Modelling the Relationship between Whole Sale Price and Consumer Price Indices: Cointegration and Causality Analysis for India

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Abstract

In this study we attempted to analyze the static and dynamic causality between producers' prices measured by WPI and consumers' prices measured by CPI in the context of India. We did our analysis in the framework of time series and for analysis, we applied ARDL bounds testing approach to cointegration and robustness of ARDL approach is examined through Johansen and Juselius (1990) maximum likelihood approach over the period of 1950-2009.
We found the evidence of bidirectional causality between WPI and CPI in both cases i.e., in the short-run and long-run. Furthermore, outside sample forecast analysis reveals that in India, WPI leads CPI. This implies that WPI is determined by market forces and also a leading indicator of consumers' prices and inflation. This gives an indication to the Indian policy analysts to control for factors affecting WPI in order to have control on CPI since CPI is used for indexation purposes for many wage and salary earners including government employees and hence it will be helpful in cutting down the excess government expenditure.

Keywords: CPI and WPI, Granger causality, cointegration VDs, IRFs.
JEL Code: E31, C32.

1. Introduction

Theoretically, all prices are determined by two conventional market forces i.e.,- demand and supply. Now if we assume that producer prices are set as a mark-up on wage costs, mark-up depends on demand pressures and thereby influences wages and finally wage rate depends on consumer prices, we will find that the causality runs from consumers' price to produces' prices. And if we say that Whole-sale Price Index (WPI) represents produces' price and Consumers' Price Index (CPI) represents consumers' price then in the above mentioned situation we can say that CPI granger causes WPI. In the case of India it is true since India's per capita income is still low, so the share of food in the consumption basket is large and in that case even if true CPI (which includes food components and industrial components together) does not cause WPI, the food component of CPI may cause WPI. However, the situation may be inverse also i.e., WPI may granger cause CPI. This kind of dynamics will appear when transmission mechanism move from the supply side or production processes to the demand side or consumption behavior. There are several reasons to support this argument. For example, since the retail sector adds value with a lag to existing production and uses existing domestic or imported materials as production input. Therefore, the price of final consumer goods will depend on the price at which raw material or what we call production inputs is purchased. Further, price of production inputs depends upon the domestic demand and domestic supply of the production inputs in one hand and imported inputs on the other hand which in turn depends upon the prices of the imported goods, the nominal exchange rate, the level of indirect taxes, the marginal cost of retail production and interest rates. Cushing and McGarvey (1990) [1] have developed theoretical basis for causal relationship running from wholesale price to consumers' prices. They argued that since primary goods are used as input with lag period in production process of consumption goods that's why wholesale prices will lead consumer prices independently. However, in contrast to this wisdom Colclough and Lange (1982) claimed that causal relationship from consumer prices (CPI) to producer prices (WPI) did not receive much attention to be investigated in the literature. They argued by developing theory from derived demand concept that since demand for inputs determined by demand for final goods and services between competing utility items and this framework indicates that opportunity cost of resources and intermediate materials is reflected by the production cost that influences the demand of final goods and services. In response this implies that consumer prices (CPI) should determine or affect producer prices (WPI). Moreover, development was made by Caporale, et al. (2002) in this direction. Caporale, et al. (2002) documented that CPI may cause WPI through the labor supply channel and which may also reflects through supply shocks in labor market provided wage earners in the wholesale sector want to preserve the purchasing power of their incomes. This effect occurs with lagged -period, it probably depends on the nature of wage-setting process along with expectations of machinery formation. Hence, we find that theoretically, CPI may granger cause WPI or WPI may granger cause CPI or both (CPI and WPI) may granger cause each other. Therefore, this study has made an attempt to investigate that whether in India CPI granger causes WPI or WPI granger causes CPI or both causes each other in the static and dynamic framework.

Rest of the paper is organized as follows. Second section presents a brief review of literature followed by methodology adopted in this paper for analysis and data source in third section. Fourth section presents data analysis and fifth section concludes.

