price 10:30AM (London time) in LBM	1968-04-01	2021-03-31	34.77	565.76	383	2061.5	USD per troy ounce
GOLDPMFED	Gold Fixing Price 3:00PM (London time) in LBM	1968-04-01	2021-03-31	34.75	564.97	383	2067.15	USD per troy ounce
Domestic gold prices								
GOLDPHYMUM	Physical gold price in Mumbai	2004-05-03	2021-03-31	5535	22664.7	26340	55950	INR per 10 gm (24 carat)
GOLDETFIND	Gold ETF	2007-04-17	2021-03-31	862.69	2469.3	2590.25	5158.85	Index in INR
Global market indices								
SPX	S&P 500 Total Returns Index	1988-01-04	2021-03-31	242.87	2160.21	1777.92	8240.38	Index in USD
Domestic market indices								
NIFTY	NIFTY Total Returns Index	1999-06-30	2021-03-31	927.03	7087.92	6417.72	21739.69	Index in INR
Exchange rate								
INRUSDFED	INR/USD exchange rate - St Louis Fed	1973-01-02	2021-03-31	7.19	34.01	35.86	76.95	Exchange rate (1 USD in INR)
Inflation								
CPI	Consumer Price Index	1998-01-31	2021-03-31	29.72	79.04	58.71	158.9	Index in INR

markets. The data for Nifty is sourced from the NSE website.¹³ For global equity markets, we use S&P 500 index that includes 500 leading companies in leading industries of the U.S. economy, which are publicly held on either the NYSE or NASDAQ, and covers 75% of U.S. equities. We use the total returns index in both (domestic and global) cases and not the price index. All US dollar denominated price indices are converted to INR using the INR-USD exchange rate using data from St. Louis Fed website.¹⁴ Table 1 presents the details of the series used in our analysis.

Table 2 reports summary statistics of the data based on monthly average index and price level. The table compares the mean, median, minimum, maximum, and the standard deviation of monthly returns for various asset classes. NIFTY exhibits more extreme returns (-26.98% to 18.15%) followed by SPX (-22.64% to 11.53%). Gold exhibits lower extreme negative movement (-12.39%) but higher positive movement (16.39%) than SPX. Exchange rate shows the least variation (-4.14% to 6.56%). Equity indices (domestic followed by global) have higher volatility than gold which has higher volatility than the exchange rate. This pattern also holds for the returns based on daily and weekly data giving support to the belief that emerging markets generally exhibit higher average returns, a higher risk (standard deviation) and more extreme values than developed markets.

Table 2 Summary statistics

The table presents the descriptive statistics of the monthly changes (in log) in various indices. Sample period goes from July 1999 to March 2021. GOLDAMFED stands for returns on gold in US dollars, while NIFTY and SPX represents returns of Total Returns Index of NIFTY and S&P 500 respectively. Since exchange rate is quoted as INR per US Dollar, increase in INR/USD represents the depreciation of Indian rupees. INFLATION is measured as the change in Consumer Price Index (CPI).

Variable	Min	Mean	Returns (%)		Standard deviation
			Median	Max	
GOLDAMFED (in USD)	-12.391	0.722	0.423	16.387	3.806
NIFTY (in INR)	-26.983	1.081	1.934	18.152	5.693
SPX (in USD)	-22.636	0.575	1.325	11.531	3.897
INR/USD	-4.140	0.200	0.056	6.557	1.617
INFLATION	-2.007	0.493	0.551	4.683	0.723

In Table 3, we compare and contrast the historical performance of gold vis-a-vis inflation and the domestic equity index NIFTY and present the returns over different time horizons. We first examine if gold has beaten inflation to provide real returns. We then examine if gold has beaten NIFTY. Columns (1)-(3) show the average returns on gold, NIFTY and inflation for different intervals. Columns (4)-(6) show the standard deviation of returns.

¹³<https://www.nseindia.com/>

¹⁴<https://fred.stlouisfed.org/series/DEXINU>

Column (7) shows the number of times that gold returns have been higher than Nifty returns, while Column (8) presents the same for inflation. Each calculation is conducted over different time horizons. For example 1m refers to returns across monthly data for the full time period. 3m and 6m refer to average returns over each three month and six month periods, using monthly data over the full period.

Table 3 Performance comparison

This table presents the performance of gold with other asset classes. Columns (1)-(3) show the average returns on gold, NIFTY and inflation for different intervals. Columns (4)-(6) show the standard deviation of returns. Column (7) shows the number of times that gold returns have been higher than Nifty returns, while Column (8) presents the same for inflation. Each calculation is conducted over different time horizons. For example 1m refers to returns across monthly data for the full time period. 3m and 6m refer to returns over each three month and six month periods, over the full period.

	Mean			St. Dev.			GOLD > NIFTY (in %)	GOLD > CPI (in %)
	GOLD	NIFTY	CPI	GOLD	NIFTY	CPI		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1m	0.92	1.08	0.49	3.85	5.69	0.72	43.68	52.87
3m	2.85	3.17	1.48	6.68	11.58	1.48	45.95	57.14
6m	5.70	6.13	2.97	9.43	17.22	2.13	44.92	57.03
1y	11.57	11.56	6.00	13.32	23.54	2.70	48.40	67.60
2y	22.80	24.50	12.13	19.40	30.55	4.89	46.22	76.47
5y	57.05	70.05	31.97	36.09	40.22	10.40	36.14	73.76
10y	126.26	133.07	70.46	35.63	36.26	7.96	44.37	99.30

On an average, the monthly log gold returns have been about 0.92% (sd: 3.85%). The average 10 year log return on gold has been 126% (sd: 35%). The average monthly log returns for Nifty were 1.08% (sd: 5.69%), while the average 10 year log returns on Nifty were higher than that of gold at 133% (sd: 36.2%). For monthly returns, gold has beaten inflation a little over half the times - that is if one were only looking at monthly returns, then 47% of the times gold would not give real returns. As one observes longer time periods, gold has been able to deliver positive real returns, and over a horizon of 10 years or more, gold has delivered positive real returns all the time. In the case of NIFTY, gold has outperformed NIFTY over any horizon for less than half the times.

4 Methodology

Our methodological approach is as follows. We first demonstrate that the returns on gold in India are correlated with the depreciation of the INR vis-a-vis the US dollar. A depreciating currency implies that domestic investors get higher returns on an asset whose prices are determined in international markets. With this, we evaluate how returns on gold have held up against inflation in India, and if they have been able to provide real

returns, especially when compared to instruments such as fixed deposits that are accessed by low income groups. We then study the relationship between gold and equity markets, and conduct a portfolio optimisation exercise to assess the weight of gold in portfolios in India.

4.1 The returns on gold in INR

One of the features of the Indian market is that it is a price-taker w.r.t gold. As a result, the INR-USD exchange rate plays an important role in determining the returns that domestic investors in India see on their gold holdings. We first show how the real price of gold and US dollar has fluctuated in India using data from July 1999 to March 2021. The real price is calculated by dividing the nominal price of gold in US dollar and in Indian rupees with the Consumer Price Index (CPI) of respective countries.

We then turn to studying how the returns on gold are correlated with the exchange rate. We regress the daily, weekly, fortnightly and monthly log changes in the exchange rate (Indian rupees per US dollar) on the daily, weekly, fortnightly and monthly log change in the price of gold respectively. A positive coefficient implies that gold returns are positively correlated with the depreciation of the rupee. That is, as the INR depreciates against the US dollar, gold returns in INR will increase. Since extreme returns are usually clustered, we use the Breusch-Pagan test to establish the presence or absence of heteroscedasticity. If the p-value is less than 0.05, we reject the null hypothesis that the variance of the residuals is constant and infer that heteroscedasticity is indeed present.

