Nonlinear Causality between Inflation Uncertainty and Stock Returns: Evidence from Pakistan

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Abstract

The basic objective of this study is to analytically observe the fact whether relationship between stocks return and inflation is potentially linear or nonlinear. The conventional linear Granger approach is widely used in literature to check the causality among different series. The current study analyzes the relationship between stock returns and inflation uncertainty by using both linear and nonlinear granger causality tests for Pakistan. The study employed GARCH approach to test the uncertainty in inflation. Monthly data on inflation and stock returns is used from the period 2001:01 to 2019:12. The results show the existence of bi-directional nonlinear causal relationship between stock returns and inflation uncertainty in Pakistan. The study proposes that stocks are good long term vehicle for hedging against inflation uncertainty.

Keywords: GARCH, Granger Causality Test, Inflation Volatility, Stock Price Index
JEL Classification: F21, G01, G19

1. Introduction

According to "The Economic Times" (2017) the stock market provides a place for sale and purchase of shares across the world. Just a few decades before participants of stock market were only individual investors and now a time stock markets became institutionalized. To recognize the stock returns-inflation relationship is an ongoing attention between different researchers. Inflation is general and observable fact. Its impact and roots are generally discussed worldwide. Uncertainty regarding future prices is the most adverse impact of inflation uncertainty on growth of economies (Zivkov *et al.* 2020).

Uncertainty arises if economic agents are not confident regarding future prices because future price level is not always same. Friedman (1977) introduced the idea that high inflation leads to greater inflation uncertainty and pointed out its adverse impacts upon the activities of economy. An another advance is Cukierman-Meltzer (CM)

proposition states that high uncertainty in inflation raises the normal inflation rate.

Empirical work on stock market and its relationship with macro economy can be depicted as mixed. Researchers have given attention on the association amid macroeconomic variables and stock markets by employing simple vector auto regressive (VAR) models. Particularly, inflation is recognized as an important variable to conclude the behavior because it has a propensity of extra deviation in contrast to other variables. Numerous researchers have emphasized their consideration on Asian stock markets as these markets afford good occasion for foreign investment (Hussain *et al.* 2015). The markets of developing nations are facing more risk and uncertainty than developed nations. So, uncertainty in inflation and work of stock markets is an essential element in developed and developing markets.

It is a key question to identify the causal relationship among some time series. Past in turn of one series can contribute to predict another series. Granger causality test studies whether lag of one variable considerably explicate another variable in a VAR expression. Linear causality tests are capable to identify the direct causal relation involving two time series but in identifying nonlinear causal linkages the performance of linear test is poor. Therefore, Baek and Brock (1992) proposed nonlinear causality test to avoid this drawback. Later on Hiemstra and Jones (1994) adapted this test by investigating the outstanding nonlinear analytical influence of residual series of one variable on another residuals taking from a linear form.

However, the multivariate causal linkages are significant except they are not well studied particularly for nonlinear causality relationship. Though, this latest method is a significant addition to unfortunate literature. Therefore, present study explores linear along with non-linear causality relationship between returns of stock market with inflation uncertainty to check the CM and Friedman theories.

The study is organized as follows. The present section provides detail about introduction, Section 2 describes literature review, Section 3 about data and methodology, Section 4 provides detail about empirical results and the last section about conclusion and policy suggestions.

2. Literature Review

The linkage between inflation and stock market has examined by different researchers in the literature. Kearney and Daly (1998) using monthly data for Australia found that inflation uncertainty was directly related to stock return volatility. Saryal (2007) examined the correlation involving inflation and conditional uncertainty in stock prices using monthly data as of 1986:01 to 2005:09. The outcomes showed significant impact of inflation on stock returns uncertainty for Turkey. The results

also showed that uncertainty in inflation has larger power to predict uncertainty in stock market.

Wang (2010) found two way causal linkages between stock market and inflation uncertainty for China by employing VAR model. EGARCH model was used to model the uncertainty in inflation. Chiou-wei (2011) considered the impact of inflation on stock prices using Structural VAR model. This study demonstrates that the inflationary force was increased for the case of Hong Kong and Singapore. Falkberg (2012) questioned the impact of inflation rate uncertainty on returns of stock index by using VAR and granger causality test. The results recommended that stock returns were inclined by the macroeconomic variable.

