An Empirical Nexus between Consumer and Wholesale Price Indexes for Pakistan

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1. Introduction

Prices are generally a measure of index. Traditionally, there are two main aggregate measures of price level, the Consumer Price Index (CPI) and the Wholesale Price Index (WPI). The CPI measures the prices paid by the consumer for the goods or services at retail level[2] (Bishop, 2006) where as WPI measures the price variation at the time of bulk distribution and that include import price as well. In other words, WPI is the price set by the producer at the time of bulk distribution, known as producer prices (Economist, 2001). The WPI has extensively taken as the leading indicator for the CPI (Clark, 1995). Moreover many studies have also evaluated the link between CPI and WPI as indicators of inflation [such as Gordon (1988); Lown and Rich (1997); Mehra (1991, 1993)]. Furthermore, CPI is also widely used as a measure of cost of living [Shiratsuka (1999); Bourassa (1998); Triplett (2001); Renwick (1998); Boskin (1998)]. The detail contents and relationship of these two indexes have discussed by Bechter and Pickett (1973).

In empirical literature many studies have evaluated the bivariate time series causality relationship between consumer and wholesale prices. The results of these studies are mixed. For example, Guthrie (1981) and Silver and Wallace (1980) are

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[2] The British call it the Retail Price Index (RPI)[Economist, 2001]

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based on a one-sided distributed lag model running from wholesale prices to consumer prices. Engle (1978) also supported this distribution. Hence according to their specification, Granger causality is unidirectional running from wholesale to consumer prices.

While Colclough and Lange (1982) found evidence of bidirectional causality between the two time series with both Granger and Sims tests and also emphasized that there are theoretical reasons to expect causality to run from consumer prices to wholesale prices through derived demand analysis whereby changes in demand for final goods cause changes in demand for primary goods. Similarly Granger, Robins and Engle (1986) found weak evidence of other way causality running from consumer to wholesale price changes. Cushing and McGarvey (1990) concluded that the magnitude of feedback from wholesale to consumer prices is greater than the consumer to wholesale prices. They also extended the bivariate price system with the addition of money growth variable and found that the feedback from wholesale to consumer prices is still dominating. Caporale, et al. (2002) studied producer price index in lieu of wholesale price index, and found bidirectional causality, in which PPI and CPI cause each other in bivariate system as opposed to five variate model where they detected unidirectional causality running from PPI to CPI.

In this study, the purpose is to statistically evaluate the connection between the consumer and the wholesale prices indexes, given some other variables such as money supply and the exchange rate in Pakistan. The rest of the paper is organized as follows. Section 2 contains a brief description of data definitions and the methodological procedure. Section 3 presents the empirical results, while concluding remarks are given in section 4.

2. Data And Methodology

This study used monthly series of CPI, WPI, money supply and real effective exchange rate of Pakistan (for the period of 1991M9 to 2006M6) drawn from the International Financial Statistics (IFS) data CD 2007. The classical linear regression model initially used to evaluate the basic statistical relationship, followed by the more advance econometric tests such as unit root test and test of cointegration proposed by Johansen (1988). Thereon we also employed the relatively new Granger Causality technique developed by Toda and Yamamoto (1995) that considered robust for the cointegration technique. The underline objective of this causality test is to overcome the problem of invalid asymptotic critical values when causality tests are performed in the presence of nonstationary series or even cointegrated. We will also conduct series of diagnostic tests to ensure the standard properties of the tests. But before it we graphically find out the trend between the monthly series from 1991M9 to 2006M6. A visual plot of the data is usually the first step in the analysis of any time series.

