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Does gold hedge stock market, inflation and exchange rate risks? An econometric investigation

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ABSTRACT

This paper conducts a comprehensive empirical study of hedging potential of gold against adverse movements of stock prices, inflation and exchange rate for India, Pakistan and the United States. Using daily and monthly data covering the period of 1990 to 2013, this paper first explains the average gold returns using an EGARCH model. The paper also investigates whether hedging potential of gold remains equally strong in several bearish and bullish conditions of gold market using a quantile regression approach. It was found that there is a fairly robust evidence of gold acting as a safe haven against exchange rate risk in Pakistan and India. However, the evidence of gold hedging stock market risk is not uniformly strong in varying gold market conditions in the three countries. Also the evidence that gold hedges inflation risk in the US is realized only during the average and bearish conditions of gold market but not during bullish trends. The paper found robust evidence of gold acting as a safe haven against deteriorating local currency in Pakistan using daily data. The hedging and safe have benefit of gold against currency risk is also fairly strong in India as evidenced in the daily data. Thus, the empirical findings of gold acting as either a hedge or a safe haven against the risks in other asset markets need some qualification pertaining to the gold market condition itself.

1. Introduction

This paper investigates the hedging potential of investment in gold to the risks of adverse movements of stock prices, commodity prices and exchange rates. Theoretically, any asset, which when added to a portfolio *P,* reduces the variance of the portfolio without reducing average returns is desirable for investors. Assets having negative correlations between them especially enhance this diversification property. Following Baur and McDermott (2010) and Baur and Lucey (2010) this paper investigates whether gold has negative or zero correlation with stock prices and positive correlation with commodity prices and exchange rates on average i.e. whether gold has ability to hedge the investment risks in these assets. The paper also investigates whether gold is a safe haven i.e. whether gold returns have negative or zero correlation with stocks in the circumstances of extremely bearish stock market and positive correlation with inflation and exchange rate (local currency per unit of foreign currency) in their adverse conditions. If this is so, gold will be a desirable asset in the portfolio of investors being a friend in rainy days. The losses due to extremely adverse stock market movement will be compensated by the upward movement of gold prices. Also, any deterioration in purchasing power due to inflation or currency depreciation will be compensated by gold.

This paper extends the work of Baur and Lucey (2010) and Baur and McDermott (2010) in several ways. Firstly, it investigates the hedging potential of gold with respect to financial asset prices and commodities price inflation for two South Asian emerging markets in particular India and Pakistan and compare the same with a developed market of the United States. Secondly, the analysis extends

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to investigate whether hedging potential of gold investment differs in different bullish and bearish conditions of gold market. The dummy variable approach adopted by Baur and McDermott (2010) and Baur and Lucey (2010) of modeling gold returns addresses the question whether gold serves as a hedge against other assets on average conditions and during certain extreme conditions for these assets. Specifically their investigation relates average gold returns to centre and to extreme quantiles of the distribution of assets against which gold is held to serve as hedge or haven. A question of equal interest is whether the hedging potential of gold is different under varying bullish and bearish conditions of gold market itself. Recently Wang, Xie, Jiang, and Stanley (2016) found that extreme risk is more quickly transmitted in the post-crisis era than in the pre-crisis era, an effect that was related to the safe-haven or risk-hedging property or the speculative value of gold.

The quantile regression enables us to investigate such relationship for several lower and higher quantiles of the gold return distribution. Thus, whereas the regression approach adopted in the literature presents a partial picture of the relationship between gold and the asset to be hedged, the quantile regression portrays a more comprehensive and refined picture. Accordingly, this study investigates whether the hedge coefficients are altered significantly if we consider several bullish and bearish periods in the gold market.

This paper employed data from India, Pakistan and the US. The countries selected for analysis in the paper have some notable features. The US has the highest reserves of official gold holdings (8133.5 tonnes as on July 2014, source: World Gold Council). India is traditionally the largest consumer of gold in the world especially due to demand for gold jewellery which amounted to 746 tonnes in 2010. Recently China is replacing India as the largest jewellery market for gold (www.goldfacts.org). Pakistan possesses typical features of an emerging market. See Iqbal (2012) for comparison of various aspects of stock markets of Pakistan and India with a selected set of countries including the US.

2. Literature review

The relationship of gold to stock market is a popular issue for the financial analysts who often assess the intensity of economic recession by the extent of drop in the ratio of Dow Jones Industrial Average to the gold price (ounces), see Gutiérrez et al. (2013). Hedging potential of gold and other precious metals against stock market has recently been investigated in several papers. Baur and Lucey (2010) and Baur and McDermott (2010) were first to formally define an asset to be a hedge or a safe haven against another asset. According to Baur and McDermott (2010) a weak (strong) hedge is defined as an asset that is uncorrelated (negatively correlated) with another asset on average. A weak (strong) safe haven is defined as an asset that is uncorrelated (negatively correlated) with another asset in adverse conditions of the market for the later. In their empirical analysis Baur and Lucey (2010) investigated whether gold is a hedge and safe haven for stocks and bonds in the UK, US and German markets. Using daily data from November 1995 to November 2005, they employed a time series regression model where gold returns was used as dependent variable and stock and bond returns and two interactive dummy variable terms were used as explanatory variables to capture extreme stock market decline. The time variations in the gold volatility was modeled using a GARCH (1,1) model. Their results show that gold appears to act as a safe haven for stocks in the United States, the United Kingdom and Germany. Gold is also found as a hedge for stocks in the United States and the United Kingdom. However, gold is found neither as a hedge nor a safe haven for bonds in both the United States and the United Kingdom. Their analysis reveals that gold is not a safe haven for stocks at all times but only in extreme bearish stock market and that the safe haven property is short-lived. Baur and McDermott (2010) examined the role of gold in the global financial system. They tested the hypothesis that gold acts as a hedge and safe haven for stocks of emerging and developed markets. Covering a sample of 30 years of daily, weekly and monthly data from March 1979 to March 2009 and employing a model similar to Baur and Lucey (2010), they found that gold acts a safe haven for most of the developed country stock markets with strongest finding being for the daily data especially for extreme shocks occurring with a probability less than one percent. They also found that investors of developed and emerging markets react in different ways to shocks. Gold is found to be a weak safe haven for some emerging markets. Thus, their results corroborate the hypothesis that the safe haven asset plays a relatively minor role in emerging markets. They interpret this finding to imply that investors, suffering losses in emerging market stocks, simply readjust their portfolios to average returns rather than seeking an alternative haven asset. Hood and Malik (2013) compared the hedge and haven property of gold, silver and platinum with the volatility index (VIX) for the US market using daily data from November 1995 to November 2010 and found that VIX is better hedge than gold. They also investigated the extent to which this hedging property of VIX and gold is retained under calendar time regimes of the VIX. These regimes were endogenously determined using Inclan and Tiao (1994) criteria. They found that in all regimes VIX was a superior hedge against stock market. Dee et al. (2013) investigated whether gold is a hedge or a safe haven against stock and inflation risk in mainland Chinese stock market. Employing daily and monthly data from October 2002 to April 2012 they found that gold could not hedge stock or inflation risk for short term investors but it did for long term investors. Using multiple and quantile regression techniques they found that gold was not a safe haven with respect to stock and inflation risk in the Chinese capital market. Capie, Mills and Wood (2005) examined whether gold acts as a hedge against the US dollar. Using an ARDL model to explain changes in gold prices with the GARCH and EGARCH error structure, they employed thirty years weekly data from January 1971 to February 2004 on the gold price and sterling–dollar and yen–dollar exchange rates. They found negative and typically inelastic relationship between gold and these exchange rates. The strength of this relationship varied over time and seemed to be highly dependent on unpredictable political attitudes and events.

Quantile regression is being increasingly applied to financial applications. Cappiello, Gerard, and Manganelli (2004) examined the contagion effect between international financial markets. They found an asymmetric contagion and that contagion was generally higher in the left tail of the distribution i.e. when the markets were in bearish conditions. Recently Mensi, Hammoudeh, Reboredo, and Nguyen (2014) used quantile regression to investigate whether dependence of stock returns of BRICS markets (Brazil, Russia,

India, China and South Africa) on global economic and financial variables is different in bearish markets (lower quantiles) and bullish market (upper quantiles). They found that the BRICS markets do exhibit asymmetric dependence on global factors. Quantile regression has also found applications in finance, especially in relation to computing value-at-risk e.g. in Gaglianone, Lima, Linton, and Smith (2011).

3. Descriptive analysis

3.1. The data and their sources

Daily and monthly data on gold prices and stock market indexes and monthly data of consumer price index for Pakistan, India and the US are collected for this study. The sample ranges of the data covers the periods from Jan 1990 to Nov 2013 for Pakistan, from Jan 1991 to Nov 2013 for India and from Jan 1991 to Nov 2013 for the US. The KSE-100 Index, BSE-100 Index and S & P-500 Index is used to represent aggregate stock market movements for Pakistan, India and the US respectively. The data on these variables are obtained from Yahoo Finance and the website of Indian Stock Exchange. We obtained monthly consumer price index data from International Financial Statistics (IFS, IMF, and Washington DC). The data on gold prices were obtained from the website of World Gold Council (http://www.gold.org). To determine gold prices in Pakistan and India we multiplied dollar denominated gold prices (per troy ounce) by current monthly closing exchange rates of Pak Rupee per US dollar and Indian Rupee per US dollar respectively. Exchange rate data were obtained from IFS. As modeling of time series variables through GARCH model requires stationary time series we computed log returns using the formula:

$$r_t = 100 \times \ln\left(\frac{P_t}{P_{t-1}}\right) \tag{1}$$

here P_t: closing value of gold price, stock market index or CPI in month t, P_{t-1}: closing value of gold price, stock market index or CPI of the previous month.