Cakan (2013) evaluated the relation of inflation volatility with stock market returns by means of linear along with nonlinear causality experiment for the case of UK and US. Inflation volatility was computed using GARCH approach. Non-linear causality approach showed a two way non-linear projecting power among the variables. Some researchers focused toward cross sectional dependency queries by nonlinear representations and asserted that Fisher's hypothesis supported using panel data sets.

Omay and Yuksel (2015) examined the general Fisher hypothesis which was useful to corporate stocks by employing newly anticipated second generation tests of panel cointegration. This study provided strong favor for the presence of cointegration among stocks and goods prices. Additionally, analysis did not reject premise that cointegration linkage was linear. Balcilar *et al.* (2016) performed a bootstrap rolling window causality procedure to assess the causal affiliation of economic uncertainty (EU) with stock returns for India and China. This approach enabled to find possible time varying causations among various series founded on sub sample data. It was found that there were bidirectional causal relationships between EU and stock return in some sub periods rather than the whole sample period. Though, a few studies in literature have found to provide importance to the asymmetrical association between stock return and inflation.

A study by Bahluol *et al.* (2017) examined influence of stock market return and instability and various macroeconomic variables like inflation rate on Islamic stock markets returns by Markov switching regression model. The study also explored that stock returns are anticipated diverse for times of inflation, as different to phases of deflation.

Ajaz *et al.* (2017) examined the dynamic connections among monetary and fiscal variables for Indian perspective. This endeavor applied an asymmetric ARDL approach developed by Shin et al., (2014), for identifying nonlinearity concentrating on long run and short run asymmetries amid financial variables. Results pointed towards existence

of asymmetric response of stock returns towards variations in exchange rate and interest rate.

Madadpour and Asgari (2019) explored the association between stock market returns and inflation for 1930-2018. Correspondingly, it was originated that outcomes in some of studies were doubtful owing to using unsuitable statistical procedures like linear regression. Lastly, present paper suggested sizable variations should be apply to existing practice for testing affiliation between inflation and stock market return, to develop more effective research. Hussain *et al.* (2020) examined linkage between macroeconomic uncertainty and stock market by employing EGARCH and VECM framework. The study found significant linkage between macroeconomic indicators like money supply, inflation volatility and stock price index.

3. Data and Methodology

In order to study the relationship between stock returns and inflation uncertainty in Pakistan monthly data from the period 2001:01 to 2019:12 is used. CPI is used as a measure of inflation rate (π_t) and KSE 100 index to calculate stock market returns (SR). The study collected data from various sources like International Financial Statistics and statistical bulletin of State Bank of Pakistan. Inflation rates are computed from monthly CPI by using formula in equation 1;

$$\pi_t = [(p_t - p_{t-1}) / p_{t-1}]*100 \quad (1)$$

Stock market returns are calculated using equation (2).

$$SR = \ln(p_t) - \ln(p_{t-1}) \quad (2)$$

where

- *ln*……. natural logarithm
- P_t……index at current time
- P_{t-1}……..value of index at preceding period

3.1 Modeling Uncertainty

Engle introduced Autoregressive conditional heteroskedasticity (ARCH) approach which used a mean inflation equation with unchanging parameters however consent the conditional variances to variable with time.

The structure of ARCH (1) model is described in equation 3 and equation 4

$$\pi_t = \beta_0 + \sum_{i=1}^{n} \beta_i \pi_{t-i} + \varepsilon_t \quad (3)$$

$$\sigma^2 \varepsilon_t = \alpha_0 + \sum_{i=1}^{n} \alpha_1 \varepsilon^2{}_{t-i} \quad (4)$$

where $\sigma \varepsilon^2{}_t = h_t$

$$h_t = \alpha_0 + \sum_{t-1}^{q} \alpha_1 \varepsilon_{t-i}^2 \quad (5)$$

Bollerslev (1986) anticipated a different generalized procedure and allowed restricted variance to be reliant on its own earlier lags plus squared residual term. General organization of GARCH process is explained in equation 6:

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon^2{}_{t-i} + \sum_{j=1}^{p} \delta_j h_{t-j} \quad (6)$$

Here $\alpha_0 \succ 0, \alpha_i \geq 0, \delta_i \geq 0$

3.2 Testing Linear Causality

Linear causality is performed using granger approach on following two equation models.