3. Empirical Results

In order to statistically evaluate the relationship between CPI and WPI, we treat CPI as the regressand and WPI as the regressor. Since CPI represents the prices paid by the consumers and WPI represents the prices paid by the producers, hence former are usually a markup on the latter. The bivariate estimated model along descriptive statistics is shown below:

$$CPI_t = 7.996479 + 0.897218 WPI_t \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

t-statistics (18.05776) (193.0017)
R^2 = 0.995297 Durban-Watson = 0.139967 F-statistic = 37249.65

Moreover, we extend our regression analysis from bivariate to multivariate analysis, for which added two additional variables, the money supply and the exchange rate. The multivariate estimated model along descriptive statistics is shown below:

$$CPI_t = 6.016227 + 0.830671 WPI_t - 0.0000015 M_t + 0.147820 ER_t \ldots\ldots\ldots(2)$$

t statistic (11.13779) (34.49426) (-3.245384) (4.89114)
R^2 = 0.996354 Durban-Watson = 0.18746 F-statistic = 15850.93

The above results demonstrate that all estimated coefficients, as well as F-statistics, are statistically significant. The high R-squared (0.99) in both equations is an indicator that there is a strong positive relationship between CPI and WPI particular and additional variables in general. However the Durbin-Watson statistic is very low in both equations that are 0.14 and 0.19 respectively. According to Granger and Newbold (1974), an R-squared greater than Durbin-Watson statistic is a good rule of thumb to suspect that the estimated regression suffers the problem of spurious regression. In other words, it indicates that we are regressing a nonstationary time series against another nonstationary one. Alternatively, a stochastic time series process is said to be stationary if its mean and variance are constant over time and the value of the covariance between two time periods depends on the distance between the two time periods and not the actual time at which the covariance is computed (Gujarati, 2003).

The **figure-1** reveals that all four series demonstrate the sustained upward trend, suggesting that the mean of the series has been changing. This further suggests that series are not stationary. This has also been analyzed by the Correlogram, though the first difference become stationary (see figure-2). To statistically test for this possibility, we employed various unit root tests and the results are shown in Table-1.

Figure-1
CPI, WPI, Money Supply (Ms) and Exchange Rate (ER)
(monthly data from 1991 to 2006)

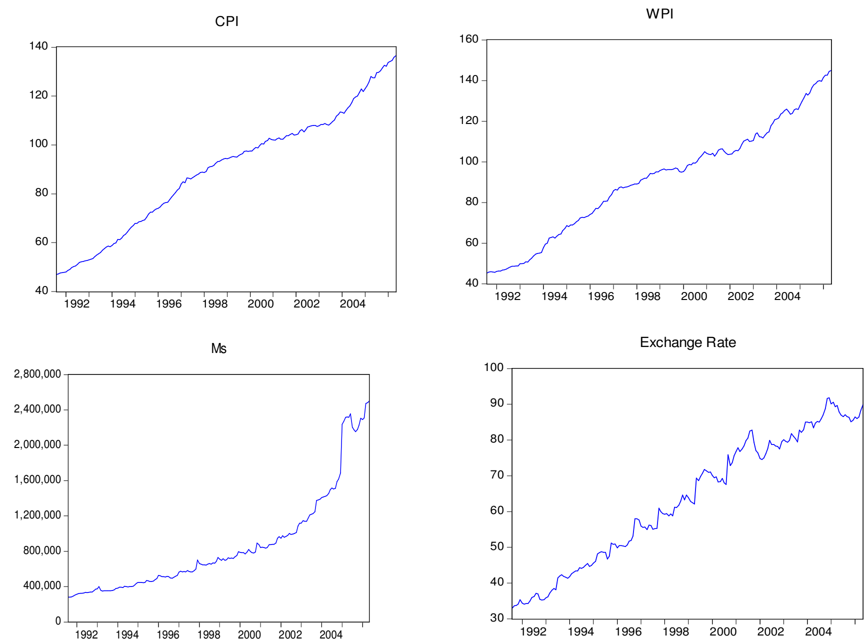
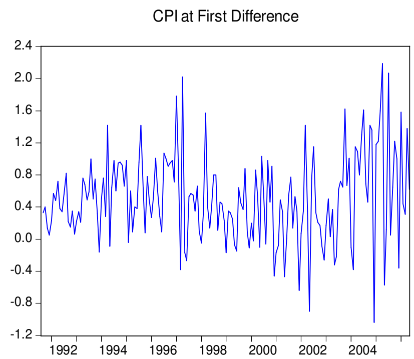
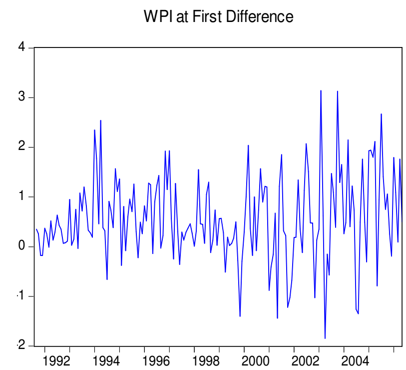
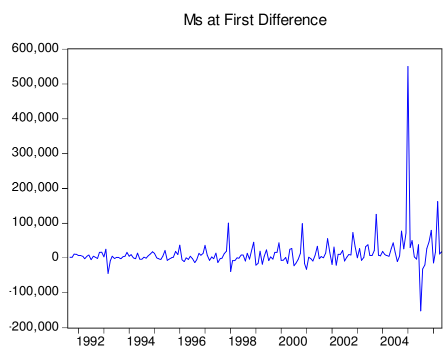
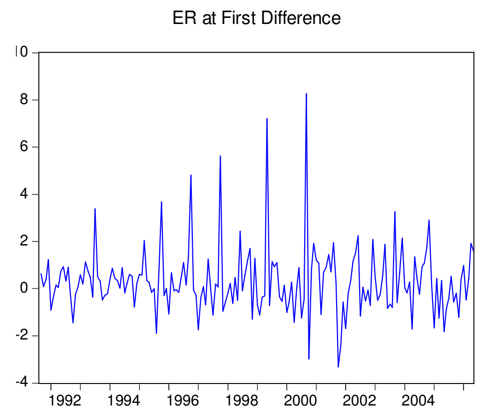