2. A brief review of literature

The studies analyzing the relation between CPI and WPI using time series techniques have found some kind of stable relationship between the two series because of inter-linkages between the wholesale market and the retail market. Guthrie (1981), for the US economy, used percentage monthly change in the WPI and the CPI from January 1947 to December 1975 for the analysis and for the analysis they also divided the entire period into two equal five year periods, 1966-70

[1] Cushing and McGarvey (1990) concluded that the magnitude of feedback from WPI to CPI is greater than that from CPI to WPI and therefore, a one-sided Granger causal pattern running from WPI to CPI can be assumed as CPI has very little incremental power. They added that these results are robust to inclusion of the money supply i.e., the feedback from WPI to CPI was still higher and therefore, such a causal ordering is perfectly consistent with a flexible price model with strong demand effects.

and 1971-75 also. The author found that there is a relationship between changes in the WPI and changes in the CPI and this relationship can be described by a Pascal distributed lag model. Addition to that the author documented that WPI changes presently take longer to work themselves into CPI changes than they did twenty-five years ago and a longer mean response time is associated with higher rates of inflation. Further, the argued that the amount of the effect of WPI changes translated into CPI changes has also increased over the years though this rate is not universally for all time periods studied. Jones (1986), for the US economy, for period January 1947 to December 1983 and also for two sub periods from January 1947 to June 1971 and May 1974 to December 1983 by using Wald test of Granger causality found evidence of bi-directional causality between WPI and CPI. Addition to that, author recommended that for bivariate model consisting of CPI and WPI simultaneous equation approach is the appropriate way to estimation. Cushing and McGarvey (1990) indicated that feedback from WPI to CPI is greater than that from CPI to WPI and therefore it can be concluded that WPI has high incremental power vis-à-vis CPI. Contrarily, Clark (1995) concluded that even though pass-through effect from producer prices to consumer prices is weak but causality is unidirectional that runs from WPI to CPI. Samanta and Mitra (1998) applied cointegration and Granger causality tests for two sub periods (i) April 1991 to April 1995 and (ii) May 1995 to 1998. A stable long-run relationship between CPI and WPI existed during 1991 to 1995, but not thereafter. On the other hand Shunmugam (2009) examines the time lag with which CPI responds to a change in WPI, the causal relationship between the two series and if they are cointegrated in the long run, over 1982 to 2009, and for pre- and post liberalization periods for India. Shunmugam (2009) finds evidence of cointegration over the entire period of study but in the pre- and post liberalization period evidence of cointegration was not found. Caporale et al. (2002) reported bidirectional causality between WPI and CPI (or even no significant links) and claimed it only exists when the causality links reflecting the monetary transmission mechanism are ignored. Ghazali et al., (2008) by using monthly data for CPI and PPI at constant prices of 2000 for the period from January 1986 to April 2007 for Malaysia find that there is an uni-directional causality running from PPI to CPI. They have obtained these results by applying both Engle Granger and Toda-Yamamoto causality tests. Sidaoui et al. (2009) documented on the basis of empirical exercise that WPI Granger causes CPI for the Mexican economy in the both long run and short run. Similarly, Shahbaz et al. (2009) and Shahbaz et al. (2010) found the evidence of bivariate causality between both WPI and CPI but the causal relation is stronger from WPI to CPI vis-à-vis CPI to WPI in case of Pakistan.

3. Methodology and data source

To test the stationary property of the data series, we applied Augmented Dickey Fuller (1981) unit root test, Dickey-Fuller unit root test with GLS Detrending (DFGLS Test)[2] and Phillips and

[2] This test was proposed by Elliott, Rothenberg and Stock (1996) this test has significantly greater power than the previous versions of the ADF test. Elliott, Rothenberg and Stock (1996) propose a simple modification of the ADF tests in which the data are de-trended so that explanatory variables are "taken out" of the data prior to running the test regression. Elliott et al., (1996) define a quasi-difference of Y_t that depends on the value a representing the specific point alternative against which we wish to test the null hypothesis:

$$d(Y_t/a) = \begin{cases} Y_t & if t = 1 \\ Y_t - aY_{t-1} & if t > 1 \end{cases} \qquad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Perron (1988)[3] unit root. However, Ng and Perron (2001) has suggested that ADF and PP unit root tests suffer from severe size distributions properties when error term has negative moving-average root. When root is close to minus one (e.g.,- -0.79) the rejection rate can be as high as 100% (see Schwert, 1989). Ng and Perron (2001) has proposed four tests utilizing GLS detrended data which are based on modified SIC and modified AIC, while DF/ADF and PP unit root tests are based on non-modified information criteria. The calculated values of these tests based on the forms of Philip-Perron (1988) *Za* and *Zt* statistics, the Bhargava (1986) R_1 statistics, and the Elliot et al., (1996) created optimal best statistics. Therefore, we also utilized Ng and Perron (2001) as a test of robustness to test the unit root property of the data series. Furthermore, to test the existence of cointegration we used a recent approach developed by Pesaran et al. (2001) and termed as autoregressive distributed lag (ARDL) bounds testing approach. However, to test the robustness of the cointegration results produced by ARDL bound testing approach we used Johansen and Juselius (1990) maximum likelihood approach to cointegration also. ARDL bounds testing approach to cointegration posses certain advantages like- in this approach the short- and long- runs parameters are estimated simultaneously; it can be applied irrespective of whether the variable are integrated of order zero i.e., *I(0)* or integrated of order one i.e., *I(1)*; it is more useful when sample size is small (Narayan, 2004); it is free from any problem faced by traditional techniques such as Engle-Granger (1987), Philips and Hansen (1990); the error correction method integrates the short-run dynamics with the long-run equilibrium, without losing long-run information. The ARDL approach of cointegration involves estimating the following unconditional error correction version of the ARDL model:

$$\Delta \ln WPI = \alpha_{\circ} + \alpha_T T + \alpha_{WPI} \ln WPI_{t-1} + \alpha_{CPI} \ln CPI_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta \ln WPI_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta \ln CPI_{t-j} + \mu_i \quad ...(2)$$

$$\Delta \ln CPI = \alpha_{\circ} + \alpha_T T + \beta_{WPI} \ln WPI_{t-1} + \beta_{CPI} \ln CPI_{t-1} + \sum_{i=1}^{p} \beta_i \Delta \ln CPI_{t-i} + \sum_{j=0}^{q} \beta_j \Delta \ln WPI_{t-j} + \mu_i \quad ......(3)$$

Where $\alpha_{\circ}$ and α_T is the drift component and time trend, and μ is assumed to be white noise error processes. The optimal lag structure of the first differenced regression is selected by Akaike Information Criteria (AIC) to ensure that serial correlation does not exist. Pesaran et al. (2001) generated two critical bounds (upper and lower critical bounds) to take the decision about the existence of long-run relationship between wholesale price index and consumer price index. The null hypothesis of no cointegration in equations- 2 and 3 is $H_{\circ} : \alpha_{WPI} = \alpha_{CPI} = 0$ and $H_{\circ} : \beta_{WPI} = \beta_{CPI} = 0$ while hypothesis of cointegration between wholesale prices and consumer prices is $H_{\circ} : \alpha_{WPI} \neq \alpha_{CPI} \neq 0$ and $H_{\circ} : \beta_{WPI} \neq \beta_{CPI} \neq 0$. Then next step is to compare the calculated F-statistics with lower critical bound (LCB) and upper critical bound (UCB) tabulated by Pesaran et al. (2001). The null hypothesis of no cointegration may be rejected if calculated value of F-statistics is more than upper critical bound. The decision may be about no cointegration if lower critical bound is more than computed F-statistics. Finally, if calculated F-statistics is between UCB and LCB then decision about cointegration is inconclusive. To check

[3] Since, PP test has advancements over DF/ADF test in the sense that whereas DF/ADF test use a parametric autoregression to approximate the ARMA structure of the errors in the test regression, PP test correct for any serial correlation and heteroskedasticity in the errors. Therefore, this test is also used.