Our model is as follows:

$$r_{gold,t} = \alpha + \beta_t r_{INRUSD,t} + \epsilon_t$$

$$h_t = \pi + \theta \epsilon_{t-1}^2 + \delta h_{t-1}$$

Here, r_{gold} and r_{INRUSD} are the returns of gold and exchange rate and we model error as GARCH(1,1) process.

4.2 Estimating if gold beats inflation

Inflation not only discourages saving but it also encourages saving in gold. For example, Badarinza et al., 2017 show that experience of inflation when young is a significant predictor of gold holdings, suggesting that households in India see gold as a hedge against inflation. In this context, it is important to evaluate if gold provides a positive real rate of return. Following Erb and Harvey, 2013, the real price is derived by dividing the gold

price in India with the domestic Consumer Price Index (CPI).¹⁵

It is also useful to evaluate if gold is a hedge against inflation. To compute the inflation beta, following (Bekaert & Wang, 2010), we run the following regression specification:

$$Gold_{Nominal\ return} = \alpha + \beta Inflation + \epsilon \quad (1)$$

If $\beta = 1$, then gold is a perfect hedge against inflation.

4.3 Estimating the hedge and safe-haven properties of gold

We follow the definition of ‘hedge’ and ‘safe haven’ as provided in Baur and Lucey, 2010 and extended by Baur and McDermott, 2010.

Hedge: A strong (weak) hedge is defined as an asset that is negatively correlated (uncorrelated) with another asset or portfolio on average.

Safe haven: A strong (weak) safe haven is defined as an asset that is negatively correlated (uncorrelated) with another asset or portfolio in certain periods only, e.g. in times of falling stock markets.

To test for gold as a hedge against equity indices, we estimate the following econometric specification:

$$r_{gold,t} = \alpha + \beta_t r_{Nifty,t} + \epsilon_t \quad (2)$$

¹⁵Note that we do not have a long time series of CPI that runs across the period. So to extend the CPI data, we use two reference price indices at consumer level-the CPI (base year 2012) and CPI-IW (base year 2016)-to build a longer time series. Since the CPI (base year 2012) is used by the Indian central bank-the Reserve Bank of India (RBI)-for the purpose for inflation targeting and for many other policy measures, we decided to extend this series.

The first time stamp of CPI (base year 2012) is January 2011 and the base year is the calendar year 2012. Given, there is no prior data available for the period before January 2011, we use CPI-IW index owing to the closest resemblance by weight for the product groups. The methodology involved multiplying the monthly CPI-IW (period before January 2011) by a linking factor. The average values of the period CPI (base year 2012) and CPI-IW (base year 2016) for the common period Jan 2012 - Dec 2012 is computed. The linking factor is arrived at by dividing the average value of CPI (base year 2012) to the average value of CPI - IW (base year 2016).

$$L = \frac{CPI\ Index\ (base\ year\ 2012)\ (Average\ value\ Jan\ 2012 - Dec\ 2012)}{CPI\ IW\ Index\ (base\ year\ 2016)\ (Average\ value\ Jan\ 2012 - Dec\ 2012)}$$

For all the months prior to Jan 2011, the price index of CPI-IW was multiplied with the above linking factor (1.377) to generate the back series. The numerator stood 100.16, while the denominator stood 72.7. Finally all such computed values starting Jan 1998 till Dec 2010 for CPI-IW was added to the CPI (base year 2012) to generate the time-series.

Here $r_{gold,t}$ and $r_{nifty,t}$ are log returns of gold and domestic equity index (NIFTY) respectively. If β is negative and statistically significant, then gold would be a strong hedge. If β is zero, then gold would be a weak hedge. Since extreme returns are usually clustered, we estimate the OLS model with GARCH(1,1) specification (see Equation 3) for the error term to account for heteroscedasticity.

$$h_t = \pi + \theta \epsilon_{t-1}^2 + \delta h_{t-1} \quad (3)$$

An interesting question is to ask whether the relationship between gold and Nifty has been the same over the entire time-period, or if it has been time-varying. This is particularly important for a country like India that has seen large number of changes in domestic policy as well as increased levels of integration with the world economy. We divide our data into smaller periods and run the same regression over the smaller datasets.

To analyse the safe-heaven properties of gold, we estimate the following econometric model:

$$r_{gold,t} = \alpha + \beta_t r_{nifty,t} + \epsilon_t \quad (4)$$

$$\beta_t = \gamma_0 + \gamma_1 D_{10}(q_{10\%}/r_{nifty}) + \gamma_2 D_5(q_{5\%}/r_{nifty}) + \gamma_3 D_1(q_{1\%}/r_{nifty}) \quad (5)$$

$$h_t = \pi + \theta \epsilon_{t-1}^2 + \delta h_{t-1} \quad (6)$$

Eq. 4 models the relation of gold and stock returns. The parameters to estimate are α and β_t . Assuming that the relationship is not constant but is influenced by extreme market movements, we define β_t as a dynamic process. We estimate parameters γ_0 , γ_1 , γ_2 and γ_3 . The dummy variables denoted as D_{10} , D_5 , and D_1 capture extreme NIFTY movements and are equal to one if the NIFTY returns falls below the 10%, 5% and 1% quantile of the return distribution. Finally Eq. 6 presents a GARCH(1,1) model which is used to account for heteroscedasticity in the data. Eqs. 4, 5, and 6 are jointly estimated with Maximum Likelihood. If one of the parameters γ_1 , γ_2 or γ_3 is negative and significantly different from zero, then we interpret gold as a strong safe heaven. If the parameters are non-positive, then gold is a weak safe haven. Gold is a hedge if two conditions hold: the parameter γ_0 is zero (weak hedge) or negative (strong hedge), and the sum of the parameters γ_1 to γ_3 are not jointly positive exceeding the value of γ_0 (Baur & McDermott, 2010).

4.4 Introducing portfolio optimisation

We employ the standard mean-variance portfolio selection framework to determine the optimal constrained portfolio, and the associated returns and risk. The Markowitz framework is as follows

$$\arg \min_w w' S w \quad \text{s.t.} \quad r w = r_p, \quad \sum_i w_i = 1, \quad w_i \geq 0$$

Here, w_i is the weight of asset i in the portfolio, w is the vector of all portfolio weights, S is the covariance matrix of asset returns in the portfolio, r_i is the expected return on each asset i , and r_p is the target return on the portfolio. The portfolio weights sum up to 1, and no short-selling is allowed. The optimisation also assumes a risk aversion coefficient of 1. The Markowitz model is essentially asking, for a given level of expected return $E(w'r)$, how can we find the lowest possible risk $w'Sw$? We use the historical covariance matrix. We also assume that the expected returns on an asset will be the same as the average historical returns.¹⁶ Since we have only 22 years of data, we estimate bootstrap standard errors to arrive at the confidence intervals for the Sharpe's ratio. The confidence interval presents the uncertainty of the estimates – which is important given the short time series.

