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A Downside Risk Analysis of Inflation Hedging Capabilities of Individual Assets and Optimal Asset Allocation

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Abstract

This study aims to examine the inflation hedging capabilities of the most widely used asset classes in Pakistan. An attempt is also made to find the possibility of creating an inflation-protected optimal asset mix. The downside analysis of these assets concludes that cash acts as an inflation hedge for all investment horizons. Further, the findings show that gold and stocks also have inflation hedging ability in the short-run, which extends to a medium-term investment horizon for gold, while stocks appear like a good inflation hedge for longer investment horizons. Finally, this study suggests that investors can strategically create optimal portfolios that are hedged against inflation.

Keywords: *Downside risk, Inflation hedging, Optimal asset allocation, VAR models*

1. Introduction

One of the biggest concerns for portfolio managers until recently is to safeguard their assets against the menace of inflation. Inflation is a cause of disaster and chaos for the economy as a result of which the value of financial portfolios, as well as individual assets, is in extreme danger. For periods of rapid inflation, certain portfolios seem to have increased by absolute values. However, when real rates of returns are taken into consideration, the increase in value becomes more apparently an illusion. Inflation contains a lot of uncertainty and it is thus very hard to predict what its movements will be. There are therefore a lot of risks associated with it, because of which a mechanism or a phenomenon is needed to protect against these perils of inflation (Salisu, Adediran, Oloko, & Ohemeng, 2019; Kantor, 1983).

The inflation hedge is accessible to financial managers, with the least risk involved, for reducing the impact of inflation on assets by protecting or even increasing their purchasing power. This mechanism should be able to work with its full potential in all kinds of economic environments and investment scenarios to be an appropriate and effective hedge. Now, it is not expected of this mechanism to enhance the returns, rather that this will maintain a steady real rate of return. A proper hedge is going to behave

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differently in alternate periods of low and high inflation. For instance, in low inflation periods, absolute returns

from an inflation hedge may be lower than any other alternative investment choice. For high inflation periods, these absolute returns will be higher. Around the globe, inflation is the most common and unending crisis. It is also widely believed that inflation is the reason behind inefficient resource allocation and as a result decreases the prospects of economic prosperity. Rising inflation does not only hamper economic growth but is also a great threat for investors. Institutional investors are not the only ones dreading inflation because consumer prices directly influence their liabilities. Private investors too are badly stuck in an inflation whirlpool as they also want to safeguard their real capital.

Our study is very crucial to the existing literature as it adds both empirically and practically. It contributes to the existing literature in two areas: inflation hedging and strategic asset allocation. Since other similar studies in the world conclude differently as per their context and circumstances, their results cannot be generalized for a developing country like Pakistan; which is also facing a lot of political, economic, security, and social disturbances. Inflation hedging research is in its infancy in Pakistan. Few studies have been conducted that deal with major assets like stocks and gold using only basic techniques. Thus, this study is an attempt at exploring inflation hedging capabilities of various asset classes by using some new techniques to get a deeper insight into the phenomenon.

2. Literature Review

2.1. Cash and Inflation:

Studies dealing with the effects of inflation on asset returns have their foundations in the Fisher theory of interest rate. It states that the sum of real rate and the compensation for expected inflation E (π) equals the nominal rate i (Fisher, 1930).

According to the Fisher hypothesis, expected inflation does not affect real interest rates and is constant over time. If this statement is true, short-term securities like T-bills will prove to be a perfect inflation hedge. These short-term instruments are also denoted as cash in the investment industry. Hoevenaars, Molenaar, Schotman, and Steenkamp (2008) show that as the inflation rate changes, T-bills are the ones that immediately get on with the change. T-bill appears to be the best hedge against inflation for all horizons due to this characteristic.

***H_1**: Cash is positively associated with the rate of inflation.*

2.2. Gold and Inflation:

Gold can be used both as a tactical inflation hedge as well as a long-term strategic asset. In periods where inflation becomes a concern for investors, gold is likely to outperform the known financial assets used for hedging by consistently delivering lower average volatility (Shahzad, Mensi, Hammoudeh, Sohail, & Al-Yahyaee, 2019). Also, the gold market is very liquid and versatile so investors can choose from a set of different

products on how to hedge their inflation risk (Dempster & Artigas, 2010). As an individual asset, gold is considered to be a very risky one. The returns on gold are generally independent of the returns on other assets (Beetsma, Chen, & van Wijnbergen, 2019).

Beckmann and Czudaj (2013), using the data for four major economies; the USA, the UK, the Euro Area, and Japan, test the hedging ability of gold from a new perspective. The results of the study suggest that in the longer run, gold is a partial hedge of future inflation and this ability is greater for the USA and the UK as compared to the other two economies. Using time-series data of gold prices, inflation, and economic growth for 1997-2011, the study reveals that gold turned out to be a good investment for hedging inflation not only in the long-run but also in the short-run.