the reliability of the results reported by ARDL model we have conducted the diagnostic and stability tests. In the diagnostic tests we examine for the presence of serial correlation, incorrect functional form, non-normality and heteroscedisticity associated with the model. The stability test is conducted by employing the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals ($CUSUM_{SQ}$). In the final step we used Impulse response functions and variance decomposition analysis in order to see outside sample dynamics of these variables. Given the existence of long run relationship between wholesale price index and consumer price index, an error correction representation can be developed as follows to examine direction of causality between them:

$$(1-L)\begin{bmatrix} WPI \\ CPI \end{bmatrix} = \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} + \sum_{i=1}^{n} (1-L)\begin{bmatrix} b_{11i} b_{12i} \\ b_{21i} b_{22i} \end{bmatrix} + \begin{bmatrix} \eta_1 \\ \eta_2 \end{bmatrix} ECM_{t-1} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \end{bmatrix} \dots (4)$$

Where $(1-L)$ is indicating the difference operator while ECM_{t-1} is the lagged error-correction term derived from the long-run cointegrating relationship and μ_{1t} and μ_{2t} are normally distributed residual terms. The direction of short run causal relationship between the test variables can be tested through the Wald test or F test and which test the null hypothesis of equality of coefficients associated lagged value of CPI when WPI is the dependent variable and lagged value of WPI when CPI is the dependent variable. However, long run causality can be tested thorough the t-test pertaining to error correction term. It is important to note that the statement “X Granger causes Y” does not imply that Y is the effect or the result of X. Granger causality measures precedence and information content but does not of itself indicate causality in the more common use of the term.

Then next step is to compare the calculated F-statistics with lower critical bound (LCB) and upper critical bound (UCB) by tabulated by Pesaran et al. (2001). The null hypothesis of no cointegration may be rejected if calculated value of F-statistics is more than upper critical bound. The decision may be about no cointegration if lower critical bound is more than computed F-statistics. Finally, if calculated F-statistics is between UCB and LCB then decision about cointegration is inconclusive. To check the reliability of the results reported by ARDL model we have conducted the diagnostic and stability test. In the diagnostic test we examined for the presence of serial correlation, incorrect functional form, non-normality and heteroscedisticity associated with the model. The stability test is conducted by employing the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals ($CUSUM_{SQ}$). In the final step we used Impulse response functions and variance decomposition analysis in order to see outside sample dynamics of these variables.

4. Data analysis and empirical findings

First of all descriptive statistics of variables has been analyzed to see the sample property and Pearson’s correlation analysis is conducted to see whether there is any evidence for comovement of both series[4]. We found that correlation is very high and its value is 0.86. In the next step stationary property of the data series of all test variables has been tested through ADF, DF-GLS and PP test and robustness of the stationary test has been examined through Ng-Perron (2001) unit root test and results are reported in Table-1.

Table-1: Estimation of Unit Root Tests and Their Robustness

Variables	ADF Test		DF-GLS Test	P-P Test
	T-calculated	Prob-value	T-calculated	Prob-value
$\ln CPI_t$	-2.7539 (4)	0.2202	-1.7358(1)	1.1850 (6)
$\Delta \ln CPI_t$	-3.6781 (2)	0.0322	-5.2664 (1)*	-4.9297(1)*
$\ln WPI_t$	-2.2798(4)	0.4374	-1.9087 (1)	0.8489 (3)
$\Delta \ln WPI_t$	-5.1889(3)	0.0004	-5.3012 (1)*	-6.0975(3)*
Variables	Ng-Perron Test			
	MZa	MZt	MSB	MPT
$\ln CPI_t$	-5.0567(1)	-1.5822	0.3129	17.9835
$\Delta \ln CPI_t$	-37.6484(1)*	-4.3341	0.1151	2.4452
$\ln WPI_t$	-4.9076(1)	-1.5654	0.3189	18.5623
$\Delta \ln WPI_t$	-24.2393(1)*	-3.4801	0.1435	3.7667

Note: The asterisks * denotes the significant at %1 level. The figure in the parenthesis is the optimal lag structure for ADF and DF-GLS tests, bandwidth for the PP unit root test is determined by the Schwert (1989) formula

Table- 1 reports that both variables have unit root problem at their level form while they are stationary at their first differenced form. This unique order of integration of the variables leads us to proceed for the application of ARDL bounds testing approach to examine the long run relationship between CPI and WPI. Results of ARDL bounds testing approach to cointegration are shown in Table-2. For the analysis we choose optimal lag structure that is 2 for both variables as suggested by AIC. It is worth mentioning that we have used both variables as dependent variable in our equation to test that in which case cointegration exists and also robustness of ARDL results has been checked by Johansen and Juselius (1990) maximum likelihood test.