5 Results

5.1 The role of currency

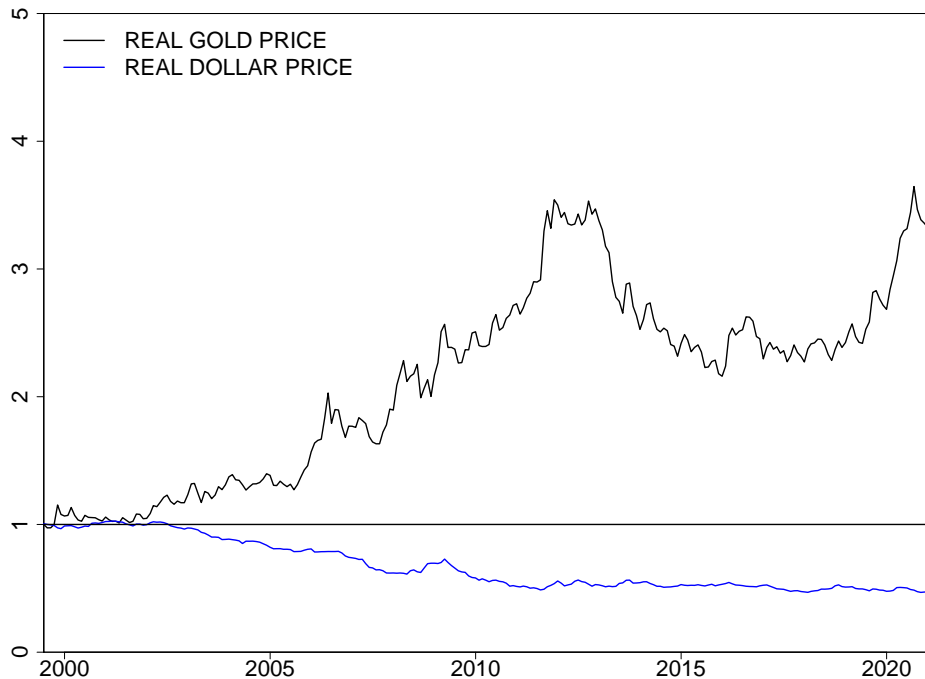
One of the features of the Indian market is that it is a price-taker w.r.t gold. As a result, the INR-USD exchange rate plays an important role in determining the returns that domestic investors in India see on their gold holdings. Figure 2 suggests that real price of gold has risen quite sharply between 1999 and 2012. It dropped sharply in 2013-14 but has recovered in the last five years. We also see a sharp correction during the last one year (of the Covid pandemic). Comparing this to the US dollar, the real value of dollar has gone down consistently over the last 20 years.

Figure 3 shows the rolling correlation between gold and INR/USD daily returns. The

¹⁶If the covariance matrix and the expected returns on an asset are not well-specified then the exercise may not provide robust results. The literature on covariance matrix estimation has actually made a lot of progress on estimation. Fund managers may have views on expected returns given the current macro and geo-political situations which may not get adequately captured by the historical return. Also, the exercise is done for one period. It is possible that this exercise will have to be continuously updated in light of changing circumstances.

Figure 2 Real price of gold

Note: Figure shows how the local currency real price of gold and US dollar has fluctuated in India. The local currency price of gold and US dollar is divided by the CPI and the resulting ratio is normalized to an initial value of 1.0 (as on 30th June 1999). The sample period runs from 30th June 1999 to 31st March 2021.



sample period runs from July 1999 to March 2021. Except for two short intervals-around mid 2004 and end 2010, the correlation remains positive.

Table 4 report the OLS result with White's heteroskedasticity-consistent robust standard errors.¹⁷

We find (see Table 4) all coefficients to be positive, suggesting that gold price is strongly related to the depreciation of the Indian rupee. For example, if the Indian rupee depreciated against the U.S. dollar by 10% in a month, then the gold price in Indian rupees increased on average about 3.63% (last column). What this implies is that interventions by the Reserve Bank of India to prevent INR-USD rate change has implications for the gold price that is seen by Indian investors. For example, if the Reserve Bank of India

¹⁷We also run the following econometric specification to account for heteroskedasticity:

$$r_{gold,t} = \alpha + \beta_t r_{INRUSD,t} + \epsilon_t$$
$$h_t = \pi + \theta \epsilon_{t-1}^2 + \delta h_{t-1}$$

Here, r_{gold} and r_{INRUSD} are the returns of gold and exchange rate and we model error as GARCH(1,1) process. We found slight variation in coefficient but qualitatively results remains the same. The results are available with the author upon request.

Figure 3 Rolling correlations: Gold vs INR/USD

Note: The figure presents the evolution of the correlation of the INR/USD exchange rate with gold based on daily data. The rolling correlation estimates are based on a window length of 252 daily observations and illustrate that the correlation is changing through time. Also noteworthy is the fact that correlations almost always stays positive. All individual indices are denominated in Indian currency. The sample period runs from 30th June 1999 to 31st March 2021.

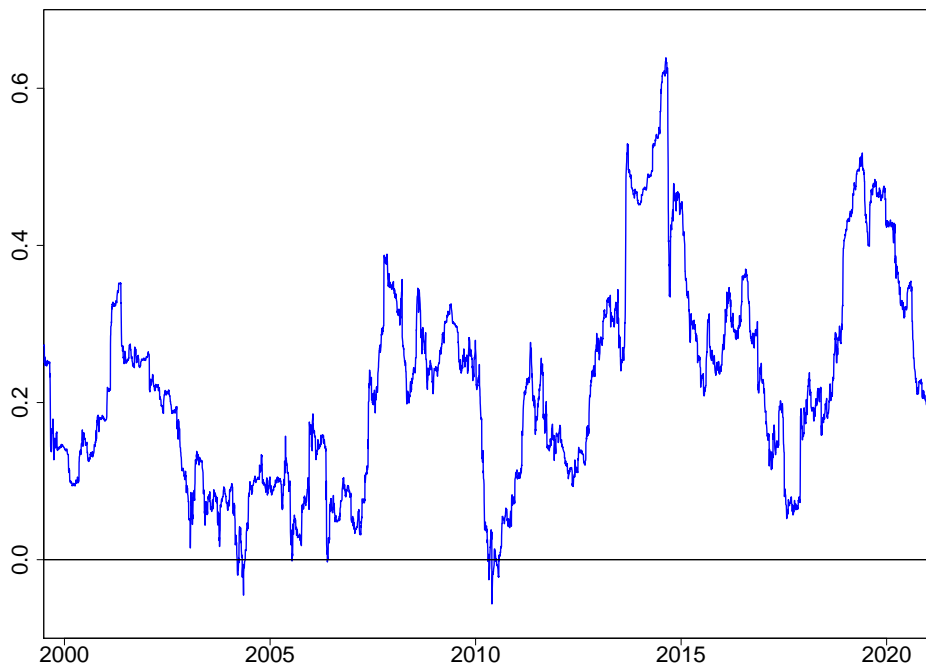


Table 4 Gold as a currency hedge

The table presents the estimation results of the regression of the percentage change in INR-USD exchange rate on gold returns. The results show that gold returns are positively correlated with the INR depreciation. Sample period: July 1999 to March 2021. Standard errors in the parenthesis show the White's heteroskedasticity-consistent robust standard errors.

	<i>Dependent variable: Gold returns (in Indian Rupees)</i>			
	Daily	Weekly	Fortnightly	Monthly
FX (INR per US dollar)	0.566*** (0.032)	0.459*** (0.076)	0.439*** (0.109)	0.363*** (0.141)
Observations	5,334	1,136	567	261

Note:

*p<0.1; **p<0.05; ***p<0.01

intervenes in the currency market to stop rapid depreciation of Indian currency, then the returns on gold would be lower compare to the scenario in which the rupee were a *de-facto* float.

5.2 Gold and inflation

Figure 4 shows the real price of gold in India. We see that in the last 20 years, real returns on gold have always been positive.