***H_2**: Gold is positively associated with the rate of inflation.*

2.3. Stocks and Inflation:

For investors, it is considered an implicit understanding that for longer horizons more focus should be diverted towards stocks as compared to investment. The underlying concept of this strategy is that with the increase in the investment horizon, risks associated with stocks start diminishing. The academic literature on stocks as an inflation hedge may sometimes give readers the notion that stocks are viewed as long term bonds by authors. But there is a huge difference between the two asset classes. A lot of previous studies have established that in the short-run there is a negative relationship between returns on stock and inflation. Only a few studies have reported the existence of the Fisher effect for stock returns in the longer horizon.

The empirical work of Anari and Kolari (2001) revolves around six industrial countries. The relationship between stock prices and inflation is initially negative but becomes positive in the long run. Hondroyiannis and Papapetrou (2006) study the dynamic relationship between real returns of stocks and both anticipated and unanticipated inflation for the Greek market. Another stance on the impact of macroeconomic variables on stock prices is taken by Erdem, Arslan, and Erdem (2005). Variables such as inflation, interest rate, money supply, industrial production, and exchange rate are considered to be very influential on stock prices and are so used to examine the nature of the relationship. An investor needs to know how these variables shape the returns of stocks so that they can be vigilant about the success of their portfolios.

***H_3**: Stock is positively associated with the rate of inflation.*

2.4. Foreign Currency and Inflation:

Currencies are traded in foreign exchange markets which are very fluctuant and fast-paced around the globe. The foreign exchange market is where currencies are bought and sold; meaning they are traded. It is the most active of all financial markets (Froot & Thaler, 1990). It has become so popular now that even larger financial institutions,

corporations, central banks, hedge funds, etc. are taking part in the excitement (Barnett, Wang, Wang, & Wu, 2019; Morvillier, 2020).

Currencies are traded for one of the two reasons that follow. Buying and selling the currencies can be used as a hedge for fluctuations in prices of the domestic currency. Secondly, when investors are not aware of the global economic turmoil, currency trade can be used as a way of speculation. During difficult situations, foreign currency is a complete and safer way to hedge because they are not related to price volatility in domestic stocks, bonds, and other asset classes. The value of the currency of a country is heavily influenced by the rate of inflation currently prevailing in the country. Inflation does not only influence the value of the domestic currency but also affects the exchange rate the currency has with other currencies.

***H_4**: Foreign Currency is positively associated with a rate of inflation.*

2.5. Real estate and Inflation:

The investors find themselves wondering what assets should be used to protect their portfolios against inflation (Taderera & Akinsomi, 2020). Various asset classes have been subject to the academic literature on determining their inflation protecting qualities. A study by Fama and Schwert (1977) proves that for expected as well as unexpected inflation private residential real estate is an effective way to hedge. Similar to these results is a study conducted by Hartzell, Hekmanand, and Miles (1987).

A recent study by Lee (2014) determines the hedging capabilities of Malaysian residential property for the period 1999-2012. The study is carried out in two stages. Firstly, using the Fama and Schwert (1977) model, hedging effectiveness of residential property over the short-run is examined. Then the dynamic ordinary least squares (DOLS) model is used for the long-run. Lee, Stevenson, and Lee (2014) examine European real estate stocks which show a little hedging capability in the short-run. For developed markets over the long horizons, these do appear to be a good hedge against expected inflation but no significant result is found for emerging markets (Adler, Lama, & Medina, 2019).

***H_5**: Real Estate is positively associated with the rate of inflation.*

2.6. Portfolios and Inflation:

The returns of a portfolio are largely dependent on the allocation of various assets available for investment. Different asset classes have different characteristics. Risks and returns associated with them are entirely different from each other. Formulating portfolios is no longer a piece of cake; a portfolio strategy has to be developed according to the goals of investment, tolerance of risk, and the time horizon of investment along with other factors. According to Adler and Biger (1975), considerably efficient alternative portfolios formulated can be transformed into an optimal risky portfolio. The combination of risky assets and risk-free assets is what makes an efficient optimal

portfolio. Investors can hedge their portfolios constantly and consistently against inflation.

Campbell and Viceira (2005) report that the riskiness of assets under analysis like T-bills, stocks, and bonds changes with time. Similarly, the correlations between these assets vary over time, and optimal asset allocation changes due to it. The VAR framework used in this study previously solely considered the term 'structure of risk' and no reference was given to inflation hedging. In recent times, Brière and Signori (2012) report that the optimal allocation of an investor drastically changes with the macroeconomic regimes. Ranging from a volatile to a more stable environment and from short to long investment horizons, the allocation of assets must be revised to protect the portfolio against inflation.