3.2. Descriptive statistics of stock market returns, consumer price inflation and gold returns

Table 3.1 presents the descriptive statistics of gold returns, inflation and stock index returns for the three countries. It is evident that both the stock markets of India and Pakistan have higher average returns and higher associated dispersion as compared to the US market. This is a typical feature of emerging markets i.e. higher risk and higher returns than the developed markets. Both the gold returns and inflation rates are higher on average in Pakistan than India and the US. The variability of the data is the highest for stock returns followed by gold returns and inflation rate for all the three countries.

3.3. Historical patterns of gold, CPI and exchange rates

The left panels of Fig. 3.1 present the time series plots of gold prices and stock market indexes for the three countries respectively for monthly data. It is observed that the stock prices are much more volatile than the gold prices in all the three countries. The nominal gold prices have increased rapidly after 2007 in India and Pakistan. Stock prices show a sharp decline being at their lowest level in around 2009 in all the three countries. In the US, gold prices appear to move in opposite direction to the stock market especially after the recent global financial crises starting from 2008. Apparently no pattern of relationship between the two variables is observed in Pakistan and India. The right panels present the time series plot of gold prices and consumer prices indexes for the three countries. Gold prices show more variability than the consumer prices.

Fig. 3.2 present the time series plot of gold prices and exchange rates of the South Asian currencies vs. US dollar. Pakistani currency was steadily decreasing in value relative to the US dollar up until 2000. After few years of stability during 2000–2007,

Table 3.1
Descriptive statistics of log percentage change of gold prices, CPI and stock market of Pakistan, India and US (Monthly Data).

		Obs	Mean	Median	Standard deviation	Minimum	maximum
PAKISTAN	Gold	275	1.05	1.14	4.49	-14.64	15.98
	CPI	275	0.72	0.65	0.73	-0.87	3.28
	KSE-100 Index	253	1.20	1.63	9.67	-44.87	28.94
INDIA	Gold	285	0.85	0.75	4.63	-13.93	18.28
	CPI	285	0.64	0.66	0.85	-2.12	4.47
	BSE-100 Index	253	1.15	1.60	9.05	-30.06	43.16
US	Gold	285	0.40	0.36	4.60	-19.08	15.99
	CPI	285	0.21	0.20	0.33	-1.93	1.21
	S & P-500 Index	285	0.58	1.09	4.31	-18.56	10.57

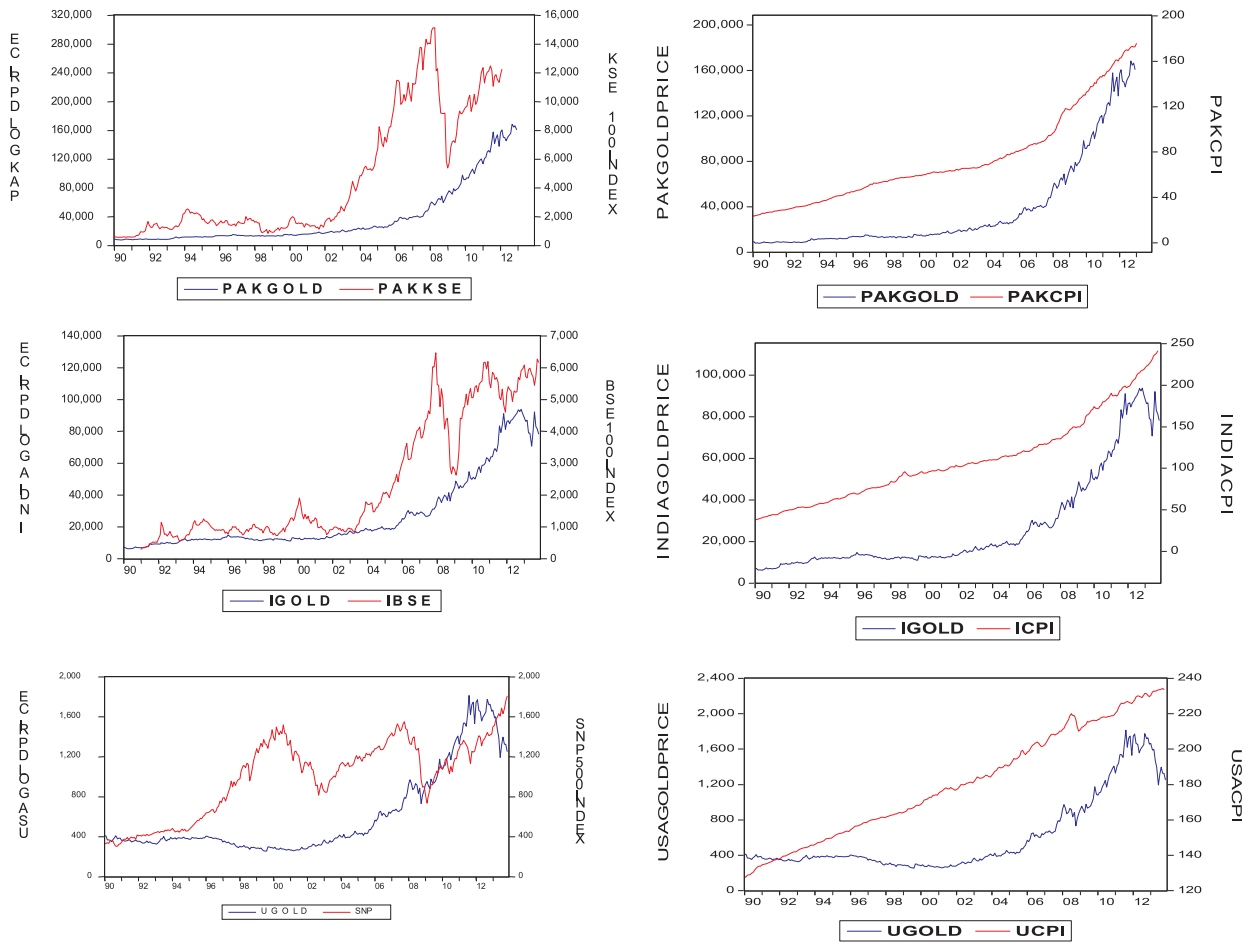

Fig. 3.1. Time series plot of gold prices, stock market Indices and CPI in Pakistan, India and US.

exchange rate resumed its deterioration. During this period, Indian rupee has also generally deteriorated in value relative to the US dollar. After 2004 the Indian currency has shown higher volatility than previous years. Again no clear pattern of any relationship is observed between the gold prices and exchange rate in the two countries. Generally positive relationship between gold prices exchange rate can be observed in Pakistan especially after 2008.

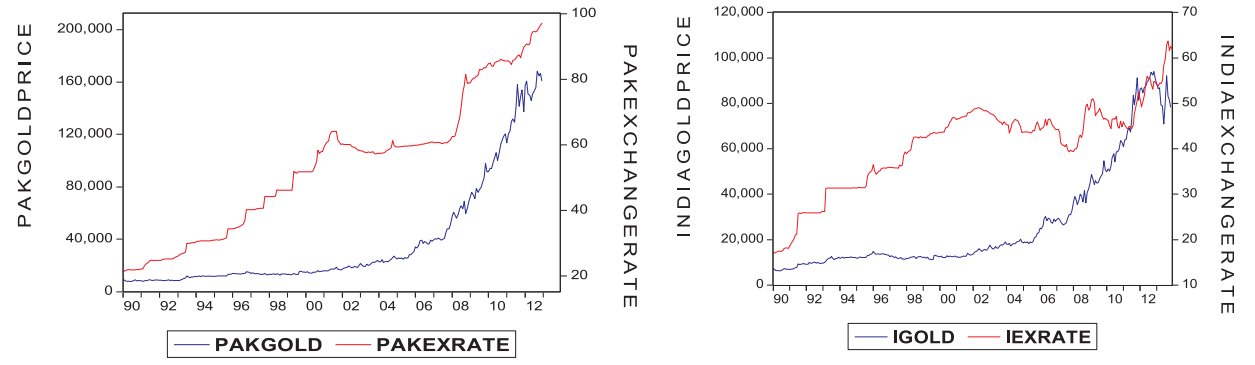

Fig. 3.2. Time series plot of gold prices and of exchange rate for Pakistan and India.

Table 4.1
Estimation output result between gold returns (%) and stock market (%) of Pakistan, India and US.