Table-2: The Results of Cointegration Test

Panel I: Bounds Testing to Cointegration		
Estimated Model	$F_{CPI_t}(\ln CPI_t / \ln WPI_t)$	$F_{WPI_t}(\ln WPI_t / \ln CPI_t)$
Optimal Lag Length	(2, 2)	(2, 2)
F-Statistics	2.9564	6.9656***
	Critical values (T = 60)[#]	
	Lower bounds $I(0)$	Upper bounds $I(1)$

[4] Results are reported in table 1 in appendix 1.

1 per cent level	7.397	8.926
5 per cent level	5.296	6.504
10 per cent level	4.401	5.462
Panel II: Diagnostic tests	Statistics	Statistics
R^2	0.8457	0.8045
Adjusted- R^2	0.8155	0.7760
F-statistics	28.0282***	28.2261***
Breusch-Godfrey LM test	1.1957 (0.3121)	1.6362 (0.2063)
ARCH LM test	0.0464 (0.8302)	0.0659 (0.7984)
White Heteroscedisticity test	1.9246 (0.0719)	0.8160 (0.6042)
Ramsey RESET	0.0568 (0.8126)	0.6615 (0.4203)
CUSUM	Stable	Stable
CUSUMsq	Stable	Stable

Note: The asterisks ***denotes the significant at 1% level. The optimal lag structure is determined by AIC. The parenthesis ( ) is the prob-values of diagnostic tests. # Critical values bounds computed by surface response procedure developed by Turner (2006).

It is evident from Table- 2 that the when CPI is forcing variable in that case only calculated F-statistics which is 6.9656 is higher than the upper critical bound i.e. 6.504 at 5 % level of significance using unrestricted intercept and unrestricted trend. This implies that there is long run relation between whole sale price and consumer price indices. In the next step we have estimated long run cointegration equation and results are reported in Table-3[5]. In Table-3 we have presented results of cointegration equation obtained from OLS and Johansen and Juselius (1990) maximum likelihood approach by assuming one of the two variables as dependent variable.

Table-3: Long Run Results and Their Robustness

Dependent Variable	OLS Regression		Johansen Regression	
	$\ln CPI_t$	$\ln WPI_t$	$\ln CPI_t$	$\ln WPI_t$
Constant	-0.1406*	0.1440*	0.0064	-0.0062
$\ln CPI_t$	…	0.9744*	…	0.9542*
$\ln WPI_t$	1.0234*	…	1.0479*	…

Note: * denotes significance at 1% level of significance

The results in Table-3 reveal that in both cases, that is when OLS model is used and when Johansen's model is used, WPI and CPI are significant when CPI and WPI are the dependent variables respectively. This implies that there is strong cointegration between the CPI and WPI. Further, in both cases we find the positive impact of WPI on CPI and vice-versa too. However, if we compare the coefficient associated with WPI and CPI we find that impact of WPI is less on CPI vis-à-vis impact of CPI on WPI. This implies that in the context of India impact of wages and producers' prices is higher on consumers' prices than the impact of consumers' prices on

[5] Results of lag length selection test and cointegration analysis are presented in table 2and 3 of appendix 1 respectively.

producers' prices. This also implies that India's percapita income, though low, is increasing and nations consumption basket is shifting towards non-core-food items Das (2009) and hence despite the high weight of food items in CPI it is unable to lead WPI in a greater extent. After establishing the relationship between the WPI and CPI we have, in the next step, presented the results pertaining to short run dynamics of the WPI and CPI using ECM version of ARDL model. Results are reported in Table-4.