3. Research Methodology

3.1. Sample:

The empirical testing of the present study is based on the five most widely used asset classes in Pakistan: cash, gold, stocks, foreign currency, and real estate. The sample period is 11 years from 01/2005 to 12/2015, with no missing data for all assets under study. The 90-day Treasury bill rate represents cash. Stocks are represented by the KSE-100 index. The US dollar exchange rate is used as a foreign currency investment. Gold prices are taken from the international US dollar per ounce rate. The analysis begins with the use of the VAR model to capture the interdependencies among asset returns. The inflation protecting capabilities of the various asset classes are then determined by first examining the horizon-dependent correlations between nominal asset returns and the inflation rate. Further investigation into individual asset inflation protection involves estimating the LPM's of these assets with the average rate of inflation as the target return. The next step of the analysis includes the construction of a minimum semi-variance portfolio of these assets with a target real return of 0% which ensures protection against inflation.

3.2. VAR Analysis:

For the analysis of the multivariate time series, the Vector Auto-Regressive model is used. The VAR model structure is developed in a form such that a linear function is created in which each variable depends on its own past lags and the past lags of the other variables included in the model. The linear interdependencies among variables are captured by VAR models. For a set of n time series variables $y_t = (y_{1t}, y_{2t,}..., y_{nt})'$, a VAR model of order p (VAR (p)) can be written as: $y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + u_t$ where the *A*'s are coefficient matrices and $u_t = (u_{1t}, u_{2t}, ..., u_{nt})'$ is the vector of unobservable i.i.d. zero mean error terms.

3.3. Lower Partial Moments:

To measure if the asset falls below the inflation rate or not, LPMs are used. Lower Partial Moments (LPMs) is a concept first introduced by Bawa (1975) and Fishburn (1977). It is a measure to account for downside return deviations. The deviations negative to a set target outcome are taken into consideration to represent the risk associated with the specific variable. Generally, the LPM of order n is defined as

$$LPM_n(\tau) = \int_{-\infty}^{\tau} (\tau - r_i)^n \, f(r_i) dr_i \quad (1)$$

where τ is the target rate, *ri* is the return of asset *i*, and f(*ri*) is the density function of the ith asset return. The order n of the LPM can be interpreted as a risk aversion parameter. The focus in this study is on three classes of LPMs: shortfall probability (n = 0), expected shortfall (n = 1), and semi-variance (n = 2).

3.4. Portfolio Choice:

A great amount of literature dealing with the hedging of inflation for portfolios as well as long-term asset allocation uses the mean-variance framework. In a mean-variance framework, the risk measure used is variance, which is to be minimized. Constructing a portfolio using downside risk measures is similar to a traditional Markowitz approach except that the variance matrix is replaced with a semi-variance matrix. The following portfolio choice problem is constructed:

$$min\ LPM_{2,p} = \sum_{i=1}^{5} w_i w_j \varphi_{ij} \quad (2)$$

$$\sum_{i=1}^{5} w_i = 1 \quad (3)$$

4. Results And Analysis

4.1. Descriptive Statistics:

The descriptive statistics of the monthly returns of asset classes are provided in Table 1 to give a summarized picture of the data. The annualized average returns, annualized volatility, minimum, maximum, skewness, kurtosis, and JB-test values are included in the descriptive statistics.

As compared to other asset classes, cash has the second-highest average returns of 10.51% with a maximum of 11.54% and a minimum of 0.345%. The highest returns are produced by stocks, with a value of 16.22% and a maximum and minimum of 20.22% and -44.87% respectively. Gold exhibits the third-highest average returns of 8.39% followed by 8.00% returns of real estate and 5.47% returns of currency. Gold has maximum returns of 13.03% and minimum returns of -19.09%.

Real estate has a maximum and minimum value of 31.02% and -31.62% respectively. Currency has 6.00% maximum returns and -6.80% minimum returns. Asset volatilities, however, do not follow the same pattern as returns. The greatest volatility is of real estate, with a value of 33.19%, while the least volatility is of cash at 0.64%. Stocks

exhibit the second-highest volatility of 26.29% followed by a 19.27% volatility of gold and a 4.64% volatility of the currency. The skewness of assets shows the asymmetry (non-normality) in returns' behaviors as none of the assets have a zero value of skewness. Real estate is the only asset that is positively skewed while cash, gold, stocks, and currency are negatively skewed. The value of Kurtosis for all assets is not 3, which again denotes that data is not normally distributed. All the assets exhibit the Kurtosis value to be greater than 3 which shows that the distribution of data is peaked (leptokurtic) as compared to the normal. The results of the Jarque-Bera test indicate that returns do not follow a normal distribution as all assets have significant values for the Jarque-Bera greater than zero (for normal distribution, the JB-test value should be equal to zero). The null hypothesis of normality is rejected at a 1% significance level for real estate, at a 5% significance level for gold, and at a 0.1% significance level for stocks and currency. The JB-test value for cash is insignificant.