Figure 4 The real price of gold

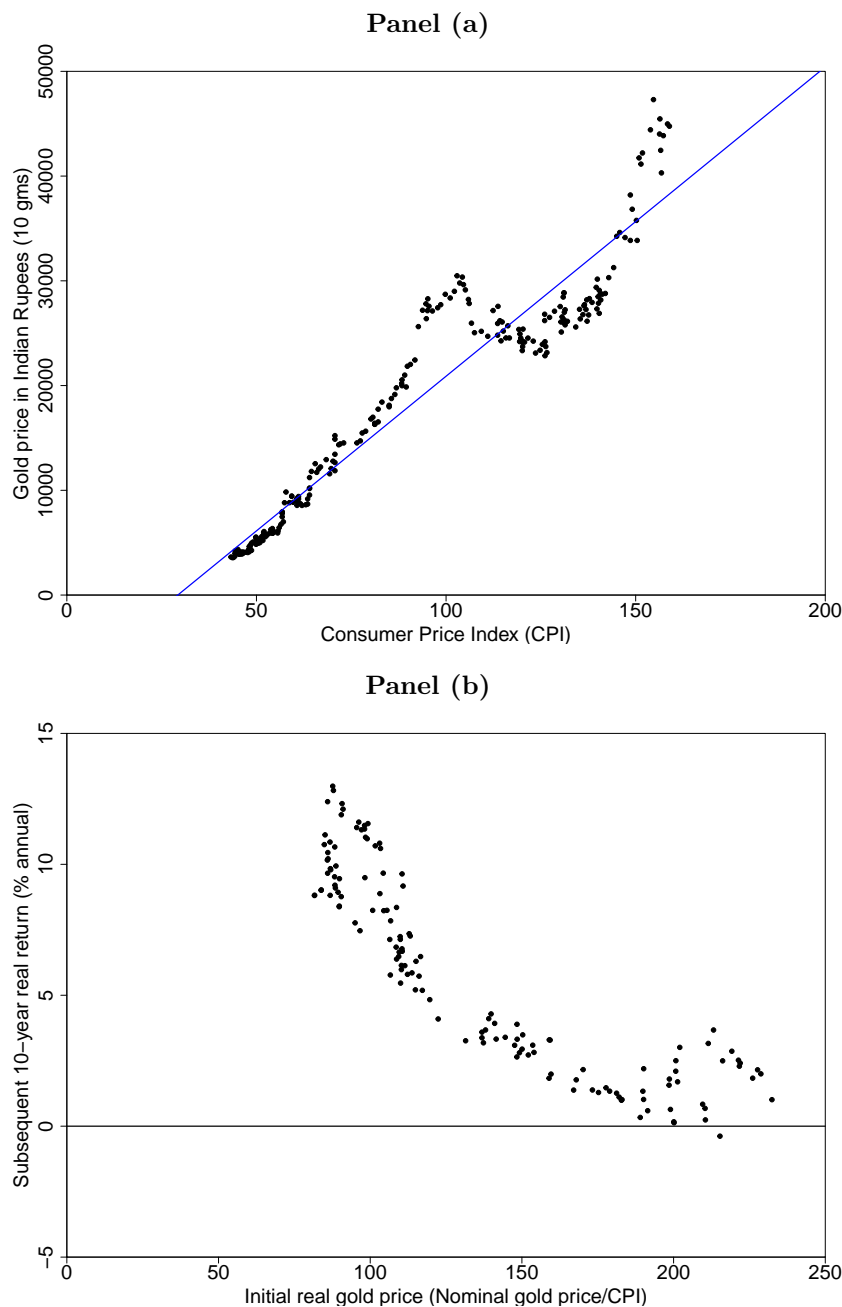
We plot the real price of gold from June 1999 to March 2021. The real price is calculated by dividing the nominal price of gold in Indian Rupees by the CPI index value. For the ease of interpretation, we have normalized the index value to 1 at the beginning of the study period (June 1999).



Another way of studying the gold and inflation relationship is to ask if gold is a hedge against inflation. That is, if inflation rises by 10% a year for the next 10 years, the price of gold should also rise by roughly 10% a year over the same period. For gold to be a good inflation hedge, its nominal return must at least be positively correlated with inflation. We show this in two ways. Figure 5 (Panel (a)) shows the average monthly value of the spot gold price versus the monthly reading for the CPI over June 1999 to March 2021. The regression line shows that on average, the higher the level of the CPI, the higher the price of gold. The scale of the plot also suggests that gold prices have risen far more than the CPI level. Panel (b) shows the initial real gold price and the subsequent ten year real return on gold. It shows that even when we start with very high real gold prices at the beginning of the period, the real gold returns have always been positive (except for one period where it is very close to zero).

We extend the analysis further by calculating the inflation beta. Table 5 presents the results. Column (1) presents the results based on monthly data. Columns (2) and (3) present the results based on yearly and 10-year rolling returns. β is statistically

Figure 5 Gold as an inflation hedge (June 1999 to March 2021)



insignificant when based on monthly data. However, when evaluated based on yearly and 10 year data, we see that β is positive and statistically significant, indicating that as inflation rises, nominal gold returns also see an increase.

In reality, gold will not have a perfect $\beta = 1$, since inflation might be correlated with other factors that are omitted from the regression (for a detailed discussion, refer to (Bekaert & Wang, 2010)). Another reason will be the tax system. If investors in gold are taxed on inflationary gains, shocks that cause a revision in expected inflation require

Table 5 Inflation β

For yearly and 10 yearly inflation, we use the monthly data but a one-year and 10-year horizon. The results in the residuals of the regression analysis reflected in Equation (1) exhibits positive serial correlation. We correct the standard errors for this using the standard approach advocated by Newey and West, 1987.

	<i>Dependent variable: Nominal gold returns</i>		
	Rolling window estimates		
	(monthly)	(yearly)	(10 yearly)
	(1)	(2)	(3)
Inflation	0.050 (0.331)	1.608*** (0.320)	0.681* (0.396)
Constant	0.897*** (0.289)	3.268 (2.192)	8.559*** (2.914)
Observations	261	250	142
R ²	0.0001	0.093	0.021
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01		

more than proportional changes in nominal expected returns to keep after-tax expected real returns unchanged. The exact prediction will be rather complex as it depends on the details of the tax system, whether inflation is expected or unexpected, and whether marginal investors in the security are taxable investors or not.¹⁸ However, the results do suggest that gold is a useful instrument in countering the effects of inflation.