GOLD RETURN	PAKISTAN			INDIA			US		
	Coef	SE	t-stat p-value	Coef	SE	t-stat p-value	Coef	SE	t-stat p-value
γ_1(hedge)	0.014	0.032	0.448 0.653	0.049	0.032	1.52 0.126	-0.098	0.077	-0.756 0.225
$\Sigma\ \gamma_i$(10%)	0.101	0.095	1.07 0.857	-0.010	0.090	-0.11 0.456	-0.096	0.15	-0.607 0.271
$\Sigma\ \gamma_i$(5%)	-0.012	0.075	-0.17 0.432	-0.139	0.074	-1.87** 0.030	-0.343	0.15	-2.15** 0.015
$\Sigma\ \gamma_i$(1%)	0.083	0.051	1.615 0.946	0.141	0.122	1.15 0.874	0.440	0.117	3.76 0.99
	Conditional volatility			Conditional volatility			Conditional volatility		
δ_0	0.398	0.183	2.16 0.03	0.847	0.594	1.42 0.15	-0.047	0.059	-0.802 0.422
δ_1	0.046	0.095	0.480 0.630	0.370	0.145	2.54 0.01	0.161	0.069	2.32 0.02
δ_2	0.274	0.085	3.20 0.001	0.201	0.092	2.18 0.02	0.033	0.047	0.704 0.481
δ_3	0.849	0.067	12.57** 0.000	0.616	0.218	2.824** 0.0047	0.974	0.022	43.03** 0.000

***,**,* indicate statistical significance at the level of 0.01, 0.05 and 0.10 respectively.

4. Econometric analysis of hedging potential of gold

4.1. Gold and stock market

The modeling framework adopted here is similar to Baur and Lucey (2010). Specifically the following equations are estimated by maximum likelihood method with EGARCH (1,1) error structure.

$$r_t = \alpha + \beta_t r_{stock} + e_t \tag{2}$$

$$\beta_t = \gamma_1 + \gamma_2 D(\mathrm{r_{stock}q_{10}}) + \gamma_3 D(\mathrm{r_{stock}q_5}) + \gamma_4 D(\mathrm{r_{stock}q_1}) \tag{3}$$

$$\log(h_t) = \delta_0 + \delta_1 log(h_{t-1}) + \delta_2 \left| \frac{e_{t-1}}{\sqrt{h_{t-1}}} \right| + \delta_3 \frac{e_{t-1}}{\sqrt{h_{t-1}}} \tag{4}$$

Here r_t and r_{stock} are the returns of gold and stock respectively. The terms $D(r_{stock}q_5)$, $D(r_{stock}q_{10})$ and $D(r_{stock}q_1)$ are dummy variable which create interaction with stock returns in the mean equation. The dummy variables have value 1 if the stock return is less than the specified quantile and zero otherwise. Thus we study the role of gold in times of stress or extreme stock market decline that are in the lowest q% quantile, where q equal, 10 and 1 respectively. We employ EGARCH (1,1) with *student t* error distribution to allow asymmetric response of shocks to the volatility. If gold and stock market relation is non-linear, one of the parameters γ_2, γ_3 and $\gamma_4$is significantly different from zero. If γ_1 is significantly negative then gold acts as a hedge against stock market. If sum of γ_1 , γ_2,γ_3 and γ_4 is less than or equal to zero then gold acts as a safe haven against stock at the 1% quantile i.e. when the stock market returns are in the lowest 1%, gold has a negative relation with stock market and gold will act as a safe haven. The sum of γ_1 through γ_3 indicates the haven property at 5% quantile and sum of γ_1 and γ_2 indicates haven property at 10% quantile respectively. Table 4.1 presents the estimation results for the role of gold as a hedge and safe haven against stock market for Pakistan, India and the US for monthly data. We tested whether the population coefficient or sum of coefficients are greater than or equal to zero against the alternative that they are less than zero. The results show that gold does not seem to hedge against stock market of the three countries as seen from the insignificance of hedge coefficients. In case of the US the hedge coefficient is negative but insignificant at the conventional significance level. Only in case of India and the US the sum of coefficients is significantly negative for 5% quantile of stock returns. This shows that when the stock returns fall below the lowest 5% quantile, gold increase in value significantly to act as a safe haven for investors in India and the US. Our results for US are slightly different from Baur and Lucey (2010) who using daily data from Nov 1995 to Nov 2005 got a significantly negative hedge coefficient and significantly positive hedge coefficient. The difference may be attributable to the fact that our sample frequency is monthly and covers a longer span from Jan 1990 to Nov 2013. i.e. including US sub-price credit crises period as well. The coefficients in EGARCH volatility model are mostly significant but the evidence of asymmetric volatility is not observed in any of the three countries.

4.2. Gold and inflation

From investor's point of view, the adverse conditions of inflation and exchange rate are those when the percentage changes of these variables attain their highest values e.g. those values exceeding the 95% quantiles.

The paper extends the Baur and Lucey (2010) approach to investigate the inflation hedging potential of gold. Specifically the econometric model is now specified as:

$$r_t = \alpha + \beta_t r_{inflation\ rate} + e_t \tag{5}$$

$$\beta_t = \rho_1 + \rho_2 D(r_{inflationrate}, q_{90}) + \rho_3 D(r_{inflationrate}, q_{95}) + \rho_4 D(r_{inflationrate}, q_{99}) \tag{6}$$

$$\log(h_t) = \theta_0 + \theta_1 \log(h_{t-1}) + \theta_2 \left[\frac{e_{t-1}}{\sqrt{h_{t-1}}} \right] + \theta_3 \frac{e_{t-1}}{\sqrt{h_{t-1}}} \tag{7}$$

Here the dummy variables $D(r_{inflation\ rate} q_{90})$, $D(r_{inflation\ rate} q_{95})$ and $D(r_{inflation\ rate} q_{99})$ accounts for asymmetries of extremely high inflation. These are the dummy variables having value 1 if the inflation rate is greater than the specified quantile and zero otherwise. In particular, we study the role of gold in times of stress or extremely high inflation rate that are in the upper q% percentiles such as the 90%, 95% and 99%. If gold and inflation rate relation is non-linear, one of the parameters ρ_2, ρ_3 and ρ_4 should be significantly different from zero. If sum of ρ_1 , ρ_2, ρ_3 and ρ_4 is greater than or equal to zero then gold acts as a safe haven against inflation rate at 99th percentile. If only ρ_1 coefficient is significantly positive then gold acts as a hedge against inflation. During inflation investors lose purchasing power of their income. Thus if gold serves a hedge against inflation risk, its price must increase to keep investors purchasing power intact. This is consistent with Fisher's (1930) theory that stipulates that nominal asset prices include an expected inflation component. We use a right tail alternative to test gold's hedge or safe haven property.

Table 4.2 presents the estimation results for the role of gold as a hedge and safe haven against inflation. The results indicate that gold acts as a hedge against inflation only in the US as the hedge coefficient is significantly positive. Also gold appears to be a safe haven asset against inflation in the US as gold returns increase in highly inflationary conditions of the economy in particular when inflation rate is higher than the upper 90th quantile. No evidence is found in support of gold acting as a hedge or safe haven against inflation in India and Pakistan. Our results are consistent with a recent study for the emerging market of China by Dee et al. (2013) who using daily and monthly data from December 2002 to March 2012, found similar results indicating that gold does not serve as a safe haven for inflation risk in China. As for South Asian markets gold prices are expressed in local currency, therefore changes in gold returns may occur due to change in gold prices in international market denominated in US dollar or due to change in exchange rate of local currency vs. the US dollar. The relationship of inflation and gold returns may therefore be difficult to establish for emerging markets.

4.3. Gold and exchange rate

To investigate whether gold is a hedge or a safe haven against deteriorating local currency, we specified the econometrics model as follows:

Table 4.2
Estimation output result between gold returns (%) and inflation rate (%) of Pakistan, India and the US.

GOLD RETURN	PAKISTAN			INDIA			US		
	Coef	SE	t-stat p-value	Coef	SE	t-stat p-value	Coef	SE	t-stat p-value
ρ_1(hedge)	-1.19	1.520	-0.78 0.782	0.204	0.988	0.206 0.418	5.89	3.38	1.74* 0.0409
Σ ρ_i(90%)	-1.12	1.78	-0.62 0.732	-1.075	1.22	-0.88 0.810	7.264	3.61	2.01** 0.022
Σ ρ_i(95%)	-1.85	1.64	-1.13 0.870	-0.459	1.178	-0.38 0.648	7.74	3.61	2.14** 0.0161
Σ ρ_i(99%)	-0.200	0.457	-0.43 0.666	-0.859	0.381	-2.25 0.987	1.21	0.82	1.48* 0.069
	Conditional volatility			Conditional volatility			Conditional volatility		
θ_0	0.466	0.200	2.33*** 0.009	1.362	0.587	2.31*** 0.010	-0.023	0.099	-0.240 0.594
θ_1	0.068	0.099	0.684 0.264	0.291	0.135	2.154** 0.015	0.251	0.100	2.49*** 0.006
θ_2	0.283	0.089	3.16*** 0.0007	0.309	0.094	3.26*** 0.000	0.033	0.057	0.585 0.279
θ_3	0.817	0.075	10.8*** 0.000	0.460	0.207	2.22** 0.013	0.942	0.041	22.67*** 0.000

***, **,* indicate statistical significance at the level of 0.01, 0.05 and 0.10 respectively.

Table 4.3
Estimation result between gold returns (%) and exchange rate returns (%) of Pakistan and India.