Figure-2
CPI, WPI, Ms and ER at First Difference









3.1. The Unit Root Analysis

The results regarding the order of integration of the series have been determined by different unit root tests. In ADF test, optimum lag length, shown in lags column, has been determined using Schwarz information criterion (SIC). Similarly the Phillips-Perron test used, which has the extra advantage over the Dickey-Fuller test that is, it has been adjusted to take into account of serial correlation by using the Newey-West (1994) covariance matrix.

Table –1

Unit Root Estimation, at first difference

Variables	Augment Dickey-Fuller			Phillips-Perron (PP)			Ng-Perron		
	Intercept and trend	Prob.	Lags	Intercept and trend	Prob.	Bandwidth	Intercept and trend		Lags
							MZa	MZt	
CPI	-6.1051	0.000	2	-12.4626	0.000	5	-43.3268	-4.6544*	2
WPI	-10.605	0.000	0	-10.5073	0.000	9	-84.7326	-6.5080*	0
M	-12.10184	0.000	0	-12.12207	0.000	3	-87.3321	-6.6076*	0
ER	-14.05207	0.000	0	-14.16008	0.000	5	-87.7432	-6.6116*	0

* level of significance at 1%

In PP tests, Bartlett kernel (default) spectral estimation method and Newey-West bandwidth (automatic selection) have been used. The conclusions about the order of integration of a particular variable are based on the tests that included the intercept and trend in the test equation. The results indicate that the CPI, WPI, Ms and ER are not stationary in their level but are stationary at their first difference in both unit root statistics. Hence the null hypothesis of nonstationary is rejected at the 1 percent level of significance for both the series.

This further analyzed by applying Ng-Perron (2001) test. GLS-detrended (default) spectral estimation method and Schwarz information criterion (automatic selection) have been used in this test. The results of these statistics also show that variables are stationary at their first difference. Therefore all the previous results have also been supported by the Ng-Perron test.

3.2. The Cointegration Analysis

Since all series found to be integrated of order one i.e., I(1), the cointegration hypothesis between the given variables has examined by the Johansen cointegration test[3], using both the Trace and maximum Eigen value tests under the null hypothesis of no cointegrating vector (see Table-2).