Table 1: Descriptive Statistics

Assets	Ave Ret. %	Vol. %	Min. %	Max. %	Skew.	Kurt.	JB-test	
Cash	10.51	0.64	0.345	11.54	-0.145	2.323	2.981	
Gold	8.39	19.27	-19.09	13.03	-0.4258	3.789	7.422*	
Stocks	16.22	26.29	-44.87	20.22	-1.9708	12.718	604.89***	
Real estate	8.00	33.19	-31.62	31.02	0.0049	4.538	13.01**	
Currency	5.47	4.64	-6.8	6.00	-0.1938	11.765	423.35***	

4.2. Vector Auto-Regression Model:

Table 2 presented below shows the VAR results. Table 2(a) represents the coefficients of the lagged variables while Table 2(b) shows the covariance structure of the residuals.

Table 2(a): VAR Estimation Results

	D(RCA)	D(RGO)	D(RST)	D(RER)	D(RRE)	D(IN)
D(RCA(-1))	0.153429	16.34409	-31.05650	0.470672	24.60130	0.060087
	(0.08599)	(18.1884)	(22.8743)	(3.68853)	(31.9846)	(0.24529)
D(RGO(-1))	0.000111	-0.560439	-0.246666	0.023067	0.083511	0.000194
	(0.00036)	(0.07692)	(0.09674)	(0.01560)	(0.13527)	(0.00104)
D(RST(-1))	-0.000545	-0.028663	-0.362167	-0.008430	-0.059447	0.000903
	(0.00030)	(0.06359)	(0.07997)	(0.01290)	(0.11183)	(0.00086)
D(RER(-1))	0.000206	-0.168326	0.723638	-0.411284	-0.023458	-0.001862
	(0.00204)	(0.43061)	(0.54155)	(0.08733)	(0.75723)	(0.00581)
D(RRE(-1))	-0.000310	0.010606	0.060920	0.001165	-0.614505	-0.000322
	(0.00019)	(0.04087)	(0.05140)	(0.00829)	(0.07186)	(0.00055)

D(IN(-1))	0.098278	-5.507545	-4.322522	0.901858	0.154527	0.274602
	(0.03110)	(6.57869)	(8.27359)	(1.33413)	(11.5688)	(0.08872)
R-squared	14.9	32.2	26.1	19.5	39	8.5
F-statistic	3.590541	9.724523	7.235906	4.969575	13.12464	1.913619

Coefficient estimates of VAR with standard errors in parenthesis

The prediction equation of cash is shown in the first column of Table 2(a). The predictability of cash is not very good as R^2 is 14.9%. Results show that the own lag has a positive effect on T-bills. The only negative coefficients for the cash equation are stocks and real estate. The second column of Table 2(a) represents the gold equation with an R^2 of 32.2%. The own lag of gold has a negative coefficient and cash is shown to have a noticeable influence on gold. The stock equation is shown in the third column, exhibiting an R^2 of 26.1%. Positive coefficients for the stock equation are foreign currency and real estate. Just like gold, stocks are negatively influenced by their lag. The fourth column of Table 2(a) shows the prediction equation for foreign currency with an R^2 of 19.5%. A negative coefficient is observed for its lag. The fifth column of Table 2(a) indicates the prediction equation for real estate with the highest value of R^2 at 39%. Cash has a notable positive influence on real estate. Real estate's lag also has a negative coefficient. The results also show that none of the coefficients from any equation is significant except for two; one is the coefficient of inflation for cash and second is the inflation's lag for inflation.

The covariance structure of residuals in Table 2(b) shows that unexpected inflation is negatively correlated to shocks to stocks while positively correlated with shocks to cash, gold, foreign currency, and real estate. The analysis shows that all other assets except stocks can be used as a hedge against inflation.