GOLD RETURN	PAKISTAN			INDIA		
	Coef	SE	t-stat P-value	Coef	SE	t-stat P-value
τ_1(hedge)	0.514	0.184	2.797*** 0.002	0.675	0.094	7.111*** 0.000
$\Sigma\ \tau_i$(90%)	1.017	0.673	1.511* 0.065	0.346	0.418	0.826 0.204
$\Sigma\ \tau_i$(95%)	0.668	0.488	1.370* 0.085	0.617	0.317	1.945** 0.025
$\Sigma\ \tau_i$(99%)	0.907	0.369	2.455*** 0.007	0.308	0.209	1.473* 0.0703
	Conditional volatility			Conditional volatility		
ω_0	0.121	0.152	0.789 0.215	0.542	0.512	1.058 0.145
ω_1	0.187	0.099	1.88** 0.029	0.339	0.134	2.53*** 0.0057
ω_2	0.137	0.080	1.703** 0.044	0.132	0.091	1.452* 0.073
ω_3	0.903	0.0600	15.05*** 0.000	0.722	0.193	3.732*** 0.000

***, **,* indicate statistical significance at the level of 0.01, 0.05 and 0.10 respectively.

$$r_t = \alpha + \beta_t r_{exchange\ rate} + e_t \tag{8}$$

$$\beta_t = \tau_1 + \tau_2 D(\mathrm{r}_{\text{exchange rate}}\mathrm{q}_{90}) + \tau_3 D(\mathrm{r}_{\text{exchange rate}}\mathrm{q}_{95}) + \tau_4 D(\mathrm{r}_{\text{exchange rate}}\mathrm{q}_{99}) \tag{9}$$

$$\log(h_t) = \omega_0 + \omega_1 \log(h_{t-1}) + \omega_2 \left[\frac{e_{t-1}}{\sqrt{h_{t-1}}} \right] + \omega_3 \frac{e_{t-1}}{\sqrt{h_{t-1}}} \tag{10}$$

Here r_{Gold} and $\mathrm{r}_{\text{exchange rate}}$ are the returns of gold and exchange rate. The term $D(\mathrm{r}_{\text{exchange rate}}\mathrm{q}_{90})$,$D(\mathrm{r}_{\text{exchange rate}}\mathrm{q}_{95})$ and $D(\mathrm{r}_{\text{exchange rate}}\mathrm{q}_{99})$ account for asymmetries of extreme shocks in the foreign exchange market.

The dummy variables have value 1 if exchange rate return is higher than the specified quantile and zero otherwise. In particular, we study the role of gold in times of stress or extremely high exchange rates e.g. exceeding the 90%, 95% or 99% quantiles. If the relationship between gold and exchange rate is non-linear, one of the parameters $\tau_2,\tau_3 and \tau_4$ should be significantly different from zero. If sum ofτ_1 , τ_2,τ_3 and $\tau_4$is greater than or equal to zero then gold act as a safe haven against adverse exchange rate movement at 99% percentile. If only τ_1 is positive and significant then gold acts as a hedge against exchange rate risk. Thus if gold hedges risk of depreciating local Pakistani or Indian currencies, its price must increase yielding an expected positive relationship with exchange rate returns. To test this hedging potential of gold we again use a right tail test on coefficients.

Table 4.3 presents the estimation results for the role of gold as a hedge and safe haven against exchange rate risk. The results indicate that gold appears to be a hedge against the adverse movement of exchange rate in both India and Pakistan. That is, when local Pakistani and Indian currencies are losing their value against the dollar, gold appears to increase in value. So we find a positive and significant relation between gold return and exchange rate. The significant positive aggregated coefficients indicate that gold is also a safe haven against extremely adverse conditions in foreign exchange market as measured by upper quantiles of exchange rate returns in both Pakistan and India. This is an important result for investors in these emerging markets who are often worried about depreciating local currencies. Thus, gold appears to compensate risk of adverse conditions in foreign exchange market. The losses of these South Asian investors are compensated by favorable movement in gold price during the average as well as in extremely bearish conditions of foreign exchange markets.

5. Quantile regression analysis of gold returns

Previous analysis focused on the relationship between average gold returns and stock market, inflation and exchange rate risks using multiple regressions. According to Mosteller and Tukey (1977) 'Just as the mean gives an incomplete picture of single distribution, so the regression curve gives a correspondingly incomplete picture for a set of distributions'. It is important to ascertain that hedging potential of gold is equally strong in several bearish and bullish conditions in the gold. In this context quantile regression, developed by Koenker and Basset (1978), is the relevant technique. In quantile regression our focus moves away from the average to other selected points on the conditional distribution of gold returns. Our analysis is different from Hood and Malik (2013)

who investigated hedging behavior of gold in calendar regimes of gold volatility. In contrast, we investigated the hedge and haven property of gold in various quantiles of gold return distribution.

For a random variable Y with probability distribution function $F(y) = P(Y \leq y)$, the τth conditional quantile of Y given $X = x$ is defined as the following inverse function:

$$Q_\tau(Y/x) = \{y: F(y/x) \geq \tau\}, \quad 0 < \tau < 1, \tag{11}$$

The linear regression model is the conditional mean as a function of explanatory variables i.e. $E(Y/x) = x'\beta$. In contrast the quantile regression is defined as $Q_\tau(Y/x) = x'\beta(\tau)$, where $\beta(\tau)$ is the vector of coefficients associated with variable x for the τth quantile. The Least Absolute Deviation (LAD) approach yields the parameter estimates as:

$$\hat{\beta}(\tau) = \arg\min_{\beta} \sum_{i=1}^{n} \rho_\tau(y_i - x'\beta) \tag{12}$$

where ρ_τ is the asymmetric weighted absolute value function defined as $\rho_\tau(z) = z(\tau - I_{\{z<0\}})$

The case $\tau = 0.5$ which minimizes the sum of absolute residuals corresponds to median regression. It can be observed that the quantile regression uses the full sample data in the estimations albeit with different weights.

As Buchinsky (1998) describes, the quantile regression's objective function is a weighted sum of absolute deviations, which gives a robust measure of location, so that the estimated coefficient vector is not sensitive to outlier observations on the dependent variable. Also when the error term is non-normal, quantile regression estimators may be more efficient than least squares estimators.

5.1. Quantile regression of gold vs. stock market

To examine the hedging properties of gold under various quantiles of the gold return distribution we specify the regression as follows:

$$Q_\tau(Y/x) = \beta_{0(\tau)} + \beta_{1(\tau)} rstock + \beta_{2(\tau)} rstock \times D(\text{rstock q10}) + \beta_{3(\tau)} rstock \times D(\text{rstock q5}) + \beta_{4(\tau)} rstock \times D(\text{rstock q1}) + e_t \tag{13}$$

Here $Q_\tau(Y/x)$ is the conditional quantile of gold returns and $D(rstock\ q10)$, $D(rstcok\ \ q5)$ and $D(rstock\ \ q1)$ represent the dummy variables that assume value 1 if stock return is below the respective quantiles and zero elsewhere. In Eq. (13) a significantly negative β_1 coefficient indicates that the gold is acting as a hedge at the specified quantile. The sum of coefficients β_1,β_2,β_3 and β_4 is used to indicate safe haven property of gold when the stock market experiences the lowest 1% returns. Tables 5.1–5.3 present the estimation of quantile regression of gold returns on stock index return for Pakistan, India and US respectively for τ = 10%, 25%, 50%, 75%, 90%. The quantile regression results reported in Table 5.1, indicate that gold is not a hedge against stock market in Pakistan during average conditions and in any bearish or bullish conditions in the gold market. The quantile regression results are similar to the Baur and Lucey (2010) approach which are reported in the 2nd and 3rd columns in Table 5.1 to facilitate comparison. The sum of coefficients corresponding to 10% quantile of gold returns show that gold can provide a safe haven against bearish stock market (returns falling in their lowest 5% quantile) only in case when gold is also in bearish mood. Table 5.2 shows that results of hedging power of gold from quantile regression are similar to the Baur and Lucey model in the case of India. Table 5.3 indicates that the safe haven property of gold remains intact during bearish conditions in stock market as well in the US as seen by the significance of aggregated coefficients at 10% and 25% quantile of gold. It is also observed that during bullish conditions in gold market as measured by 90th quantile, gold has a significant negative relation with stock market in its bearish conditions (represented by 10% quantile).

Table 5.1
Quantile regression of gold vs. stock for Pakistan.

Gold	Baur and Lucey		Quantiles Regression									
	Coef	t-stat pvalue	10th		25th		50th		75th		90th	
			Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue
$\beta_1(hedge)$	0.014	0.448 0.653	0.016	0.29 0.76	-0.03	-0.76 0.44	0.05	1.12 0.26	-0.05	-1.07 0.28	-0.04	-0.70 0.47
$\Sigma\ \beta_2(10\%)$	0.101	1.07 0.85	1.072	0.65 0.741	0.01	0.15 0.55	0.10	0.99 0.83	0.20	1.72 0.95	0.23	1.81 0.96
$\Sigma\ \beta_3(5\%)$	-0.012	-0.17 0.432	-0.170	-1.93** 0.026	-0.10	-1.03 0.15	0.10	1.48 0.93	0.002	0.04 0.51	0.09	1.41 0.92
$\Sigma\ \beta_4(1\%)$	0.083	1.615 0.946	1.615	0.55 0.708	0.08	1.23 0.89	0.05	0.28 0.61	-0.06	-1.06 0.144	-0.009	-0.02 0.49

***, **, * indicate statistical significance at the level of 0.01, 0.05 and 0.10 respectively.

Table 5.2
Quantile regression of gold vs. stock for India.