Table – 2: Johansen Cointegration Test

H_0	Trace Statistic	5 percent Critical Value	Prob.	H_0	Max-Eigen Statistic	5 percent Critical Value	Prob.
$r = 0$	86.8106	62.9207	0.0002	$r = 0$	38.3971	31.4599	0.0075
$r \leq 1$	48.4135	42.1147	0.0128	$r = 1$	26.1417	25.2147	0.0454
$r \leq 2$	22.2718	25.2263	0.1316	$r = 2$	16.8824	18.8352	0.1114
$r \leq 3$	5.3894	12.0405	0.5414	$r = 3$	5.3894	12.0405	0.5414

Note: The lag order in Cointegration process is 6.

Since 86.8106 exceeds the 5 percent critical value of 62.9207 of the λ_{trace} statistic, it is possible to reject the null hypothesis of no cointegrating vectors and accept the alternative of one or more cointegrating vectors. Next, we use the $\boldsymbol{\lambda_{trace}(1)}$ statistic to test the null of $r \leq 1$ against alternative of two cointegrating vector, again 48.4135 exceeds the 5 percent critical value of 42.1147 of the $\lambda_{trace}(1)$ statistic, but since the 22.2718 is less than the 5 percent critical value of 25.2263, we cannot reject the null hypothesis at this significance level. The $\boldsymbol{\lambda_{trace}(2)}$ statistic indicates no more than two cointegrating vector at 5 percent significance level.

The $\boldsymbol{\lambda_{max}}$ statistic also helps to clarify the issue. The null hypothesis of no cointegrating vectors ($r = 0$) against the specific alternative $r = 1$ is clearly rejected. The calculated value of $\boldsymbol{\lambda_{max}}$, 38.3971 exceeds the 5 percent critical value of 31.4599. The test of the null hypothesis $r = 1$ against the specific alternative $r = 2$ also rejected at the 5 percent significance level, since the 26.1417 is greater than the 5 percent

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[3] For detail discussion on the topic see Enders (2004)

critical value of 25.2147. Note that the test of the null hypothesis ***r = 2*** against the specific alternative ***r = 3*** cannot be rejected at the 5 percent significance level, since the 16.8824 is less than the 5 percent critical value of 18.8352. Thus both $\boldsymbol{\lambda_{trace}(2)}$ and $\boldsymbol{\lambda_{max}(2)}$ statistics indicate that data-generating process contain only two cointegrating vector. Thus it is possible to say that there is long run equilibrium relation between the variables.

3.3. The Causality Analysis

The next step is to estimate Toda-Yamamoto test, the Augmented Granger Causality test for the given four variables, say, $\mathbf{d}_{max}$, exhibited the maximum order of integration in the process of interest (in our case, it is one), the optimum lag length (k) of VAR is determined by using the Schwarz Information Criterion (SIC), was found to be 2 (i.e., 2 months). We then estimate a VAR[4](k + d_{max}) to use the Wald test for linear restriction on the parameters of a VAR(k), which has an asymptotic χ^2 distribution. Moreover the coefficient of the extra lag will not be used in the computation of the Wald test for causality. Therefore, we ignore the coefficient of the last $\mathbf{d}_{max}$ of order of integration and applied the linear restriction only on the first k coefficients of matrices by mean of Wald test. We estimated the following system of equations to analyze the Augmented Granger causality test:

$$CPI_t = \sum_{i=1}^{3}\alpha_i WPI_{t-i} + \sum_{i=1}^{3}\beta_i CPI_{t-i} + u_{1t} \quad \ldots\ldots\ldots\ldots(3)$$

$$WPI_t = \sum_{i=1}^{3}\lambda_i CPI_{t-i} + \sum_{i=1}^{3}\delta_i WPI_{t-i} + u_{2t} \quad \ldots\ldots(4)$$

$$CPI_t = \sum_{i=1}^{3}\alpha_{1i} WPI_{t-i} + \sum_{i=1}^{3}\beta_{1i} CPI_{t-i} + \sum_{i=1}^{3}\lambda_{1i} M_{t-i} + \sum_{i=1}^{3}\delta_{1i} ER_{t-i} + u_{3t} \quad \ldots\ldots(5)$$

$$WPI_t = \sum_{i=1}^{3}\alpha_{2i} WPI_{t-i} + \sum_{i=1}^{3}\beta_{2i} CPI_{t-i} + \sum_{i=1}^{3}\lambda_{2i} M_{t-i} + \sum_{i=1}^{3}\delta_{2i} ER_{t-i} + u_{4t} \quad \ldots\ldots(6)$$