4.3. The Residuals Covariance Matrix

Table 2(b): The Residuals Covariance Matrix

	r_{ca}	r_{go}	r_{st}	r_{er}	r_{re}	infl
r_{ca}	0.0000141%	0.000151%	-0.0003%	-0.00012%	-0.00011%	0.0000024%
r_{go}	-	0.5097%	-0.0733%	-0.0143%	-0.103%	0.000226%
r_{st}	-	-	0.8062%	-0.016%	-0.02%	-0.000181%
r_{er}	-	-	-	0.021%	0.00605%	0.000213%
r_{re}	-	-	-	-	1.5762%	0.00144%
infl	-	-	-	-	-	0.0000927%

4.4. Correlation between Assets and Inflation

The inflation-hedging abilities of the individual assets are examined by analyzing the correlations between an individual asset's nominal returns and inflation depending on the investment horizon. The extent to which two variables are in a linear relationship with each other is unveiled by the Correlation Analysis. Correlations among inflation and individual assets are important to reveal assets in a linear relationship with inflation. The results of the correlation analysis are reported in Table 3.

Table 3: Correlation between Assets and Inflation

years	cash	gold	Stock	currency	real estate
1	-0.58	-0.29	-0.46	-0.03	0.20
2	-0.57	-0.30	-0.01	0.00	0.07
5	0.68	-0.17	-0.37	0.54	-0.02
11	0.68	0.05	-0.25	0.31	-0.02

The correlation between cash and inflation is negative in the short term and becomes positive for a long-term horizon. The correlation for a 1-year horizon is -58% and -57% for a 2-year horizon. For a 5-year and 11-year investment horizon, the value of correlation increases to 68%. Cash shows the highest value of correlation among all other asset classes. On the whole, a generally increasing trend is noticed in the cash-inflation correlation. The correlation between gold and inflation is negative for horizons except the last. Again, an overall increasing trend is observed as the value of correlation is -29% for a 1-year horizon, -30% for a 2-year horizon, -17% for a 5-year horizon, and lastly 5% for an 11-year horizon.

The correlations between stocks and inflation are negative for all investment horizons. The stock-inflation relationship is negative for both short-term and long-term investment horizons. For a 1-year horizon, it shows a value of -46%. In a 2-year horizon, it increases to a mere -1% which is again reduced in a 5-year horizon to a value of -37%. For an 11-year horizon, it shows a value of -25%. The correlation between foreign currency and inflation starts with a -3% for a 1-year horizon which then shifts to no correlation for a 2-year horizon. For a 5-year horizon, a tremendous 54% correlation is observed which later decreases to 31% for an 11-year horizon. The foreign currency relationship with inflation is negative to none in the short term while positive for long term horizons. For a 1-year horizon, real estate shows a value of 20%, which decreases to 7% in a 2-year horizon. For a 5-year and 11-year horizon, the value of correlation remains at -2%. According to the correlation analysis, gold, stocks and foreign currency show poor inflation hedging abilities for all investment horizons. Cash is by far the best choice for hedging inflation as per a 5-year and 11-year horizon, exhibiting the highest positive values. Real estate, on the other hand, is a somewhat fair option for short term hedging. Foreign currency has a good value of correlation for a medium horizon but is not as good as cash. All other asset classes fail to provide a hedge against inflation.

4.5. LPM with the Inflation Rate as Target Return

Further analyzing the potential of assets to hedge inflation, the LPMs of cash, gold, stock, foreign currency, and real estate are considered. The risk that an asset will fall below the inflation rate is measured by exploring the LPM of order 0, 1, and 2 for different investment horizons. The LPM of order 0 shows the shortfall probability of the asset. The LPMs of orders 1 and 2 reveal the expected shortfall and semi-variance of the asset respectively. The following table shows the LPMs of order 0, 1, and 2 for the assets with different investment horizons.

Table 4: LPM with the Inflation Rate as Target Return

	LPM_0	LPM_1	LPM_2	LPM_0	LPM_1	LPM_2
	1-year Investment Horizon			2-year Investment Horizon		
cash	100.00%	0.19%	0.00%	80.00%	0.08%	0.00%
gold	41.67%	1.35%	0.05%	40.00%	1.43%	0.06%
stock	41.67%	2.15%	0.15%	44.00%	2.47%	0.21%
currency	100.00%	0.70%	0.01%	100.00%	0.61%	0.00%
real estate	58.33%	6.52%	0.97%	64.00%	5.40%	0.85%
	5-year Investment Horizon			11-year Investment Horizon		
cash	73.33%	0.20%	0.00%	60.61%	0.09%	0.00%
gold	43.33%	1.96%	0.16%	48.48%	2.24%	0.18%
stock	50.00%	3.42%	0.66%	42.42%	2.42%	0.36%
currency	81.67%	0.75%	0.01%	74.24%	0.69%	0.01%
real estate	65.00%	5.12%	0.74%	53.03%	3.48%	0.46%