Table-4: Short Run Results

Variable	Dep. Variable = $\Delta \ln CPI_t$		Dep. Variable = $\Delta \ln WPI_t$	
	Coefficient	T-Statistics	Coefficient	T-Statistics
Constant	0.0176	3.7078*	-0.0026	0.6684
$\Delta \ln CPI_t$	…	…	1.0030	12.9113*
$\Delta \ln WPI_t$	0.7478	12.9131*	…	…
ECM_{t-1}	-0.1502	-2.7983*	…	…
ECM_{t-1}	…	…	-0.1203	-1.8181***
R^2	0.7720		0.7547	
Ad- R^2	0.7639		0.7459	
F-Statistics	94.8600*		86.1505*	
D. W	1.5576		1.8003	
Test	F-statistic	Prob-value	F-statistic	Prob-value
$\chi^2 Serial$	1.8597	0.1656	0.3491	0.7069
$\chi^2 ARCH$	0.0036	0.9519	1.7023	0.1973
$\chi^2 Hetero$	1.5327	0.2249	0.0753	0.9275
$\chi^2 \mathrm{Re}set$	0.7699	0.3840	0.0040	0.9494

Note: $\chi^2 Serial$ is the Breusch-Godfrey LM test statistic for no serial relationship, $\chi^2 ARCH$ is the Engle's test statistic for no autoregressive conditional heteroskedasticity, $\chi^2 Hetero$ is the heteroscedisticity and $\chi^2 \mathrm{Re}set$ is Ramsey's test statistic for no functional misspecification. * and *** show significant at 1% and 10% level of significance respectively.

It is evident from Table-4 that in short run WPI has positive impact on CPI and vice-versa too; similar results we found as we obtained from cointegration. Apart from that, we also find that error correction term in both cases is negative and significant indicating that any disequilibrium in the CPI and WPI will get corrected with the rate of adjustment of 15% and 12% on annual basis respectively.

Next we have conducted diagnostic tests in order to see weather our results are free from problem of serial autocorrelation, heteroskedasticity, misspecification and nonlinearity of residuals. We found none of the problem exists in our estimates. Therefore, we can say that the empirical evidence reported in Table- 4 indicates that error term is normally distributed and there is no serial correlation among the variables in short span of time. Model is well specified as shown by F-statistics provided by Ramsey Reset test. Finally, short run models pass the test of autoregressive conditional heteroscedisticity and same inferences can be drawn for white heteroscedisticity. Besides that, we have also tested for presence of structural breaks through Chow test and we found no evidence for the presence of structural breaks (results are presented in Table- 2 in appendix1). In the final step of diagnostic checks we have tested for the parameter stability as Hansen (1992) cautions that in the time series analysis estimated parameters may vary over time therefore, we should test the parameters stability test since unstable parameters can result in model misspecification and so may generate the potential biasness in the results. Therefore, we have applied the cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMSQ) tests proposed by Brown et al. (1975) to assess the parameter constancy[6]. The null hypothesis to be tested in these two tests is that the regressions coefficients are constant overtime against the alternative coefficients are not constant. Brown et al. (1975) pointed out that these residuals are not very sensitive to small or gradual parameter changes but it is possible to detect such changes by analyzing recursive residuals. They argue that if the null hypothesis of parameter constancy is correct, then the recursive residuals have an expected value of zero and if the parameters are not constant, then recursive residuals have non-zero expected values following the parameter change. We find the evidence of parameter consistency as in both cases that is in case of CUSUM and $CUSUM_{SQ}$ plot have been within the critical bound of 5 % level of significance (see the figure 1, 2, 3 and 4 in appendix 1). Results of Grange causality analysis are presented in Table-5.

Table-5: The Results of Granger Causality

Dependent variable	Type of Granger causality				
	Short-run			Long-run	Joint (short- and long-run)
	$\Delta \ln CPI_t$	$\Delta \ln WPI_t$	ECT_{t-1}	$\Delta \ln CPI_t, ECT_{t-1}$	$\Delta \ln WPI_t, ECT_{t-1}$
	F-statistics [p-values]		T-statistics [p-values]	F-statistics [p-values]	
$\Delta \ln WPI_t$	–	83.5146* [0.0000]	–0.1226*** [0.0815]	–	56.0189* [0.0001]
$\Delta \ln CPI_t$	82.6922* [0.0000]	–	-0.1308** [0.0215]	59.0172* [0.0000]	–

Note: The asterisks *, ** and *** denote the significant at the 1%, 5% and 10% levels, respectively.