5.3 Gold and equity returns

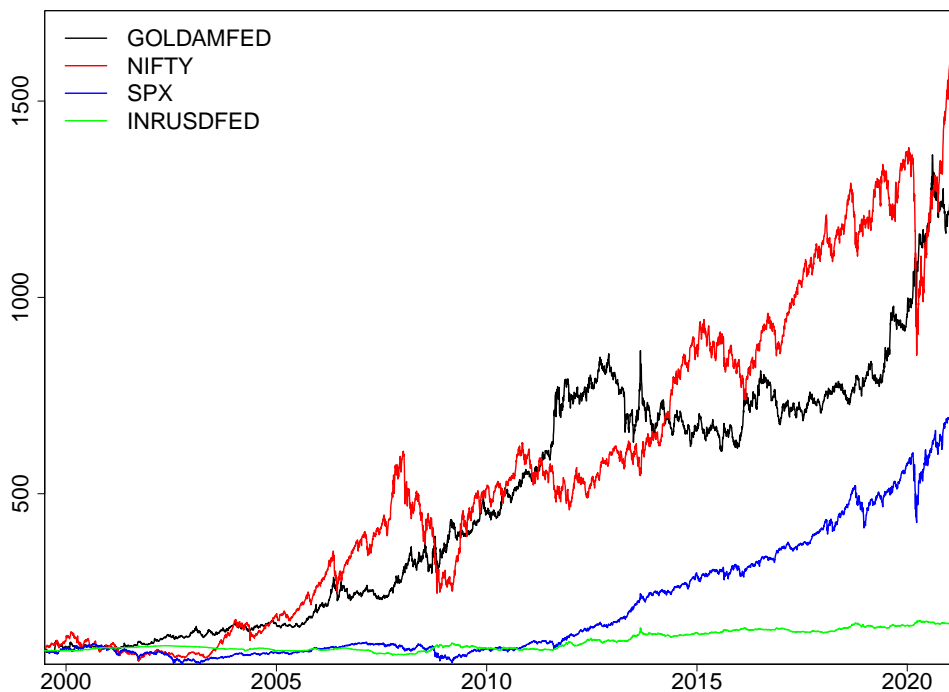
The equity premium in India has been estimated to be about 9.7% above the corresponding risk free security post 1991, which is rather high (Mehra, 2006). However, it is important to study how equity has performed vis-a-vis gold. Figure 6(a) presents the evolution of gold price together with domestic and world equity index and INR-USD exchange rate for the entire sample period, while Figure 6(b) illustrates the time-varying volatility of the respective return series estimated with a GARCH(1,1) model. To compare the indices, we have normalized the value of all the indices as on 30th June 1999 to 100.

As shown in the figure, there has been a steady rise in NIFTY in the last 20 years. The first boom is evident from the period 2004-2008 which was a period of high GDP

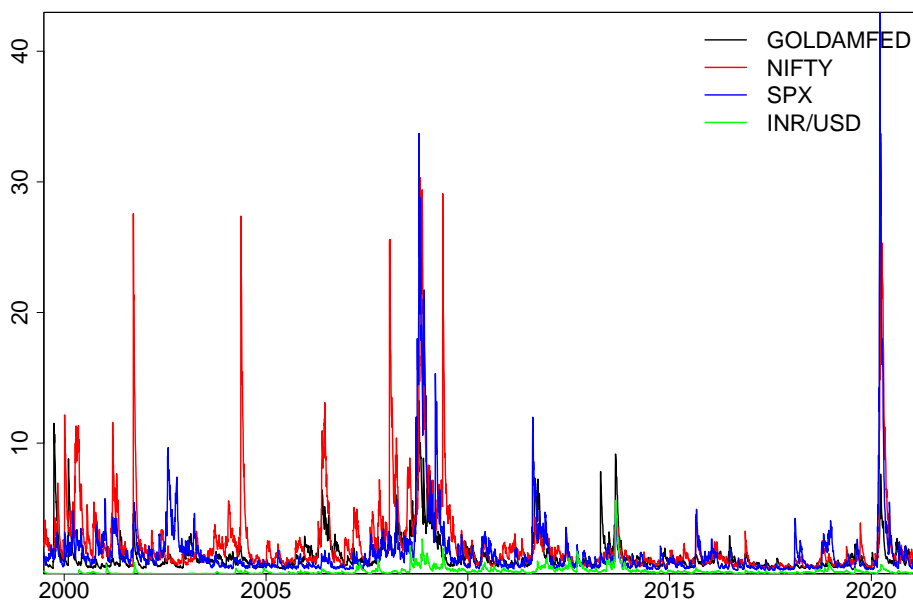
¹⁸In a world where gold is a perfect hedge, hedging will still be difficult to accomplish in practice (especially if it involves short positions), and such hedge portfolios will not likely to be easily and cheaply accessible to retail investors.

Figure 6 Relative performance of market indices

Note: Figure (a) shows the evolution of daily normalized index value, while Figure (b) shows the daily conditional volatility (GARCH(1,1) estimates) of gold, S&P 500 Total Returns Index, NIFTY Total Returns Index and the value of US dollar from June 1999 to March 2021. For the sake of easy comparison, the index values are normalized to 100 at the beginning of the period (30th June 1999). All indices are measured in Indian Rupees (INR). The sample period runs from 30th June 1999 to 31st March 2021.



(a) Index levels



(b) GARCH(1,1) volatility estimates

growth in India. NIFTY saw a sharp fall around the time of the global financial crisis but recovered soon after. Since 2014, the market has been steadily rising, though it dropped sharply in March, 2020 - most likely on the news of Covid-19 imposed lockdown in India.

Gold and NIFTY seem to have moved together till about 2008, after which NIFTY saw a sharp fall, while gold continued with its upward trajectory. The two asset classes moved together till about 2014, and then from 2015 till early 2020. There seems to be a divergence in the series around 2014, when NIFTY was rising steadily while gold prices fell before rising again. On the other hand, SPX shows a slow steady rise from 2003 to 2007 before seeing a sharp drop in 2008. However, from March 2009, we observe a consistent rise in the SPX till late 2018.

To understand the co-movement of gold and equity indices, Figure 7 plots the 252 days rolling correlation based on daily returns. As can be seen, except for the 2006-2008 period, we consistently find negative correlation between gold and NIFTY returns. However, for SPX, we do find periods of high positive correlations as well as periods of significant negative correlation. This also suggests that the relation between gold and equity indices is constantly evolving, i.e. the beta changes over time.

Table 6 presents the results on gold as a hedge. Each panel shows the results for a subset of the data. The first panel estimates the relationship for data over the full time period. The second panel shows the results with the last 20 years of data, while the last panel shows the results with only five years of data. Each column presents the results where returns are calculated over a different time interval. These are non-overlapping periods, and hence do not suffer from the problem of serial correlation.

Across all time periods, we find that gold is a strong hedge against the Nifty when measured in daily frequency. In the last 10 years, this relationship had become stronger. It is negative and statistically significant when returns were measured on higher frequencies as well. This is also consistent with the results presented in Figure 7 in the previous section - which shows that the correlation between the two assets has turned negative in more recent years.¹⁹ Gold is a weak hedge when measured using a fortnightly and monthly frequency.²⁰