The above four equations system is estimated by seemingly unrelated regression (SUR) method. At the bivariate level, if we want to test that 'WPI does not Granger

[4] VAR order is now VAR (3) that is we added extra lags of the variables equal in number to the maximum order of integration.

cause CPI' the null hypothesis will be $\boldsymbol{H_0: \alpha_i = 0}$ where α_i are the coefficients of WPI_{t-i}, $\boldsymbol{i = 1, 2}$ ($\boldsymbol{H_0}$: $\alpha_1 = \alpha_2 = 0$) in the equation 3 of the system. Similarly the other null hypothesis for equation 4 is $\mathbf{H_0}$: $\lambda_i = \mathbf{0}$ where λ_i are the coefficients of CPI_{t-i}, $\boldsymbol{i = 1, 2}$ ($\boldsymbol{H_0}$: $\lambda_1 = \lambda_2 = 0$) that is the 'CPI does not Granger cause WPI'. This we implemented by means of a Wald test with the null hypothesis that the values of the estimated coefficients (α_i and λ_i) are zero. The results of the Toda-Yamamoto tests of augmented Granger causality are given in Table-3. of the estimated coefficients (α_i and λ_i) are zero, obtained from the SUR estimation of the level VAR model outlined in equation (3) and (4), are in table-3. The null hypothesis that 'WPI does not Granger cause CPI' can decisively

The results of Wald test with the null hypothesis that the values be rejected at the 1 percent level of significance. On the other hand, the hypothesis that 'CPI does not Granger cause WPI' can be rejected at the 5 percent level of significance. Therefore we on the whole found out the evidence that there is bidirectional causality where CPI and WPI Granger cause one another. This would imply that there are feedback effects between CPI and WPI at bivariate level. However, the magnitude of feedback from wholesale to consumer prices index is greater than the consumer to wholesale prices index as suggest by estimated values of chi-square and F statistics. The degree of freedom (df = 2) equals to the number of restrictions in the system.

Nevertheless, the results are some extension to conventional rationale in the empirical literature that WPI is a leading indicator for CPI. The CPI represents the prices paid by the consumers, where as the WPI represents the prices paid by the producers. The former are usually a markup on the latter. Granger causality refers here the effect of past two month's values of WPI on the current values of CPI. Hence Granger causality actually measures whether the current and past values of WPI help to forecast the future value of CPI. If we reject the hypothesis that 'WPI does not Granger cause CPI' it actually means that WPI does actually cause the CPI and so does in improvement of the forecasting performance of WPI.

On the other hand, the causality rationale from CPI to WPI is consistent with theory in two ways. First, in derived demand analysis demand for final goods affects the production cost through the price of inputs. Second, wage setters in the wholesale sector increase wages when they observe an increase in consumer price[5]. Hence past two month's values of CPI also helps effect forecast the future values of WPI with a lesser magnitude.

At the multivariate analysis, we estimated six different versions of equations 5 and 6, in first version where we want to test that 'WPI does not Granger cause CPI', given exchange rate, we put restriction on all three lag coefficients of money supply and first two lag coefficients of WPI. We rejected the given hypothesis at 1 percent level of significance and conclude the WPI does cause CPI, similar results have also been found in second version where we test that 'CPI does not Granger cause WPI' even if we put restriction on money supply coefficients given exchange rate variable (for detail see Table-3).