Gold	Baur and Lucey		Quantile regression									
	Coef	t-stat pvalue	10th		25th		50th		75th		90th	
			Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue
$\beta_1(hedge)$	0.049	1.52 0.126	-0.04	-0.75 0.45	-0.001	-0.03 0.96	-0.05	-1.34 0.18	0.09	1.36 0.17	0.16	2.43 0.01
$\Sigma\ \beta_2(10\%)$	-0.010	-0.11 0.456	-0.0098	-0.78 0.21	-0.0009	-0.005 0.49	-0.08	-0.64 0.26	-0.03	-0.38 0.35	-0.2	-0.53 0.29
$\Sigma\ \beta_3(5\%)$	-0.139	-1.87** 0.03	-0.476	-1.13 0.12	-0.08	-0.56 0.28	0.12	-1.15 0.12	-0.1	-2.0** 0.02	-0.1	-1.2 0.11
$\Sigma\ \beta_4(1\%)$	0.141	1.15 0.874	2.736	5.39 0.99	0.39	4.50 0.99	0.16	0.95 0.82	0.09	0.79 0.78	0.22	2.77 0.99

***, **, * indicate statistical significance at the level of 0.01, 0.05 and 0.10 respectively.

5.2. Quantile regression of gold vs. inflation

To investigate whether gold hedges inflation risk we estimated the following quantile regression model:

$$Q_\tau(Y/x) = \beta_{0(\tau)} + \beta_{1(\tau)} r\mathrm{inf}lation + \beta_{2(\tau)} r\mathrm{inf}lation \times D(\text{rinflation q90}) + \beta_{3(\tau)} r\mathrm{inf}lation \times D(\text{rinflation q95}) + \beta_{4(\tau)} r\mathrm{inf}lation \times D(\text{rinflation q99}) + e_t \quad (14)$$

Here the dummy variables correspond to upper quantiles of the distribution inflation rate. Tables 5.4–5.6 report the results for Pakistan, India and the US respectively. The results of quantile regression are not different from Baur and Lucey model when we investigate the relationship between gold and inflation rate in Pakistan (Table 5.4). The relationship remains insignificant therefore gold is not found to be a hedge or a safe haven against inflation in any bullish or bearish condition of gold market or extreme inflation conditions. Table 5.5 shows that although average gold return has no relation with inflation in India as observed from Baur and Lucey model, at its lower quantiles (10% and 25%) gold appears to hedge inflation. Table 5.6 shows that the evidence of gold hedging inflation risk in the US in Baur and Lucey (2010) model is fairly robust since gold retains its hedging power in various bearish and bullish conditions of gold market. In its bearish conditions gold also appears to act as a safe haven against extremely high inflationary environment in the US. This safe haven property against extreme inflation is not retained when gold market conditions are bullish. Thus the strong evidence of gold acting as a safe haven against inflation using Baur and Lucey model needs some qualification pertaining to the gold market condition itself. Our results on inflation hedging are consistent with some earlier studies. Chua and Woodward (1982) using data from 1975 to 1980 found that over the one and six month horizons gold has been an effective hedge against the US inflation. When the actual inflation rate was decomposed into an expected and unexpected component, it was again found that only the US investors could hedge themselves against inflation using gold. Beckmann and Czudaj (2013) employing data from January 1970 to December 2011 and using Markov-switching vector error correction model found that gold is only partially able to hedge future inflation in the long-run most notably in the US while during short-run periods where no price adjustment is observed, gold is not able to shield a portfolio against inflation. They found that the adjustment of the general price level is characterized by regime-dependence, implying that the usefulness of gold as an inflation hedge for investors crucially depends on the time horizon and is therefore non-linear. In an earlier Indian study using the data from 1978–1979 to 1999–2000 Mani and Vuyyuri

Table 5.3
Quantile regression of gold vs. stock for the US.

Gold	Baur and Lucey		Quantile regression									
	Coef	t-stat pvalue	10th		25th		50th		75th		90th	
			Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue
$\beta_1(hedge)$	-0.098	0.756 0.205	0.01	0.089 0.92	-0.04	-0.51 0.607	-0.04	-0.55 0.58	-0.15	-1.01 0.31	0.02	0.18 0.85
$\Sigma\ \beta_2(10\%)$	-0.096	-0.607 0.271	0.12	0.22 0.58	0.05	0.21 0.58	-0.2	-0.94 0.17	-0.4	-0.36 0.35	-0.69	-2.53*** 0.005
$\Sigma\ \beta_3(5\%)$	-0.343	-2.15** 0.015	-0.6	-4.3*** 0.00	-0.4	-3.9*** 0.000	-0.3	-2.9*** 0.001	-0.3	-2.1*** 0.01	-0.15	-0.9 0.18
$\Sigma\ \beta_4(1\%)$	0.440	3.76 0.99	0.75	9.19 0.99	0.91	7.86 0.999	0.37	1.81 0.96	-0.03	-0.10 0.46	0.2	1.02 0.84

***, **, * indicate statistical significance at the level of 0.01, 0.05 and 0.10 respectively.

Table 5.4
Quantile regression of gold vs. inflation rate in Pakistan.

Gold	Baur and Lucey		Quantile regression									
	Coef	t-stat pvalue	10th		25th		50th		75th		90th	
			Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue
$\beta_1(hedge)$	-1.19	-0.78 0.782	-0.033	-0.085 0.533	-0.62	-1.17 0.879	-1.65	-2.33 0.999	-0.122	-0.146 0.558	-0.953	-1.60 0.949
$\Sigma\ \beta_2(90\%)$	-1.12	-0.62 0.732	2.349	1.218 0.111	-0.371	-0.209 0.582	-2.02	-1.4 0.925	-1.243	-0.823 0.794	-0.708	-0.557 0.711
$\Sigma\ \beta_3(95\%)$	-1.85	-1.13 0.870	-0.102	-0.109 0.546	0.209	0.177 0.429	-2.00	-1.358 0.912	-0.810	-0.677 0.75	0.188	0.181 0.428
$\Sigma\ \beta_4(99\%)$	-0.200	-0.43 0.666	0.259	0.392 0.347	0.456	0.679 0.248	-0.34	-0.474 0.682	-0.236	-0.361 0.64	0.650	0.856 0.195

***, **,* indicate statistical significance at the level of 0.9, 0.95 and 0.99 respectively

(2003) found positive but insignificant relationship of gold and inflation. They also observed significant positive relationship at 10% with exchange rate while gold had no relation with stocks in India.

5.3. Quantile regression of gold vs. exchange rate

The quantile regression is also invoked to investigate whether gold hedges exchange rate risk in the South Asian markets of India and Pakistan. The following model estimated:

$$Q_\tau(Y/x) = \beta_{0(\tau)} + \beta_{1(\tau)} rexchange\ rate + \beta_{2(\tau)} rexchange\ rate \times D(\text{rexchnage rate q90}) + \beta_{3(\tau)} rexchange\ rate \times D(\text{rexchnage rate q95}) + \beta_{4(\tau)} rexchange\ rate \times D(\text{rexchnage rate q99}) + e_t \quad (15)$$

Here the dummy variables correspond to upper quantiles of the exchange rate returns. Tables 5.7 and 5.8 present the estimation results for Pakistan and India respectively. The evidence of gold acting as a hedge against depreciating local currency in Pakistan is quite robust since the hedge property remains intact during various bearish and bullish conditions in the gold market (Table 5.7). Also when the rate of depreciation of local Pakistani currency is in 95% quantile or higher, gold is found be a safe haven against exchange rate risk.

Similarly, the hedging power of gold against depreciating Indian rupee is also robust in various bearish or bullish moods of gold market, (Table 5.8). Also when exchange rate depreciation is extremely high (95% quantile or higher), gold is found be a safe haven in India.

The left three panels of Fig. 5.1 present the quantile regression (aggregated) coefficients, with 95% confidence bands, of gold vs. stock regression for Pakistan, India and the US respectively. These correspond to the aggregated coefficients of dummy variable of 5% quantile of stock returns. For Pakistan gold appears to lose its safe haven benefit as gold market gradually moves from bearish to bullish. In the case of India, the evidence of gold acting as safe haven against stock is not observed. The US investors, however, enjoy the safe haven benefit of gold especially in bearish and average conditions of gold market. The hedging power of gold against extreme bearish stock market deceases as gold market moves from bearish to bullish condition. The right three panels of Fig. 5.1 present the aggregated quantile regression coefficients with 95% confidence bands for the case of gold vs. inflation for the three countries. The

Table 5.5
Quantile regression of gold vs. inflation rate in India.