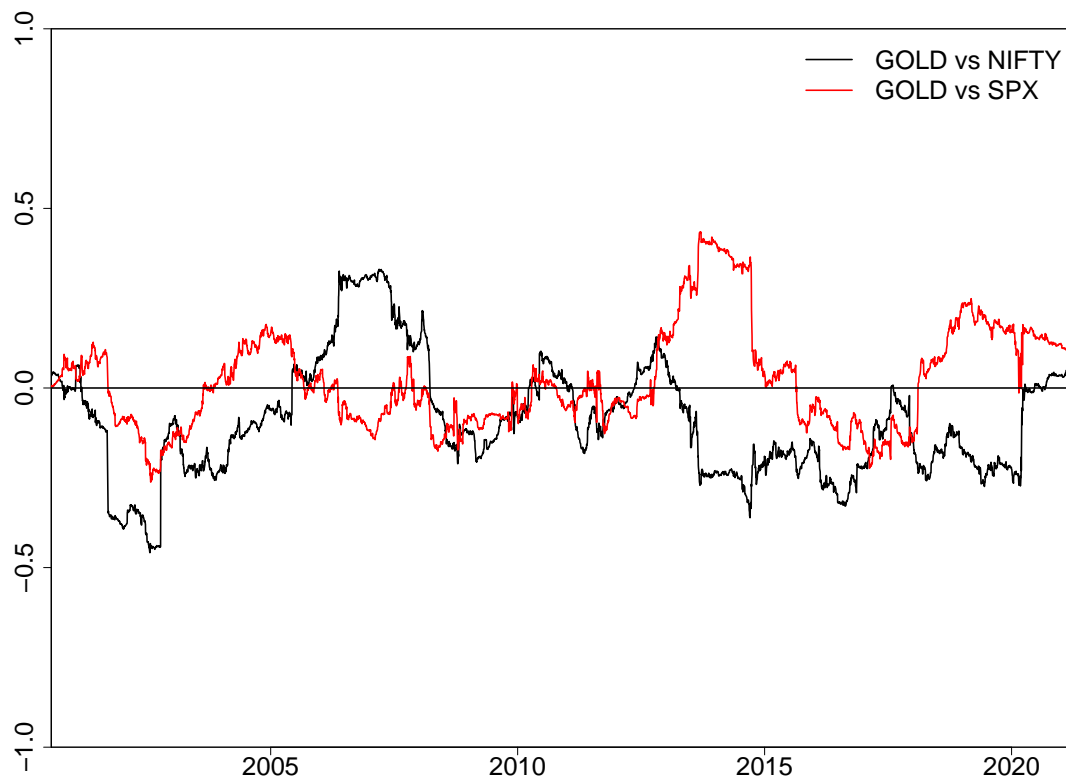
Table 7 presents the results on gold as a safe haven. The first panel shows the results with extreme NIFTY returns, while the second panel shows the results when we consider

¹⁹As an additional robustness check, Appendix B documents the results when we do the same analysis using physical gold price and gold ETF prices in India. The results broadly remain the same.

²⁰This is consistent with the results of (Manuj, 2021) who finds that gold is not a hedge for “long term investors”

Figure 7 Rolling correlation: Gold vs domestic/global equity index

We plot the rolling correlations based on the past 252 days daily returns. The black line shows the evolution of gold price and NIFTY Total Returns Index while the red line shows the relationship between gold prices and S&P 500 Total Returns Index.



extreme NIFTY volatility. The results are shown for returns calculated daily, weekly, fortnightly and monthly. The overall effect for any quantile is given by the sum of all coefficient estimates up to the chosen quantile. γ_0 is negative and statistically significant for daily returns, and non-positive for returns at lower frequencies, when we use extreme returns as well as extreme volatility. This is consistent with the previous section which demonstrates that gold is a weak hedge against NIFTY. For daily returns we find γ_3 as negative and statistically significant. When we estimate the model using domestic market volatility, we find γ_1 and γ_2 to be statistically significant for daily returns as well. The overall effect (γ) is generally negative at all frequencies. However, we do not get statistically significant results, suggesting that gold is a “weak” safe-haven. These properties of gold make it useful for households to hold some gold as a hedge against extreme market conditions.

Table 6 Is gold a hedge?

*Note:*The table presents the estimation results for the role of gold as a hedge asset for daily, weekly, fortnightly, and monthly returns. Zero and negative coefficients indicate gold as a weak and strong hedge (against stocks) respectively. The results show that gold is a strong hedge against NIFTY and the relationship is quite consistent throughout the period. Sample period: July 1999 to March 2021.

	Gold returns			
	Daily	Weekly	Fortnightly	Monthly
All years				
NIFTY	-0.077*** (0.011)	-0.049** (0.022)	-0.034 (0.031)	-0.032 (0.042)
Observations	5087	1136	567	261
Last 20 years				
NIFTY	-0.088*** (0.012)	-0.067*** (0.024)	-0.073** (0.033)	-0.061 (0.044)
Observations	4670	1044	522	240
Last 15 years				
NIFTY	-0.066** (0.014)	-0.067** (0.030)	-0.054 (0.040)	-0.086 (0.053)
Observations	3497	783	391	180
Last 10 years				
NIFTY	-0.131*** (0.019)	-0.136*** (0.042)	-0.154*** (0.054)	-0.162* (0.087)
Observations	2323	523	261	120
Last 5 years				
NIFTY	-0.126*** (0.026)	-0.076 (0.049)	-0.145** (0.065)	-0.039 (0.100)
Observations	1163	262	131	60

5.4 Gold in a household's portfolio

Gold is a useful instrument from the perspective of beating inflation in India. The other avenues of investment for households have been fixed deposits (FDs) and insurance products. Financial repression has meant that interest rates of FDs have been low, and have been consistently falling over the 1999-2021 period from an interest of 9-10% to about 4%.²¹ Figure 8 shows the ten year inflation rate, gold returns and FD returns. Apart from a few years around 2018, gold has consistently beaten returns on fixed deposits.

FDs also require a lock-in which is problematic if the household has liquidity concerns. Endowment insurance products have provided very low IRRs (between 1-5%), along with concerns of mis-selling and fraud (Halan et al., 2014; Sane & Halan, 2017). In this environment of high inflation, low interest rates and limited access to equity markets, gold is able to provide positive real returns, which makes it an important asset class for

²¹See <https://www.capitalmind.in/2020/09/chart-of-the-day-bank-fd-rates-from-1976/>

Table 7 Is gold a safe-heaven?

The table presents the estimation results for the role of gold as a safe haven asset. Zero (negative) coefficients in extreme market conditions ($\gamma_1, \gamma_2, \gamma_3$ for quantile 0.10, 0.05, 0.01) indicate that gold is a weak (strong) safe haven. The first panel shows the results with extreme NIFTY returns, while the second panel shows the results when we consider extreme NIFTY volatility. The results show that gold is a hedge and a strong safe haven for India based on daily data, but these findings do not hold for weekly, fortnightly and monthly returns data. Sample period: July 1999 to March 2021.

	γ_0	γ_1	γ_2	γ_3	γ	# of obs.
Panel A: With extreme NIFTY returns						
Daily	-0.059*** (0.014)	-0.013 (0.039)	0.008 (0.044)	-0.098*** (0.036)	-0.103	5087
Weekly	-0.029 (0.030)	-0.000 (0.083)	-0.022 (0.094)	-0.065 (0.079)	-0.087	1136
Fortnightly	-0.032 (0.045)	-0.071 (0.115)	0.131 (0.122)	-0.086 (0.106)	-0.027	567
Monthly	-0.021 (0.062)	-0.047 (0.177)	-0.074 (0.181)	0.228 (0.156)	0.107	261
Panel B: With extreme NIFTY volatility						
Daily	-0.052*** (0.011)	-0.302*** (0.036)	0.236*** (0.091)	-0.154 (0.167)	-0.220	5087
Weekly	-0.039* (0.023)	-0.308** (0.153)	0.199 (0.235)	-0.079 (0.321)	-0.188	1136
Fortnightly	-0.029 (0.031)	-0.431** (0.190)	0.726** (0.307)	-0.140 (0.450)	0.542	567
Monthly	-0.019 (0.043)	-0.450 (0.283)	0.246 (0.399)	0.188 (0.490)	-0.016	261

Indian households.