In third version of equation 5 and 6, where we want to test that 'WPI does not Granger cause CPI', given money supply, we put restriction on all three lag coefficients of exchange rate and first two lag coefficients of WPI. Hence, we can reject the given hypothesis at 10 percent level of significance and conclude the WPI does cause CPI, similar results have also been found in fourth version where we test that 'CPI does not Granger cause WPI' even if we put restriction on lag coefficients money supply with the presence of exchange rate

Table-3: Toda-Yamamoto Test of Granger Causality a Modified Wald test

Equations	Null Hypothesis	Test Statistics					
		χ^2-statistic			F-statistic		
		Value	**df**	**Prob.**	**Value**	**df**	**Prob.**
Bivariate-CPI and WPI							

[5] For detail see Caporale, Katsimi and Pittis (2002)

Equation-3	WPI does not Granger Cause CPI	11.0921	2	0.0039 *Reject H_0*	5.54503	(2,168)	0.0047 *Reject H_0*
Equation-4	CPI does not Granger Cause WPI	6.80459	2	0.0333 *Reject H_0*	3.40230	(2,168)	0.0356 *Reject H_0*
Multivariate-CPI, WPI, Money Supply (Ms), and Exchange Rate (ER)							
Equation-5	WPI does not Granger Cause CPI (given ER)	16.0775	5	0.0068 *Reject H_0*	3.21549	(5,162)	0.0085 *Reject H_0*
Equation-6	CPI does not Granger Cause WPI (given ER)	18.3946	5	0.0025 *Reject H_0*	3.67892	(5,162)	0.0035 *Reject H_0*
Equation-5	WPI does not Granger Cause CPI(given Ms)	9.1478	5	0.1033 *Reject H_0*	1.82955	(5,162)	0.1098 *Reject H_0*
Equation-6	CPI does not Granger Cause WPI (given Ms)	9.3438	5	0.0961 *Reject H_0*	1.86876	(5,162)	0.1026 *Reject H_0*
Equation-5	WPI does not Granger Cause CPI (given both Ms and ER)	7.32529	2	0.0257 *Reject H_0*	3.66265	(2,168)	0.0278 *Reject H_0*
Equation-6	CPI does not Granger Cause WPI (given both Ms and ER)	6.9289	2	0.0313 *Reject H_0*	3.46447	(2,168)	0.0336 *Reject H_0*

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In fifth version of equation 5 and 6, where we want to test that 'WPI does not Granger cause CPI', we included both money supply and exchange rate, while put restriction on first two lag coefficients of WPI. We reject the given hypothesis at 5 percent level of significance and conclude the WPI does cause CPI, similar results have also been found in final version where we test that 'CPI does not Granger cause WPI' with the presence of both money supply and exchange rate (for detail see Table-3). This would again imply that there are feedback effects between CPI and WPI even at multivariate level. The presence of money supply and exchange rate do not effect the broader conclusion that there is bidirectional causality between consumer price index and wholesale price index.

3.4. The Diagnostic Tests

The results of different diagnostic tests overall ensured that the underline assumptions hold for SUR equations. Diagnostic tests were carried out for serial correlation, model specification, Heteroskedasticity and for normality in the residuals of VAR. The results are reported in Table-4.

Table - 4: Diagnostic Tests

Equations	**LM Test**	***ARCH* Test**	**Ramsey RESET Test**	**Jarque-Bera Test**
Equation-2	2.105157 (0.125067)	8.005370 (0.005219)	0.434216 (0.510835)	5.348286 (0.068966)
Equation-3	1.489862 (0.228402)	0.778755 (0.378754)	2.073967 (0.151703)	7.642359 (0.021902)
Equation-4	1.050102 (0.3523)	1.753253 (0.1763)	2.626583 (0.0187)	4.480577 (0.106428)
Equation-5	0.051064 (0.9502)	2.396451 (0.1234)	2.943277 (0.0064)	8.356040 (0.015329)

Note: The figures in parentheses are the p-values.

The Breusch-Godfrey serial correlations LM Test, autoregressive conditional heteroskedasiticity (ARCH) and Ramsey RESET specification test overall verify the suitability of SUR estimation, while the normality test does not show vigorous results. The stability of the models is based on the CUSUM and CUSUM of squares tests (Brown, Durbin, and Evans, 1975) of the recursive residuals. The test find parameter stability as the CUSUM goes inside the area between the two critical values but the CUSUM of squares movement outside the critical lines is suggestive of parameter or variance instability in SUR (see figure-3, figure-4, figure-5 and figure-6).