Here, h_t and π_t in Eq.7 and Eq.8 are stationary variables.

$$h_t = \partial_0 + \sum_{i=1}^{n} \lambda_{1i} h_{t-i} + \sum_{i=1}^{m} \beta_{1i} \pi_{t-1} + e_{1t} \quad (7)$$

$$\pi_t = \partial_1 + \sum_{i=1}^{n} \lambda_{2i} h_{t-i} + \sum_{i=1}^{m} \beta_{2i} \pi_{t-1} + e_{2t} \quad (8)$$

4. Results and Discussions

This study first checked the descriptive statistics of the variables. The results in Table 1 showed that value of Jarque-Bera test is high indicating abnormal data distribution. Values of skewness and kurtosis also show that distribution of inflation is negatively skewed and leptokurtic. The value of skewness is -11.31 less than zero and statistic of kurtosis is 143.62 which is greater than 3.

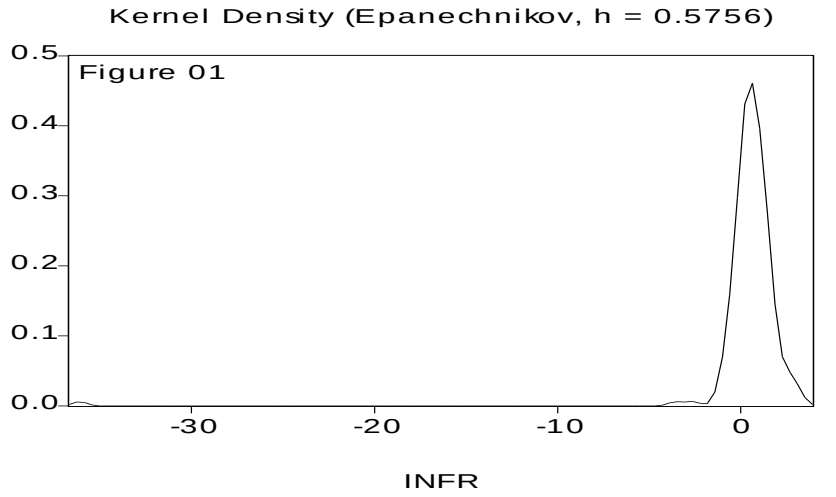
Further the researcher has plotted Kernal density function and the figure 01 below also shows that data is leptokurtic and negatively skewed.

Table 1: Descriptive Statistics of Variables

	π_t	SR
Mean	0.44	0.02
Median	0.57	0.02
Max	3.33	0.69
Min	-36.10	-0.96
Std.dev.	2.88	0.16
Skewness	-11.31	-0.85
Kurtosis	143.62	14.04
Jarque-Bera	1522.24	932.32
Prob.	0.00	0.00
Observations	228	228

Source: Author's own calculation

Figure 1: Kernal Density Function



GARCH (1, 1) is used in the next step to model uncertainty in inflation reported in Table 2. Selection of lag length depends on the minimizing the Akaike information criteria and Schwartz criteria.

To model the uncertainty in inflation the researcher has made GARCH variances series. The graph of variance series according to the time period is shown in figure 2 below.

Table 2: GARCH (1, 1) Results

Dependent Variable: π_t				
ML – ARCH				
Sample Adj. 2001:02 -2019:12				
Variables	**Coefficient**	**Std. Error**	**z-Stat**	**P value.**
β(0)	3.09	14.32	0.22	0.83
Π_t (-1)	0.98	0.07	13.75*	0.00
	Variance Equation			
α (0)	32.78	12.72	2.57	0.01
α(1)	-0.01	0.01	-0.71	0.48
δ (1)	0.59	0.12	4.83*	0.00
R^2	0.87	Mean dep var		163.75
R BAR SQ	0.87	S.D. dep var		44.37
S.E. of reg.	7.21	AIC		6.84
Sum SQ resid.	906.22	SBC		6.92
Log likelihood	-607.18	F-stat		1638.94
DW stat.	1.90	P value(F-stat)		0.00