For horizon 1, which is a 1- year investment period, the shortfall probabilities for cash, gold, stock, foreign currency, and real estate are 100%, 41.67%, 41.67%, 100.00%, and 58.33% respectively. For a 2-year horizon, the shortfall probability for cash decreases to 80%. A slight decrease in the shortfall probability of gold is also seen, which now stands at 40%. For stocks, shortfall probability slightly increases to 44%. Foreign currency's shortfall probability is the same as that in horizon 1, that being 100%, while the probability for real estate for this period increases to 64%. For a 5-year horizon, the shortfall probability of cash increases to 73.33, and the value of shortfall probability for gold increases minimally to 43.33%. For stocks, shortfall probability increases to a value of 50%, whereas it incurs a decrease reaching a value of 81.67% for foreign currency. Again, for real estate, the shortfall probability has a minor increase to 65%. For an 11-year horizon, cash has a decline in its shortfall probability, reaching a value of 60.61% while the probability for gold increases to 48.48% and that for stock to 42.42%. Foreign currency keeps its declining trend, making a value of 74.24%. A decrease in shortfall probability was also observed for real estate, reaching a value of 53.03%.

The expected shortfall for cash in horizon 1 is 0.19%, decreasing to 0.08% for horizon 2, increasing to 0.20% for horizon 5 and again down reaching a value of 0.09% for horizon 11. For gold, the expected shortfall in horizon 1 is 1.35%, increasing to 1.43% for horizon 2 and further to 1.96% for horizon 5, ultimately reaching a value of 2.24% for horizon 11. The expected shortfall for horizon 1 of stocks is 2.15%, increasing to 2.47% for horizon 2 and further to 3.42% for horizon 5 before decreasing to a value of 2.42% for horizon 11.

For foreign currency, the expected shortfall is 0.70% for a 1-year horizon, decreasing to 0.61% for a 2-year horizon before increasing to 0.75% for a 5-year horizon and finally reaching a value of 0.69% for an 11-year horizon. Real estate shows a 6.52% value of expected shortfall for horizon 1, 5.40% for horizon 2, 5.12% for horizon 5, and finally a value of 3.48%.

The semi-variance of cash for a 1-year, 2-year, 5-year, and 11-year horizon stills at 0%. For gold, the semi-variance for horizon 1 is 0.05%, slightly increasing to 0.06% for horizon 2 and further to 0.16% and 0.18% for horizon 5 and 11 respectively. For horizon 1 the semi-variance for stocks is 0.15%, 0.21% for horizon 2, 0.66% for horizon 5, and decreases to 0.36% for horizon 11. The semi-variance of foreign currency is the same for all horizons, fixed at 0.01% except for in the case of horizon 2 where it is 0%. The semi-variance for real estate shows a decreasing trend from horizon 1 to 11, with values of 0.97%, 0.85%, 0.74% and 0.46% for horizon 1, 2, 5 and 11 respectively.

Considering expected shortfall and semi-variance, cash exhibits the lowest values for all investment horizons. If only the shortfall probabilities are taken into consideration, for a 1-year horizon, gold and stocks share the same spot by showing the lowest shortfall probabilities. For horizons 2 and 5, gold has the lowest shortfall probability whereas, for an 11-year investment horizon, stocks take its place.

Comparing the results of the correlation analysis with the LPM analysis, quite different results are obtained. According to the correlation analysis, cash is good enough to provide a hedge against inflation for long-term investment horizons, and foreign currency could be a good inflation hedge for medium horizons. For short-term investment horizons, real estate shows the greatest correlation with inflation. But the LPM analysis has uncovered the abilities of some other assets to provide a hedge against inflation, like gold and stocks. Thus, it is concluded that a high correlation does not mean a minimum LPM will be yielded as well.

Following Briere and Signori (2012), the downside analysis of inflation hedging capabilities of the individual assets will be concluded in terms of shortfall probabilities as it is providing more contrasting results. It shows that gold and stocks prove to be good inflation hedges for short-term investments. The hedging capabilities of gold are exceeded to medium term investments but for longer horizons, stocks prove to be a more effective hedge.

4.6. Minimum Semi-Variance Portfolio with target real return of 0%

Table 5 shows the portfolios constructed for various investment horizons which ensure minimum semi-variance and a target real return of 0%. Portfolios are constructed maintaining a minimum semi-variance as well as achieving a target real return of 0% to hedge inflation.