[6] The first of these involves a plot of the cumulative sum (CUSUM) of recursive residuals against the order variable and checking for deviations from the expected value of zero. Symmetric confidence lines above and below the zero value allow definition of a confidence band beyond which the CUSUM plot should not pass for a selected significance level. A related test involves plotting the cumulative sum of squared (CUSUMSQ) recursive residuals against the ordering variable. The CUSUMSQs have expected values ranging in a linear fashion from zero at the first-ordered observation to one at the end of the sampling interval if the null hypothesis is correct. Again, symmetric confidence lines above and below the expected value line define a confidence band beyond which the CUSUMSQ plot should not pass for a selected significance level, if the null hypothesis of parameter constancy is true. In both the CUSUM and CUSUMSQ tests, the points at which the plots cross the confidence lines give some in diction of value(s) of the ordering variable associated with parameter change.

It is evident from Table-5 that bivariate causality exits between WPI and CPI in short and long runs. This implies that in the context of India consumers' prices, in general and food prices in particular, leads producers prices and producers' prices leads consumers' prices in both the long and short run i.e., both prices are highly interlinked. And if one could control any one of these two another one will, automatically, be under control.

After confirming that our model does not suffer from any sort of problem we can proceed to conduct out of sample forecast analysis. Therefore, we have preceded for Impulse response Functions and Forecast error Variance Decomposition analysis. IRFs analysis has been conducted by using generalized IRFs analysis as it is free from ordering of the variables under consideration. Results of VDs are presented in Table-6 and plots of IRFs is presented in appendix 1 and named as Figure-5 respectively.

Table-6: Variance Decomposition Approach

Period	Variance Decomposition of $\ln CPI_t$			Variance Decomposition of $\ln WPI_t$		
	S.E.	$\ln CPI_t$	$\ln WPI_t$	S.E.	$\ln CPI_t$	$\ln WPI_t$
1	0.0478	100.0000	0.0000	0.0571	75.4786	24.5213
2	0.0787	99.4612	0.5387	0.0898	76.9137	23.0862
3	0.1038	98.2108	1.7891	0.1162	76.6862	23.3137
4	0.1256	96.4518	3.5481	0.1391	75.8279	24.1720
5	0.1453	94.3870	5.6129	0.1598	74.7402	25.2597
6	0.1637	92.1792	7.8207	0.1788	73.5941	26.4059
7	0.1811	89.9442	10.0557	0.1967	72.4662	27.5337
8	0.1978	87.7580	12.2419	0.2136	71.3910	28.6090
9	0.2140	85.6669	14.3330	0.2298	70.3828	29.6171
10	0.2298	83.6962	16.3037	0.2454	69.4463	30.5536
11	0.2451	81.8577	18.1422	0.2605	68.5809	31.4190
12	0.2601	80.1538	19.8461	0.2751	67.7834	32.2165
13	0.2747	78.5817	21.4183	0.2892	67.0498	32.9501
14	0.2891	77.1350	22.8649	0.3030	66.3752	33.6247
15	0.3032	75.8060	24.1939	0.3165	65.7548	34.2451

VDs results show that in the first year, fifth year, 10^{th} year, and 15^{th} year the variation in CPI is, due to one standard deviation (SD) shock/innovation, attributed by CPI itself is 100%, 94.38%, 83.69% and 75.80% respectively and rest of the part is explained by WPI. However, in case of WPI, in the first year, Fifth year, 10^{th} year and 15^{th} year the variation in WPI is, due to one standard deviation (SD) shock/innovation, explained by WPI itself is 75.48%, 74.74%, 69.45% and 65.75% respectively and rest of the part of variation is explained by CPI. Three things become quite clear from Table-6. First is even though, in the first year all variation in CPI is explained by CPI itself but the fall in the explanatory power of CPI in their own variation is very high and it increases over years. Second, the explanatory power of WPI in variations in itself is very low in the first year itself and speed of fall of the explanatory power is quite low in case of WPI. Third, both variables are exogenous in the system as the most of variation in their series is explained by themselves itself. Quite similar results we find from the IRFs analysis. It is evident from Figure-5 (in the appendix-1) that response of CPI to one SD shock/innovation in WPI is much higher vis-à-vis response of WPI to one SD shock/innovation in CPI.