Source: Author's own calculation

Figure 2: Graph of GARCH Variance Series

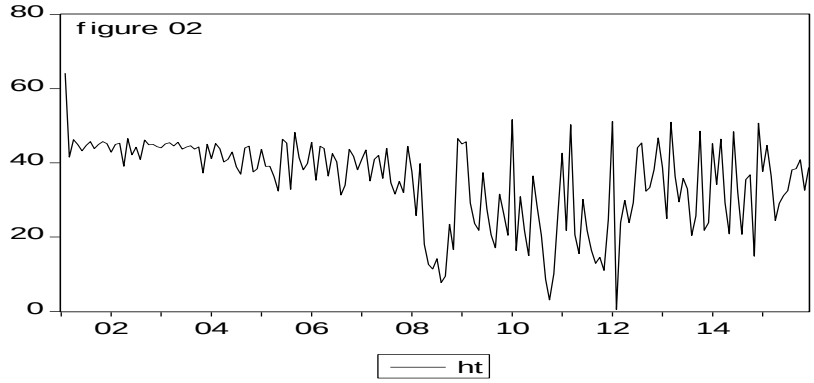


Table 3 shows the results of unit root test. ADF and PP test is performed with trend and intercept both at level and first difference. Inflation uncertainty ($H_{\pi t}$) and stock returns both variables are stationary at level.

Table 3: Unit Root Tests

Variables	ADF test		PP test	
	Level	1st difference	Level	1st difference
Hπt	-6.03*	-10.09*	-7.83*	-16.14*
SR	-7.94*	-12.57*	-14.54*	-29.43*
*shows at 1% significance level				

Source: Author's own calculation

The pre-condition to apply granger causality test is that the variables are stationary at level and this is fulfilled by both ADF and PP test Statistics. To determine causal relationship the linear granger causality test is performed at lag 2. The results of granger causality test are shown in Table 4.

Table 4: Linear Causality Testing

Pairwise Granger Causality Test				
Model: 2001:01 2019:12				
H0:	**Lags**	**Obs**	**F-Stat**	**P-value**
Hπt does not Granger Cause SR	2	225	0.05	0.94
SR does not Granger Cause Hπt	2	225	0.03	0.96

Source: Author's own calculation

The result in Table 4 shows that no causal linkage exists of inflation volatility with stock returns at 5% significance level. Moreover, the outcomes show that stock returns also did not granger caused inflation uncertainty at five percent significance. The results specify that both Friedman and CM hypotheses are not valid for Pakistan.

4.1 Testing Nonlinear Granger Causality

Complexity in linear causality methods is that these analyses have less power identifying certain types of non-linear causal linkages. Baek and Brock (1992) developed non-parametric algebraic technique for revealing this interaction. Table 5 below shows the outcomes of non-linear causality test. The results suggest significant existence of bi-directional non-linear causality among the variables.

Table 5: Nonlinear Granger Causality Testing

Null Hypothesis	Ly=Lx	TVAL	CS
Hπt ≠> SR	3	4.46*	0.01
SR ≠> Hπt	3	5.99*	0.00

Notes:*, denote rejections of the null hypothesis at the 1% significance level and the symbol "≠>" means no existence of non-linear causality. The distribution of test statistic is N (0, 1). CS and TVAL are the conditional probabilities and standardize test statistics. The critical value at 1% significance level is 2.33.

Source: Author's own calculation

5. Conclusion and Implication

The association among stock market and inflation uncertainty can be negative, positive or statistically insignificant. The association of inflation uncertainty with stock returns is explored in present study for Pakistan. The data is collected on monthly basis on the variables like inflation and stock prices from the period 2001:01 to 2019:12. The study collected data from State Bank of Pakistan, business recorder and International Financial Statistics.

GARCH family models and granger causality testing procedure were employed for estimation purpose. As compared to linear outcomes, non-linear causality analysis demonstrate that two way non-linear Granger causality is existing between inflation instability and stock prices for Pakistan. Current research projected that stocks are good long term vehicle for hedging against inflation volatility.

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