Gold	Baur and Lucey		Quantile regression									
	Coef	t-stat pvalue	10th		25th		50th		75th		90th	
			Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue
$\beta_1(hedge)$	0.204	0.206 0.418	1.140	4.18*** 0.000	0.488	1.315* 0.09	-0.14	-0.29 0.614	-0.045	-0.04 0.51	-0.99	-2.37 0.99
$\Sigma\ \beta_2(90\%)$	-1.075	-0.88 0.810	-1.45	-2.22 0.986	-0.55	-0.76 0.77	-0.58	-0.73 0.76	-1.03	-0.75 0.77	-5.11	-2.82 0.99
$\Sigma\ \beta_3(95\%)$	-0.459	-0.38 0.648	0.977	0.909 0.181	-0.005	-0.005 0.501	-1.40	-1.31 0.904	-2.17	-1.50 0.93	-2.593	-1.49 0.93
$\Sigma\ \beta_4(99\%)$	-0.859	-2.25 0.987	-0.94	-1.8 0.964	-0.61	-1.4 0.919	-0.73	-1.59 0.944	-1.680	-2.40 0.99	-1.784	-1.33 0.908

***, **, * indicate statistical significance at the level of 0.01, 0.05 and 0.1 respectively

Table 5.6
Quantile regression of gold vs. inflation rate in the US.

Gold	Baur and Lucey		Quantile Regression									
	Coef	t-stat pvalue	10th		25th		50th		75th		90th	
			Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue
$\beta_1(hedge)$	5.89	1.74** 0.0409	8.33	3.74*** 0.000	4.84	1.586* 0.056	4.562	1.501* 0.066	4.83	2.50*** 0.006	2.229	1.74** 0.04
Σ β_2(90%)	7.264	2.01** 0.022	18.66	5.05*** 0.000	12.23	2.92*** 0.001	6.75	0.87 0.192	2.58	0.68 0.248	-0.29	-0.08 0.531
Σ β_3(95%)	7.74	2.14** 0.0161	16.64	4.707*** 0.000	10.21	2.60*** 0.004	7.710	1.75** 0.04	2.45	0.66 0.254	1.87	0.75 0.222
Σ β_4(99%)	1.21	1.48* 0.069	8.992	3.16*** 0.000	2.96	1.365 0.086	0.347	0.20 0.42	-1.1	-0.66 0.745	-1.48	-1.63 0.94

***, **, * indicate statistical significance at the level of 0.01, 0.05 and 0.1 respectively

Table 5.7
Quantile regression of gold vs. exchange rate in Pakistan.

GOLD	Baur and Lucey		Quantile Regression									
	Coeff	t-stat pvalue	10th		25th		50th		75th		90th	
			Coeff	t-stat pvalue	Coeff	t-stat pvalue	Coeff	t-stat pvalue	Coeff	t-stat pvalue	Coeff	t-stat pvalue
$\beta_1(hedge)$	0.514	2.797*** 0.002	0.729	7.15*** 0.000	0.053	2.87*** 0.002	0.407	2.06** 0.019	1.27	4.08*** 0.000	0.99	4.67*** 0.000
Σ β_2(90%)	1.017	1.511* 0.065	1.92	2.57*** 0.005	1.93	2.13** 0.016	0.28	0.31 0.37	0.68	0.81 0.20	0.92	0.716 0.236
Σ β_3(95%)	0.668	1.37* 0.085	1.807	2.92*** 0.001	1.08	2.39*** 0.008	0.54	0.668 0.252	0.56	0.75 0.22	1.156	1.259 0.104
Σ β_4(99%)	0.907	2.45***	1.206	3.19*** 0.000	1.66	4.283*** 0.000	0.86	1.095 0.13	-0.16	-0.24 0.594	0.44	0.49 0.312

***, **, * indicate statistical significance at the level of 0.01, 0.05 and 0.1 respectively

Table 5.8
Quantile regression of gold vs. exchange rate in India.

GOLD	Baur and Lucey		Quantile Regression									
	Coeff	t-stat pvalue	10th		25th		50th		75th		90th	
			Coeff	t-stat pvalue	Coeff	t-stat pvalue	Coeff	t-stat pvalue	Coeff	t-stat pvalue	Coeff	t-stat pvalue
$\beta_1(hedge)$	0.675	7.111*** 0.000	0.623	6.373*** 0.00	6.373	3.589*** 0.000	0.911	6.47*** 0.000	0.785	0.785 0.216	0.97	1.68** 0.046
Σ β_2(90%)	0.346	0.826 0.204	1.695	1.142 0.126	-0.10	-0.142 0.55	0.329	0.614 0.269	-0.03	-0.072 0.528	0.665	0.959 0.1687
Σ β_3(95%)	0.617	1.945** 0.025	2.034	3.090*** 0.001	1.380	1.28* 0.100	1.270	2.237** 0.012	0.196	0.5194 0.301	1.099	1.710** 0.043
Σ β_4(99%)	0.308	1.473* 0.0703	0.398	1.027 0.152	0.313	0.908 0.181	0.463	1.767** 0.038	0.068	0.292 0.385	0.328	1.254 0.1049

***, **, * indicate statistical significance at the level of 0.01, 0.05 and 0.1 respectively

curves indicate that gold is not a safe haven against inflation in any gold quantile in Pakistan although the relationship turns insignificantly positive at extremely bullish conditions in gold market. In case of the US gold is seen to be a strong safe have as evidenced from large and positive aggregated coefficients at the lower quantile of the gold return distribution. The hedging power of gold against extremely high inflation, however, decreases as the conditions in gold market improve.

Fig. 5.2 presents the aggregated quantile regression coefficients of dummy variable corresponding to 95% quantile of exchange rate for Pakistan and India. For both the countries the hedging potential of gold against adverse local currency market is found to be highly non-linear. Gold appears to provide a safe haven against depreciating local currencies at the bearish conditions of gold market in India and Pakistan but this safe haven property gets weaker at average and bullish market conditions.

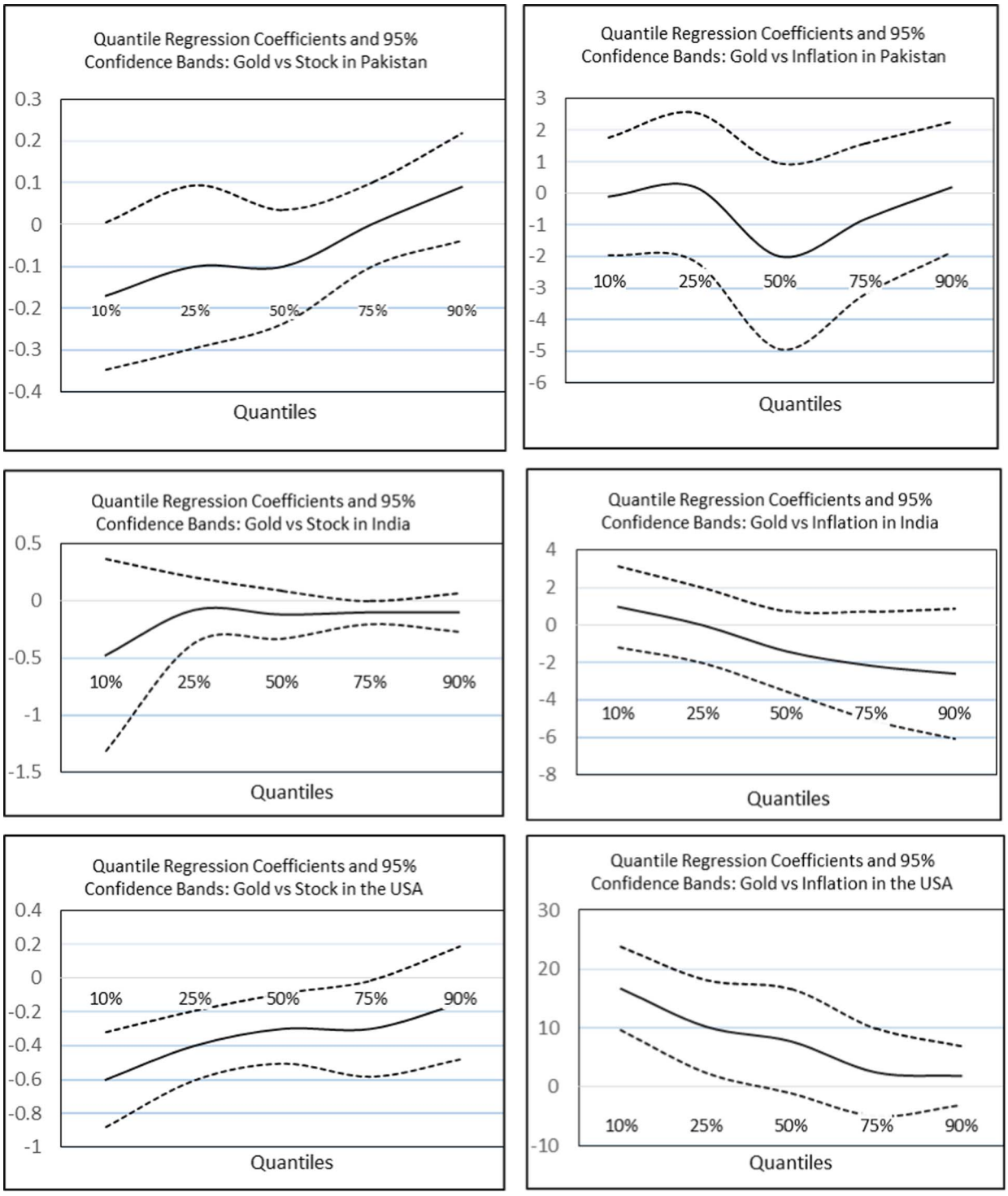

Fig. 5.1. Quantile regression coefficients of gold with 95% confidence bands at extreme 5% quantiles of stock and 95% quantile of inflation.