Table 5(a): Minimum Semi-Variance Portfolio with target real return of 0%

Investment Horizon (years)	1	2	5	11
Cash	89.19%	92.90%	75.22%	97.67%
Gold	6.28%	4.98%	24.78%	0.00%
Stocks	4.54%	2.12%	0.00%	2.33%
Currency	0.00%	0.00%	0.00%	0.00%
Real estate	0.00%	0.00%	0.00%	0.00%
Target Inflation rate	0.7569%	0.7083%	0.9779%	0.8460%
Portfolio Return	0.7569%	0.7083%	0.9779%	0.8460%
Portfolio Risk	0.0023%	0.0010%	0.0241%	0.0007%

Table 5(a) shows the allocation of the assets for achieving the target real return of 0%. It can be seen that for each investment horizon, different percentages of the assets are presented. It can be seen by taking a holistic view of results that the maximum amount of portfolio is invested in cash. For a 1-year portfolio, cash is at 89.19% and for a 2-year portfolio, it further increases to 92.9%. Real estate and foreign currency are not part of any portfolio. For a 5-year investment portfolio, gold is taking 24.78% of the portfolio and the rest is allocated to cash again. For an 11-year horizon, cash reaches a maximum percentage of 97.67% to achieve the target real return of 0%.

The fact that all the portfolios have cash as the major or only asset is due to the reason that it exhibits the least semi-variance as compared to all other assets i.e. 0%. And as portfolios are constructed to minimize semi-variance, cash seems to be the better choice as it decreases the semi-variance and also achieves the target real return of 0%. But that's not the ultimate answer. This asset allocation can be changed merely by removing cash from the mix and seeing what other assets can bring to the portfolio, which is very evident from the LPM analysis of the individual assets.

Table 5(b) reports the asset allocation in the absence of cash to ensure the inflation hedging of the portfolio. It is completely evident now how assets can be used strategically to create inflation hedged portfolios. Hence, it is shown as a result of the analysis that hedging inflation is surely possible using an optimal asset mix. This optimal asset mix will be different for each investment horizon depending on the investment horizon and motive.

4.7. Minimum Semi-Variance Portfolio with target real return of 1%, 2% & 3%

Taking the analysis, a step further for an investor who is more performance-oriented, target real returns are increased from 0%. Three different scenarios are developed for a target real return of 1%, 2%, and 3%. The portfolio compositions for these three targets are presented in Table 6.

Table 5(b): Minimum Semi-Variance Portfolio with target real return of 0% excluding cash

Investment Horizon (years)	1	2	5	11
Gold	22.29%	27.91%	41.63%	28.06%
Stocks	11.62%	10.58%	1.83%	39.17%
Currency	66.09%	61.51%	56.54%	22.52%
Real estate	0.00%	0.00%	0.00%	10.25%
Target Inflation rate	0.7569%	0.7083%	0.9779%	0.8460%
Portfolio Return	0.7569%	0.7083%	0.9779%	0.8460%
Portfolio Risk	0.0171%	0.02006%	0.0724%	0.1705%

Table 6(a): Minimum Semi-Variance Portfolio with a target real return of 1%

Investment Horizon (years)	1	2	5	11
Cash	31.57%	0.00%	0.00%	0.00%
Gold	39.39%	64.63%	100.00%	0.00%
Stocks	29.04%	35.37%	0.00%	100.00%
Currency	0.00%	0.00%	0.00%	0.00%
Real estate	0.00%	0.00%	0.00%	0.00%
Target Inflation rate	1.7569%	1.7083%	1.9779%	1.8460%
Portfolio Return	1.7569%	1.7083%	1.5249%	1.2528%
Portfolio Risk	0.0839%	0.1456%	0.3909%	0.8698%

Table 6(b): Minimum Semi-Variance Portfolio with target real return of 2%

Investment Horizon (years)	1	2	5	11
Cash	0.00%	0.00%	0.00%	0.00%
Gold	37.16%	0.00%	100.00%	0.00%
Stocks	62.84%	100.00%	0.00%	100.00%
Currency	0.00%	0.00%	0.00%	0.00%
Real estate	0.00%	0.00%	0.00%	0.00%
Target Inflation rate	2.7569%	2.7083%	2.9779%	2.8460%
Portfolio Return	2.7569%	1.9963%	1.5249%	1.2528%
Portfolio Risk	0.3089%	0.5909%	0.3909%	0.8698%

Table 6(c): Minimum Semi-Variance Portfolio with target real return of 3%

Investment Horizon (years)	1	2	5	11
Cash	0.00%	0.00%	0.00%	0.00%
Gold	0.00%	0.00%	100.00%	0.00%
Stocks	100.00%	100.00%	0.00%	100.00%
Currency	0.00%	0.00%	0.00%	0.00%
Real estate	0.00%	0.00%	0.00%	0.00%
Target Inflation rate	3.7569%	3.7083%	3.9779%	3.8460%
Portfolio Return	3.5810%	1.9963%	1.5249%	1.2528%
Portfolio Risk	0.7319%	0.5909%	0.3909%	0.8698%

Now for investors who are more performance-oriented, target real returns are increased to 1%, 2%, and 3%. An analysis is carried out to see if these performance-oriented goals can be achieved. For a target real return of 1%, the allocation of the assets is greatly changed. For horizon 1, cash is drastically reduced to 31.57%, gold is allotted 39.39% and stocks take 29.04% of the portfolio. For horizon 2, cash is down to 0% while gold and stocks are raised to 64.63% and 35.37% respectively. Achieving the target real return of 1% is only possible for a 1-year and 2-year investment horizon. For 5-year and 11-year investment horizons, maximum returns can be achieved by investing in gold and stocks respectively.