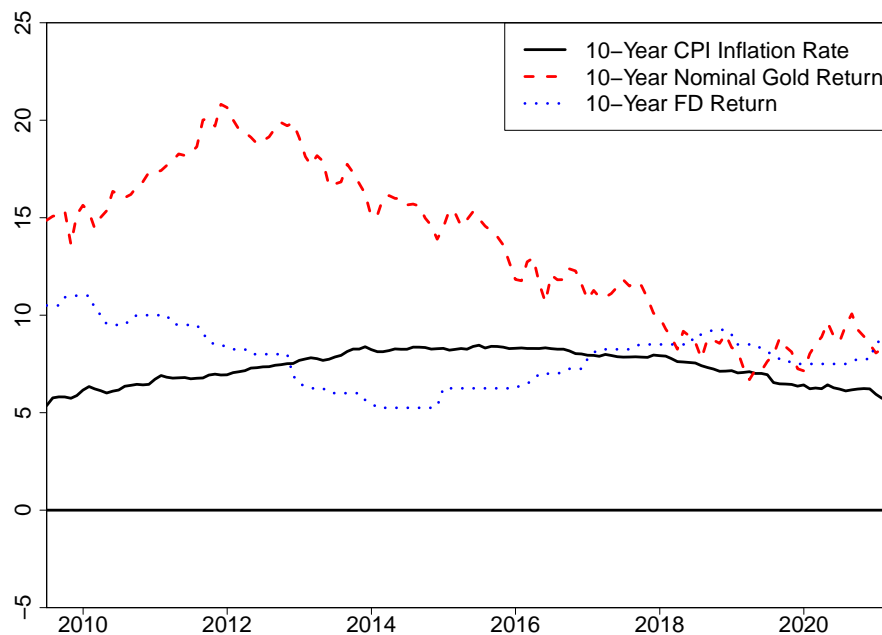
One could argue that equity also beats inflation by its very nature: stock returns keep pace with the growth of the economy, and inflation is built into the growth of the economy. Participation in equity markets, however, has been low - this is not a feature only of the Indian economy - it has been seen in more developed markets as well because of reasons of risk aversion, financial literacy, trust, background risk among others.²² Low participation in India is compounded because of low saving ability, lack of access, financial literacy, as well as trust. For households with low income and low access to finance, equity has not been an instrument of choice.

We turn our attention to measuring how equity and gold have performed over the last twenty years. Table 8 presents the results of a Markowitz mean-variance portfolio optim-

²²There is a rich literature that explores low participation in financial markets. Some of this includes (C.Hsu, 2012; Georgarakos & Pasini, 2011; Heaton & Lucas, 2000; Rooij et al., 2011)

Figure 8 Fixed deposits as long term inflation hedge and gold returns (June 1999 to March 2021)

The plot shows the trailing 10-years rates of inflation (rolling monthly observations), together with nominal returns of gold and fixed deposits (FDs). The FD rates considered in our analysis is based on the State Bank of India's 10-year FD rate. For our study period, State Bank on India is consistently the biggest bank in India with more than a quarter of total public deposits. More than 70% of public deposits in India rests with the public sector banks which closely follow the deposit rates quoted by the State Bank of India.



isation.

The table presents the weights and the Sharpe's ratio for a range of annual target portfolio returns from 13.3% to 14.7%. The global minimum variance portfolio suggests a weight of 63% in gold and 37% in NIFTY. This achieves a target annual return of 13.3% and a Sharpe's ratio of 5.6%. However, the confidence interval on the Sharpe's ratio is quite wide - between 2.9% and 8.3%. This suggests that there is considerable uncertainty in these estimates. As the target return increase, we see that the weight of gold in the portfolio falls. For a target annual return of 14.7%, the weight in gold is down to 4% while that of NIFTY is 96%. The Sharpe's ratio is, however, lower at 3.8%, suggesting that this portfolio carries much more risk. Here too, the confidence interval on the Sharpe's ratio is very wide - from 1% to 6.5%.

When one does a similar optimisation exercise including the SPX 500 returns, the global minimum variance portfolio suggests a weight of 46.5% for gold, 31.3% for NIFTY and 22.2% for SPX. This gives a Sharpe's ratio of 6.2% (CI: 3.4% - 8.8%). Once international

Table 8 Results from a M-V portfolio optimisation

The table presents the results from a Markowitz mean-variance portfolio optimisation. We use data from 31 July 1999 to 31 March 2021. SR stands for Sharpe’s ratio and LCI and UCI for Lower and Upper confidence intervals of the Sharpe’s ratio respectively. w-GOLD and w-NIFTY are the weights of gold and nifty in the portfolio respectively.

Sharpe’s Ratio (SR)	LCI-SR	UCI-SR	w-GOLD	w-NIFTY	Annual Target Return (%)
5.6	2.9	8.3	0.628	0.372	13.311
5.5	2.6	8.2	0.521	0.479	13.595
5.2	2.4	7.7	0.401	0.599	13.879
4.7	1.9	7.3	0.281	0.719	14.164
4.2	1.4	7.0	0.161	0.839	14.450
3.8	1.0	6.5	0.041	0.959	14.736

diversification is possible, the weight of gold has fallen by almost 16 percentage points. Given the performance of gold and NIFTY, and the difficulties of international diversification households have not been entirely unreasonable to hold gold in their portfolios.

6 Robustness checks

To test the robustness of our findings, we do two additional checks. First, in Appendix C, we document the results when we do the same analysis using physical gold prices and gold ETF prices in India. Secondly, we extend the time period of our analysis (till 1988) by substituting NIFTY with the S&P BSE SENSEX index. The S&P BSE SENSEX is India’s most tracked bellwether index. It is designed to measure the performance of the 30 largest, most liquid and financially sound companies across key sectors of the Indian economy that are listed at the Bombay Stock Exchange. We use the S&P BSE SENSEX closing price series since we do not have the total returns series available. Section D in the Appendix shows results using this longer S&P BSE SENSEX series.

We also simulate portfolios based on exogeneously determined weights to understand the relevance of gold in household portfolios. We generate 10,000 returns series for a five year period for different weights of gold and nifty from a bivariate distribution based on historical gold and Nifty returns. Table 9 presents the results. The best Sharpe’s ratio is possible with a portfolio weight of 60% on gold and 40% on equity. This is very similar to the global minimum variance portfolio from the Markowitz framework. The highest returns are possible with a portfolio weight of 30% in gold ad 70% in equity. However, this portfolio has a higher standard deviation implying that the risk would be higher.

Table 9 Simulation results (Exogenous portfolio weights, 10000 simulations)

The table shows simulated portfolios based on exogenously determined weights. They are based on 10,000 returns series generated from a bivariate distribution based on historical gold and Nifty returns.

	Gold-Wt	Nifty-Wt	Mean Portfolio Ret	Mean Portfolio SD	Sharpe Ratio
1	1.00	0.00	59.21	40.95	1.45
2	0.90	0.10	62.74	36.18	1.73
3	0.80	0.20	65.42	33.55	1.95
4	0.70	0.30	67.49	32.54	2.07
5	0.60	0.40	69.05	32.86	2.10
6	0.50	0.50	70.17	34.30	2.05
7	0.40	0.60	70.88	36.66	1.93
8	0.30	0.70	71.20	39.82	1.79
9	0.20	0.80	71.09	43.73	1.63
10	0.10	0.90	70.52	48.43	1.46
11	0.00	1.00	69.37	54.20	1.28

7 Conclusion

India is one of the largest consumers of gold with 25% share in global aggregated demand. The equity premium, in India, has been very high. And yet, gold has continued to dominate household portfolios. The standard reasons understood so far include its importance for accessing credit, as well as significance in cultural and political settings. What is relatively less understood is how gold has performed as an asset class given the macroeconomic and financial environment in India.