6. Econometric analysis with daily data

Baur and Lucey (2010) show that the safe haven property of gold is short lived. This paper now investigated the hedging and safe have potential of gold against stock and exchange rate risks with daily data as monthly data might have aggregated the short term effects. Tables 6.1, 6.2, and 6.3 report the results of hedge and safe haven investigation of gold against stock for Pakistan, India and the US respectively for the daily data. It is found that for Pakistan there is some weak evidence of gold acting as safe haven during the

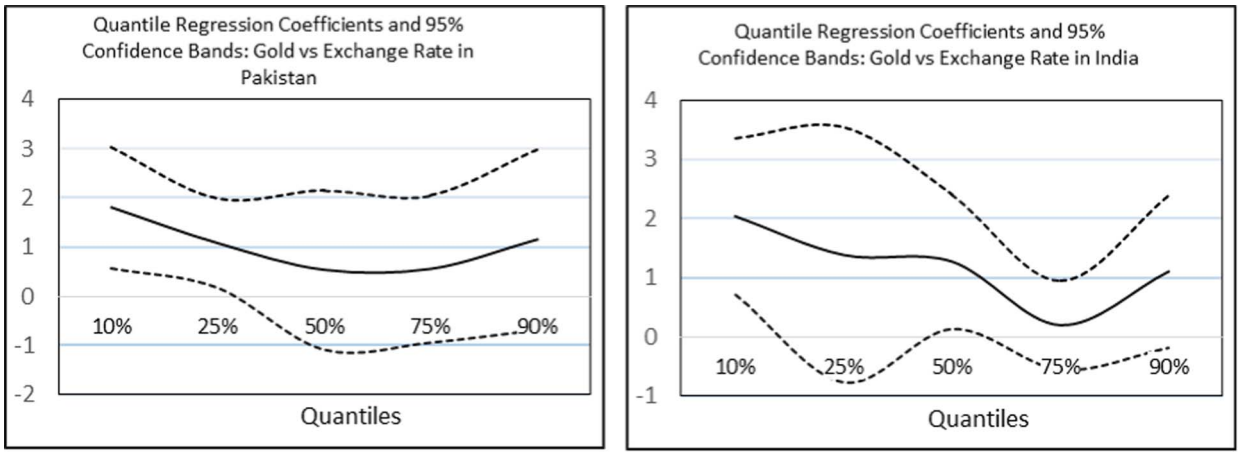

Fig. 5.2. Quantile regression coefficients of gold with 95% confidence bands at extreme 95% quantiles of exchange rate in Pakistan and India.

Table 6.1
Quantile regression of gold vs. stock for Pakistan (Daily).

Gold	Baur and Lucey		Quantiles Regression									
	Coef	t-stat pvalue	10th		25th		50th		75th		90th	
			Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue
$\beta_1(hedge)$	0.0056	0.715 0.762	-0.0149	-0.388 0.349	-0.011	-0.772 0.235	0.013	1.465 0.928	0.032	1.820 0.965	0.0264	0.765 0.777
$\Sigma\ \beta_2(10\%)$	-0.019	-1.014 0.155	-0.033	-0.542 0.293	-0.069	-2.081** 0.018	-0.027	-1.314* 0.094	-0.065	-1.717** 0.042	-0.065	-0.916 0.179
$\Sigma\ \beta_3(5\%)$	0.0177	1.137 0.877	0.072	1.562 0.940	0.0269	0.921 0.821	0.016	1.207 0.886	0.012	0.421 0.663	-0.053	-0.576 0.282
$\Sigma\ \beta_4(1\%)$	0.0053	0.356 0.639	0.0458	0.669 0.999	0.0163	0.448 0.673	-0.003	-0.211 0.416	0.016	1.047 0.852	0.033	0.558 0.711

***, **,* indicate statistical significance at the level of 0.01, 0.05 and 0.10 respectively.

Table 6.2
Quantile regression of gold vs. stock for India (Daily).

Gold	Baur and Lucey		Quantile regression									
	Coef	t-stat pvalue	10th		25th		50th		75th		90th	
			Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue
$\beta_1(hedge)$	-0.0241	-3.091*** 0.001	-0.067	-2.74*** 0.003	-0.052	-3.480*** 0.0001	-0.05	-0.023*** 0.002	-0.003	-0.318 0.357	0.018	0.835 0.798
$\Sigma\ \beta_2(10\%)$	0.0163	0.793 0.786	0.206	2.93 0.998	0.061	1.45 0.926	-0.004	-0.203 0.415	-0.015	-0.330 0.367	-0.16	-2.919*** 0.002
$\Sigma\ \beta_3(5\%)$	-0.008	-0.47 0.319	0.177	2.977 0.998	0.030	1.205 0.885	0.0025	1.49 0.559	-0.027	-0.953 0.170	-0.113	-2.108** 0.017
$\Sigma\ \beta_4(1\%)$	0.0006	0.379 0.647	0.134	4.425 0.991	0.065	1.657 0.951	0.0013	0.046 0.518	-0.023	-0.79 0.214	-0.122	-1.532* 0.062

***, **, * indicate statistical significance at the level of 0.01, 0.05 and 0.10 respectively.

times when gold returns falls between 25% and 75th quantile when stock market returns falls below 10% quantile. For other quantiles of gold distributions the relationship between gold and stock appear is insignificant. For the Indian case gold appears to hedge stock especially at the bearish and the average conditions in the gold market. When the gold market is bullish mood (gold returns in 90% quantile) gold is found to act as safe have against stock market risk as well. Thus in this case the use of daily data clearly shows the benefit of gold as safe haven in India during good times in the gold market and bad times in stock market. The results (Table 6.3) show that gold acts as hedge against stock in the US only during times when gold is in bearish or average mood.

Table 6.3
Quantile regression of gold vs. stock for the US (Daily).

Gold	Baur and Lucey		Quantile regression									
	Coef	t-stat pvalue	10th		25th		50th		75th		90th	
			Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue	Coef	t-stat pvalue
$\beta_1(hedge)$	-0.0413	-4.027*** 0.000	-0.132	-4.423*** 0.000	-0.083	-4.904*** 0.000	-0.011	-0.936 0.174	-0.001	-0.068 0.472	0.103	4.111 0.999
$\Sigma\ \beta_2(10\%)$	-0.0218	-0.886 0.312	0.271	2.836 0.979	0.093	1.256 0.985	-0.041	-1.251 0.105	-0.149	-3.258*** 0.000	-0.142	-2.206** 0.013
$\Sigma\ \beta_3(5\%)$	-0.016	-0.886 0.312	0.135	2.193 0.982	0.074	1.944 0.974	-0.034	-1.546* 0.061	-0.106	-2.535*** 0.005	-0.123	-2.430*** 0.007
$\Sigma\ \beta_4(1\%)$	-0.059	-2.501*** 0.006	0.385	7.100 0.999	0.177	9.020 0.999	-1.539	-3.28*** 0.001	-0.224	-3.237*** 0.001	-0.385	-11.1*** 0.000

***, **, * indicate statistical significance at the level of 0.01, 0.05 and 0.10 respectively.

Table 6.4
Quantile regression of gold vs. exchange rate in Pakistan (Daily).

GOLD	Baur and Lucey		Quantile Regression									
	Coeff	t-stat pvalue	10th		25th		50th		75th		90th	
			Coeff	t-stat pvalue	Coeff	t-stat pvalue	Coeff	t-stat pvalue	Coeff	t-stat pvalue	Coeff	t-stat pvalue
$\beta_1(hedge)$	1.100	28.45*** 0.000	0.993	9.15*** 0.000	1.029	14.5*** 0.000	1.069	25.8** 0.019	1.090	12.95*** 0.000	1.141	17.79*** 0.000
$\Sigma\ \beta_2(90\%)$	0.894	5.81*** 0.000	0.531	0.836 0.201	0.539	1.858** 0.031	0.999	15.04*** 0.000	1.015	3.086*** 0.000	1.302	3.11*** 0.000
$\Sigma\ \beta_3(95\%)$	0.881	13.0*** 0.000	0.936	2.425*** 0.007	0.893	4.92*** 0.000	0.975	9.904*** 0.000	0.913	5.73*** 0.000	0.886	7.41*** 0.000
$\Sigma\ \beta_4(99\%)$	1.010	39.1*** 0.000	1.089	49.9*** 0.000	1.029	14.9*** 0.000	1.009	44.8*** 0.000	1.003	54.6*** 0.000	0.934	59.4*** 0.000

***, **,* indicate statistical significance at the level of 0.01, 0.05 and 0.1 respectively

Table 6.5
Quantile regression of gold vs. exchange rate in India (Daily).