Figure-3: For Equation 2

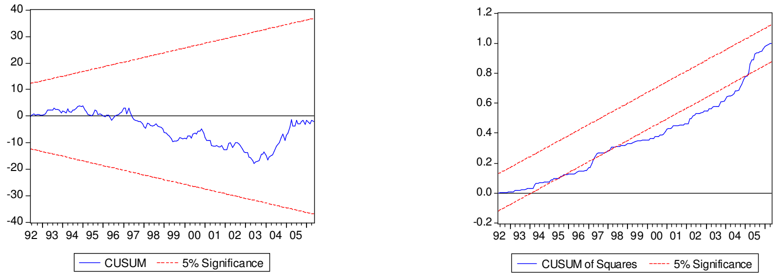


Figure 4: For Equation 3

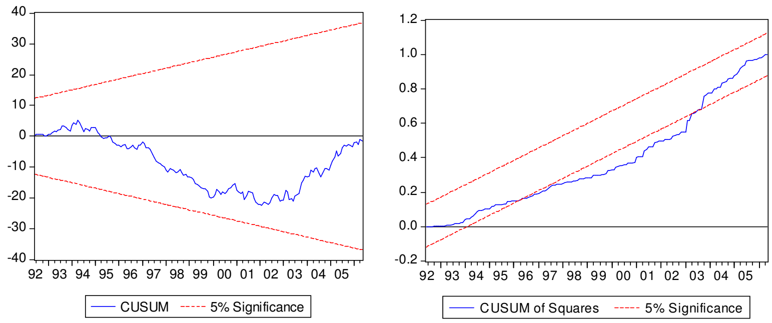


Figure 5: For Equation 4

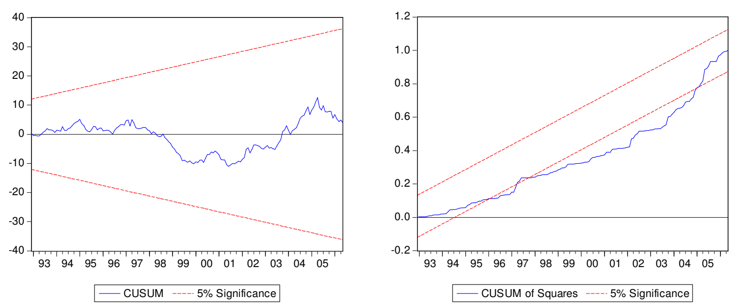
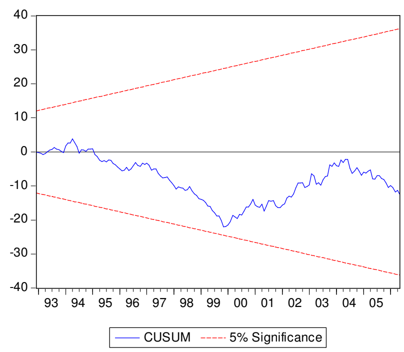
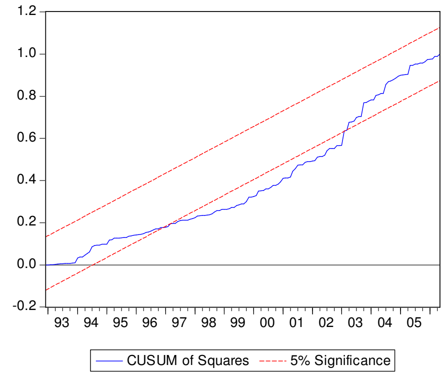


Figure 6: For Equation 5





4. Conclusion

This paper was an endeavor to analyze the causal association between the Consumer Price Index and Wholesale Price Index, as been the target of many earlier studies. This relationship is helpful in predicting the future inflationary movements in the economy and also gives ample time to policy makers to avoid it, or at least lessen the negative consequences of inflation in Pakistan. To search for the nature of the relationship between CPI and WPI, we have implemented the Toda-Yamamoto Augmented Granger Causality test at bivariate and multivariate levels. The results indicated bidirectional causality, where CPI and WPI Granger cause one another. Thus the empirical evidences found in this study are consistent with the earlier studies which show bidirectional relationship between CPI and WPI.

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