In this paper, we use data from June 1999 to March 2021 to evaluate how gold performs vis-a-vis inflation, and vis-a-vis the Indian equity market. We find that over this time period, gold has beaten inflation in India, and is also a hedge and a weak safe-haven in Indian markets. These properties would suggest a much larger weight in a household portfolio in India relative to what may be seen internationally. We, therefore, conduct a Markowitz portfolio optimising exercise to understand how much of one's portfolio should one allocate to gold and NIFTY. The global minimum variance portfolio suggests a 63% weight to gold for target annual return of about 13%. As the target return increases, we see that the weight allocated to gold drops to about 3%. The Sharpe's ratio, however, has wide confidence intervals owing to the very short time series of 22 years for which data is available.

Our analysis suggests that gold has provided the means to Indian households to overcome the difficulties associated with high inflation in a financially repressed macroeconomic environment with capital controls. If policy has to channel household savings to more productive uses, it has to confront the underlying issues in the macroeconomic environment which make gold a preferred investment choice.

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Appendix

A What's the benchmark price of gold for Indian households?

In the Indian households context, it is important to justify our choice of instrument for multiple reasons: First, in India, we have multitude of instruments available to invest in gold: (1) Gold bars; (2) Jewellery; (3) Gold deposit schemes; (4) Indian gold coins; (5) Sovereign gold bonds; (6) Gold ETFs etc. and different households use different instrument for investment. For comprehensive details, refer to Ponnathpur and Dasgupta, 2020. Second, their prices differ considerably. Figure 1 shows the difference between physical price of gold and gold ETF in India. Additionally, the choice of instrument will tell us how long a period we can analyse. Gold ETFs started trading in India from 2007, while daily physical price of gold is available since 2004. However, if gold prices track the LBMA prices closely, we can extend our analysis and go back till 1968.

We use the LBMA 10:30 AM gold fix prices. There are multiple reasons for selecting this price series. First, physical gold prices in India differs significantly from international gold prices and gold ETFs in India. This divergence in prices can be explained by the frequent changes in taxes. For example, on 17 January 2012, India put an ad valorem duty of 2% on the import of gold. Before this, government used to charge a nominal tax of 300 rupees per 10 grams. On 28th February, 2012, the duty was further raised by 2%. On 21 January, 2013, it was revised further and increased to 6% from 4%. On 13 August 2013, the taxes on gold were further increased to 10%. The duty were further increased to 12.5% on July 5, 2019. In 2021, the duties are revised downward to 7.5% but an additional 2.5% cess is added, effectively making the total duty at 10%.

Second, in the absence of government interventions, the gold prices in India track London prices very closely (see Figure 1). A quick glance at Figure 1 suggests that the physical gold prices in India used to track the London gold prices quite closely till 2012, when government used to charge a nominal tax of 300 rupees per 10 grams. And from 2007, the gold ETF prices in India track the LBMA prices closely. This suggests that gold ETF prices are a better indicator of gold prices though they are used less frequently by the Indian households to invest in gold.

Third, most Indian ETFs explicitly states their scheme benchmark as the Morning Fixing of Gold by LBMA.²³ To test this empirically, we calculated the root mean square distance

²³For example, refer to <https://www.sbimf.com/en-us/other-schemes/sbi-etf-gold> for SBI ETF gold

between the Gold ETF prices in India and both London AM and PM fix prices, and found London AM fix prices to be closer to the Indian ETF price. Note that we are using the longest available gold ETF series in India for our analysis here.

Lastly, using London AM fix helps us extend our analysis till July 1999. Given the cost and benefits associated with various gold price indices, in most cases, we also document our results based on physical and gold ETF prices in India as additional robustness checks.

B Physical gold and Gold ETF as hedge against NIFTY

Table 1 Physical gold/ETF as hedge

Note: The physical gold price data is not available from March 20, 2020 to June 25, 2020.

	Physical gold returns			
	Daily	Weekly	Fortnightly	Monthly
Full sample (May 2004 to Mar 2021)	-0.038***	-0.056**	-0.007	-0.068
	(0.013)	(0.027)	(0.035)	(0.043)
Obs.	3712	838	418	196
Last 10 years	-0.114***	-0.151***	-0.050	-0.120**
	(0.021)	(0.042)	(0.046)	(0.055)
Obs.	2198	504	252	118
Last 5 years	-0.024	-0.083	-0.050	0.200**
	(0.051)	(0.053)	(0.054)	(0.100)
Obs.	1070	246	123	58
	Gold ETF returns			
	Daily	Weekly	Fortnightly	Monthly
Full sample (Apr 2007 to Mar 2021)	-0.046**	-0.041	0.017	-0.050
	(0.013)	(0.025)	(0.033)	(0.052)
Obs.	3311	729	364	168
Last 10 years	-0.088**	-0.072**	-0.046	-0.119
	(0.016)	(0.033)	(0.040)	(0.078)
Obs.	2366	523	262	120
Last 5 years	-0.108***	-0.025	0.018	0.039
	(0.020)	(0.039)	(0.058)	(0.109)
Obs.	1183	262	131	60

C Physical gold and Gold ETF as safe heaven against NIFTY

Table 2 Gold as safe heaven

	Physical gold returns				Obs.
	γ_0	γ_1	γ_2	γ_3	
Daily	-0.024 (0.015)	-0.054 (0.044)	0.018 (0.051)	-0.067 (0.050)	3712
Weekly	-0.027 (0.035)	-0.066 (0.104)	-0.025 (0.116)	0.032 (0.096)	838
Fortnightly	-0.048 (0.047)	0.253* (0.142)	-0.199 (0.163)	0.011 (0.125)	418
Monthly	0.021 (0.074)	-0.795*** (0.220)	0.539** (0.233)	0.691*** (0.142)	196
	Gold ETF returns				Obs.
	γ_0	γ_1	γ_2	γ_3	
Daily	-0.039** (0.017)	-0.055 (0.043)	0.017 (0.048)	0.103** (0.048)	3311
Weekly	-0.051 (0.031)	0.085 (0.094)	-0.162 (0.108)	0.168* (0.097)	729
Fortnightly	-0.035 (0.043)	0.252** (0.123)	-0.381*** (0.137)	0.321*** (0.118)	364
Monthly	-0.039 (0.072)	-0.181 (0.250)	-0.153 (0.259)	0.576*** (0.165)	168

D Gold and S&P BSE SENSEX

Table 3 Gold as a hedge

Sample period: January 1988 to March 2021. Note that S&P BSE SENSEX closing prices are used instead of total returns index.

	Daily	Weekly	Fortnightly	Monthly
Estimate	-0.041*** (0.007)	0.004 (0.014)	0.017 (0.020)	-0.002 (0.027)
# of Obs.	7495	1724	861	399

Table 4 Gold as a safe-heaven

Sample period: January 1988 to March 2021. Note that S&P BSE SENSEX closing prices are used instead of total returns index.

	γ_0	γ_1	γ_2	γ_3	nobs
With extreme BSE returns					
Daily	-0.027*** (0.009)	0.006 (0.026)	0.018 (0.030)	-0.162*** (0.026)	7495
With extreme BSE volatility					
Daily	-0.029*** (0.007)	-0.254*** (0.032)	-0.001 (0.075)	0.447*** (0.144)	7495
With extreme SPX returns					
Daily	-0.023*** (0.007)	-0.033 (0.034)	-0.077* (0.044)	-0.228*** (0.045)	7495
With extreme SPX volatility					
Daily	-0.042*** (0.007)	0.029 (0.039)	-0.019 (0.053)	-0.054 (0.083)	7495

E Data availability

The datasets were derived from sources in the public domain mentioned in the manuscript. The consolidated data underlying this article will be shared on reasonable request to the corresponding author.