GOLD	Baur and Lucey		Quantile Regression									
	Coeff	t-stat pvalue	10th		25th		50th		75th		90th	
			Coeff	t-stat pvalue	Coeff	t-stat pvalue	Coeff	t-stat pvalue	Coeff	t-stat pvalue	Coeff	t-stat pvalue
$\beta_1(hedge)$	0.777	25.72*** 0.000	0.778	8.17*** 0.000	0.788	18.6*** 0.000	0.741	14.02*** 0.000	0.466	7.399*** 0.000	0.206	1.505* 0.066
$\Sigma\ \beta_2(90\%)$	0.898	11.36*** 0.000	-0.371	-1.387 0.916	0.865	3.42*** 0.00	0.938	11.1*** 0.000	0.982	6.56*** 0.000	1.178	4.86*** 0.000
$\Sigma\ \beta_3(95\%)$	0.806	14.99*** 0.000	-0.683	-2.84 0.997	0.331	1.992* 0.023	0.819	13.6*** 0.000	0.736	6.58*** 0.000	0.994	9.04*** 0.000
$\Sigma\ \beta_4(99\%)$	1.013	3.089*** 0.000	0.423	1.513* 0.065	0.888	1.637* 0.050	0.993	34.6*** 0.000	0.980	69.5*** 0.000	0.955	116.1*** 0.000

***, **, * indicate statistical significance at the level of 0.01, 0.05 and 0.1 respectively

During good times in the gold market it does not hedge against stock risk. Gold in its bullish and average conditions acts as a safe have to safe gaud the US investors from the adverse stock market conditions.

Tables 6.4 and 6.5 report the results of investigation of whether gold can provide hedge and be a safe haven against the risk of deteriorating local currency vs the US dollar in the two South Asian countries. The results indicate that gold can provide a hedge and safe haven against the worsening local currency to Pakistani investors more than the Indian investors as both the hedge and safe haven effects are quite strong in the case of Pakistan in all the states of the gold market. In Pakistan's case the effects using daily data

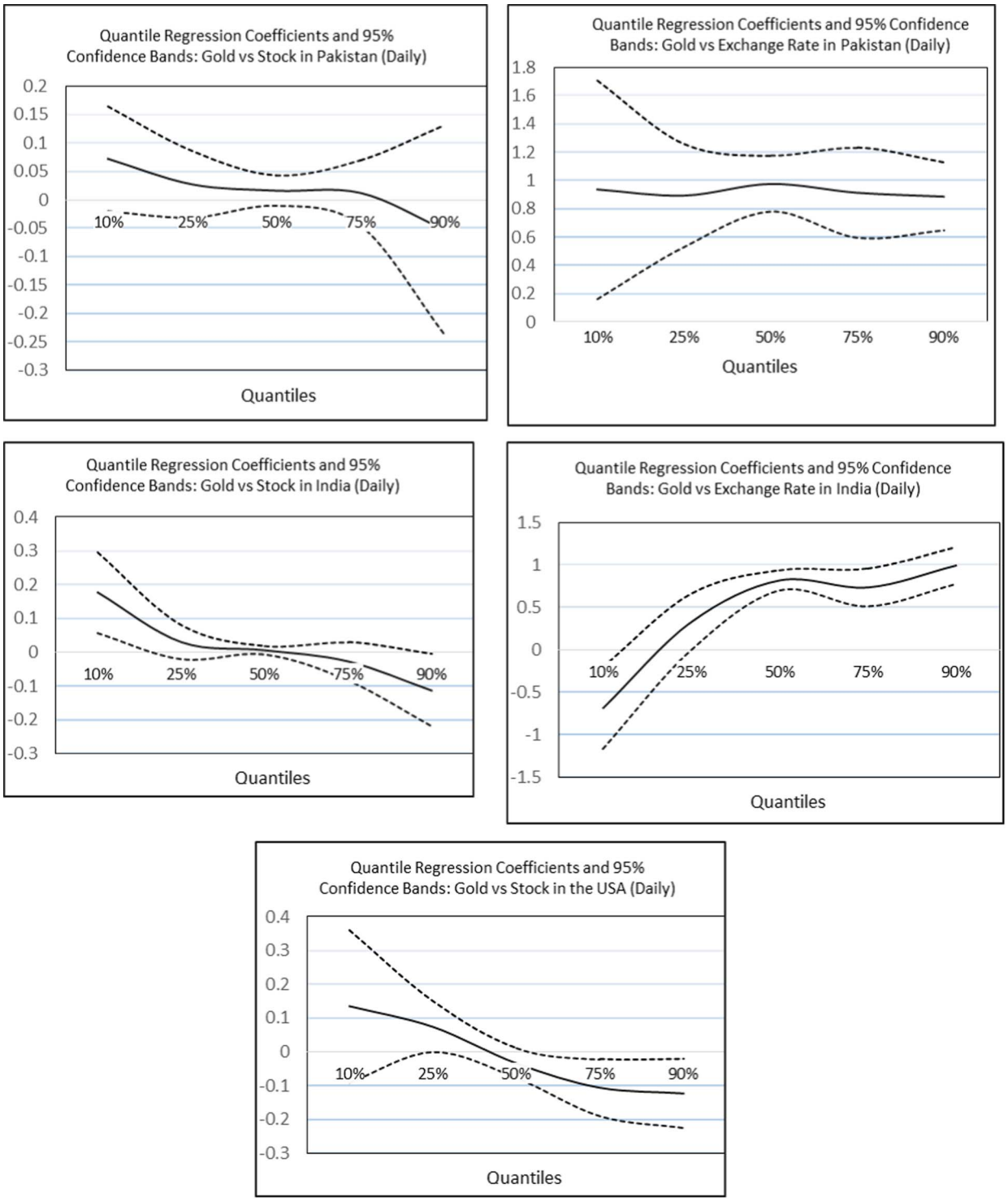

Fig. 6.1. Quantile regression coefficients of gold with 95% confidence bands at extreme 5% quantiles of stock and 95% quantile of exchange rate for daily data.

are also more prominent as compared to the monthly data. For the Indian case the evidence of gold acting as a hedge is fairly strong but the evidence supporting safe have benefit of gold against currency risk is stronger during the bullish gold market as compared to the bearish periods of gold.

Fig. 6.1 displays the results of quantile regression graphically for the daily data. Interestingly the plot showing safe haven potential of gold against stock risk is similar in the two developing countries to that in the US. For India the plots indicate that gold

can be a safe haven (at 95% quantile of stock) only when gold is in bullish mood. The hedging potential of gold against stock is more powerfully observed for the US market during bullish gold periods. When gold is itself in difficult times, it cannot safe guard investors against the stock market risk. This result was not obvious in the earlier studies which employed the GARCH and OLS regressions. The results reported in this paper demonstrate the benefit of quantile regression.

7. Conclusion

This paper examined whether investment in gold provides a hedge or a safe haven against stock market, exchange rate and inflation for India, Pakistan, and the US. In contrast to the previous studies e.g. Baur and Lucey (2010), the analysis in this paper presents a deeper and more elaborated picture of the hedging power of gold against adverse conditions in stock markets, commodity price inflation and foreign exchange market. Using the Baur and Lucey's model we found that gold does not hedge stock market risk in the three countries. When stock index returns fall below the lowest 5% quantile, the gold returns increase significantly to act as a safe haven for investors in India and the US.

Whereas the earlier approaches, e.g. Baur and Lucey (2010), explain average condition of gold market, we perform quantile regression which sheds light on whether hedging power of gold is equally strong when gold is trading in bearish and bullish conditions. The quantile regression analysis shows that gold can provide a safe haven against bearish Pakistani stock market only in case when the gold is also in bearish mood i.e. when gold returns fall in their lowest 5% quantile. Our quantile regression analysis results show that gold does not hedge stock market risk in India in any bearish or bullish conditions of the gold market. In case of the US the safe haven property of gold remains intact during bearish conditions in stock market as well. It is also found that during bullish conditions in the gold market, gold is seen to compensate the US investors for adverse conditions in stock market. This evidence is more convincing using daily data as compared to monthly data. This finding corroborates the earlier research that the safe haven property of gold against stock is short lived.

Whereas the Bauy and Lucey's model is unable to uncover the hedging power of gold against inflation in India and Pakistan, the quantile regression shows that gold can provide a safe haven against deteriorating purchasing power of currency in India since the lower quantile of gold returns has significant positive relationship with inflation. We found a fairly robust evidence of gold hedging inflation risk in the US as gold retains its hedging power in all the bearish and bullish conditions. In its bearish conditions gold also appears to act as a safe haven against extremely high inflationary environment in the US. However, this safe haven benefit against extreme inflation is not retained in the bullish gold market. Thus the strong evidence of gold acting as a safe haven against inflation in the US using multiple regression models needs some qualification pertaining to the gold market condition itself. Our results corroborate some earlier findings reporting non-linearities in gold-inflation relationship in the US.

We found that gold acts as a hedge against the risk inherent in the adverse movement of exchange rate in both India and Pakistan. That is, when local Pakistani and Indian currencies are losing their purchasing power against the US dollar, gold appears to increase in value. Gold is also found to be a safe haven against extremely adverse conditions in foreign exchange market as measured by upper quantiles of exchange rate returns in India and Pakistan. The evidence is much stronger using daily data. The hedge and safe haven benefit of gold against currency risk are stronger in Pakistan than India.

Thus, this paper provides evidence that hedging potential of gold against adverse movement of stock, inflation and exchange rate is more complex than the linear relationship investigated in earlier studies. This paper provides useful information to investors in managing their portfolios against the adverse conditions of assets to be hedged in the three countries since this paper reveals conditions in which gold can be a reliable asset in the investor's portfolios which compensates losses realized in these investments. The hedging potential of gold is not uniformly strong but is dependent on the state of the gold market itself.

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