For a target real return of 2% in horizon 1, the percentage of cash is down to 0% while gold and stocks tale 37.16% and 62.89% of the portfolio portion respectively. Achieving the target real return of 2% is only possible for horizon 1 as per results. For the rest of the horizons, the shining assets are gold and stocks, with stocks covering most investment horizons. For a target real return of 3%, no possible combination is achieved. Maximum returns can be achieved by investing in stocks for short-term as well as long-term investment periods.

5. Conclusion

The present study empirically explores the inflation hedging capabilities of the most widely used assets in Pakistan. The study also intends to construct optimal portfolios that are protected from the coercive effects of inflation by employing returns of assets such as cash, gold, stocks, foreign currency, and real estate from 2005 to 2015. The inflation protecting abilities of the assets are analyzed in the first step by capturing their correlation and lower partial moments, and then the portfolios are constructed for several investment horizons which provide a cushion against inflation. Unlike other studies dealing with this particular topic, the present study also employs the downside risk measure to explore individual inflation hedging abilities as well as to construct the portfolios. Inflation hedging capabilities of the individual assets are checked through correlation and lower partial moments. It is believed that the traditional approach of considering the correlations for assessing the inflation-asset relationship can be deceptive. The results of correlation, when compared with the LPM analysis, paint a very different picture of the inflation hedging capabilities. The results of the correlation analysis conclude that real estate is the best inflation hedge for short-term investment horizons while cash is good for medium to longer investment horizons. According to the correlation analysis, gold, stocks and foreign currency are no good for inflation hedges. Foreign currency exhibits some inflation hedging abilities for a 5-year investment horizon but it is not better than cash. Using lower partial moments with inflation as a target rate, it is concluded that considering shortfall probabilities of the assets, gold and stock seem to be a good option for short-term investments. Gold is prominent for medium-term investment horizons but stocks take the place in longer horizons. (Fama, 1976; Hoevennars et al., 2008; Ibrahim & Agbaje, 2013; Nasir & Shah, 2012; Luintel & Paudyal, 2006; Chua, Sick & Woodward, 1990; Ghosh et al., 2004; Rubbaniy, Lee & Verschoor, 2011).

The inflation hedging properties of assets change with the investment horizon and thus the optimal asset allocation, which also ensures protection from inflation, is affected. The minimum semi-variance portfolios constructed, which are inflation-protected, are with a target real return of 0% and then for some optimistic investors who desire to achieve target real returns of 1%, 2%, and 3%. The results of the analysis show that inflation-protected portfolios can be constructed using an optimal asset mix. Inflation hedged portfolios can be constructed if investors know how to strategically create an optimal asset mix (Fleischmann, Rehring, and Sebastian, 2010; Brière and Signori, 2012). As per the current analysis, cash proves to be a better inflation hedge along with gold for short-term investments. For longer horizons, however, the inflation hedging abilities are tilted towards stocks. Other portfolios are also constructed, which are for more performance-oriented investors. It is found that achieving a target real return of 1% and 2% is possible only for the short-term but maintaining a 3% return is not possible even so. In the context of the above discussion, this study suggests that investors can strategically create optimal portfolios that are hedged against inflation.

AUTHOR CONTRIBUTION

Aftab Hussain Tabassam; Developed the theory and verified the analytical methods.
Arshad Ali Bhatti; Contributed to the design and implementation of the research, to the analysis of the results.
Zafar Iqbal: Presented the idea of research study, performed the analytic calculations, and performed the numerical simulations.
Amna Mushtaq; Wrote the manuscript with input from all other authors.

DATA AVAILABILTY STATEMENT

The data analyzed during the study is openly available for all. The authors did not have any special access that others do not have. All raw data of KSE-100[5] Index, currency rate[6], gold prices[7], treasury bill[8] and real estate[9] is available without any restriction

CONFLICT OF INTEREST

No conflict of interest

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[5] https://dps.psx.com.pk/historical
[6] https://www.investing.com/currencies/usd-pkr
[7] https://www.investing.com/commodities/gold
[8] https://www.investing.com/rates-bonds/pakistan-government-bonds?maturity_from=60&maturity_to=60
[9] https://www.zameen.com/

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