5. **Conclusions and Policy Implications**

The basic objective of this study is to analyze the static and dynamic causal direction of two inflation indices namely CPI and WPI in India; where CPI refers to consumers’ prices and WPI producers’ prices. For the analysis we preferred ARDL bounds testing approach to cointegration because of its superiority over other approaches like Johansen and Juselius (1990) maximum likelihood approach and analysis are carried out for period 1950-2009.

We found that both variables are nonstationary in their level form while stationary in first difference form that is both variables have first order auto-regressive scheme. Cointegration test conducted through ARDL approach and Johansen and Juselius (1990) maximum likelihood approach show that both variables are cointegrated in the long run implying that they will move together. Addition to that, comparison of coefficient associated with each one of these variables in cointegration equation, when second variable is dependent, revels that impact of WPI on CPI is higher vis-à-vis impact of CPI on WPI. We find the evidence of bidirectional causality between WPI and CPI in both cases i.e.,- in the short-run and long-run. Furthermore, outside sample forecast analysis reviles that in India, WPI leads CPI. This implies that WPI is determined by market forces, as in the case of Pakistan (Shahbaz et al., 2010) and also a leading indicator of consumers’ prices and inflation.

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Appendix 1

Table-1: Descriptive Statistics and Correlation Matrix

Variables	Mean	Median	Maximum	Minimum	$\ln CPI_t$	$\ln WPI_t$
$\ln WPI_t$	2.8760	2.8514	4.8395	1.1281	1.0000	0.8604
$\ln CPI_t$	2.8038	2.6408	4.8641	1.0919	0.8604	1.0000

Table-2: Lag Length Criteria

VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-12.1229	NA	0.005677	0.5043	0.5767	0.5324
1	220.7800	440.8520*	1.60e-06	-7.6707	-7.4537*	-7.5865*
2	224.9793	7.6487	1.59e-06*	-7.6778*	-7.3161	-7.5376
3	228.4665	6.1025	1.62e-06	-7.6595	-7.1531	-7.4632

4	230.2430	2.9819	1.76e-06	-7.5801	-6.9291	-7.3277

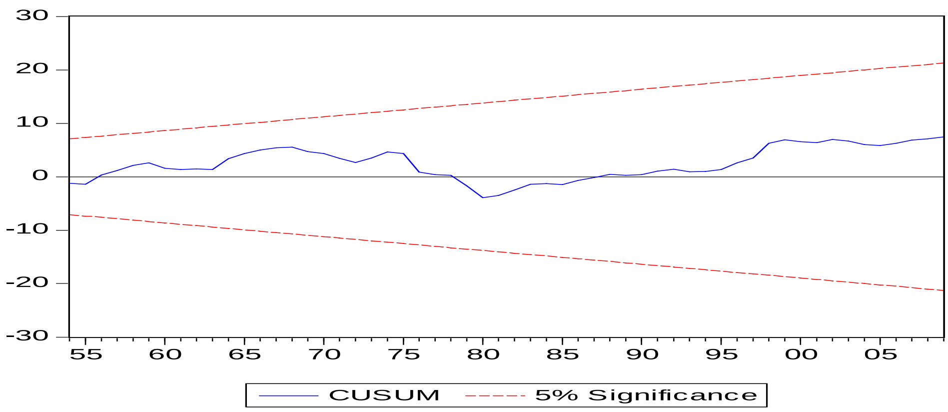
* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table-3: Johansen Maximum Likelihood Test for Cointegration

Hypotheses	Likelihood Ratio	5 %	Prob-value	Maximum eigen values	5 %	Prob-value
$R = 0$	21.6123	20.2618	0.0324	18.3718	15.8921	0.0200
$R \leq 1$	3.2405	9.1645	0.5367	3.2405	9.1645	0.5367

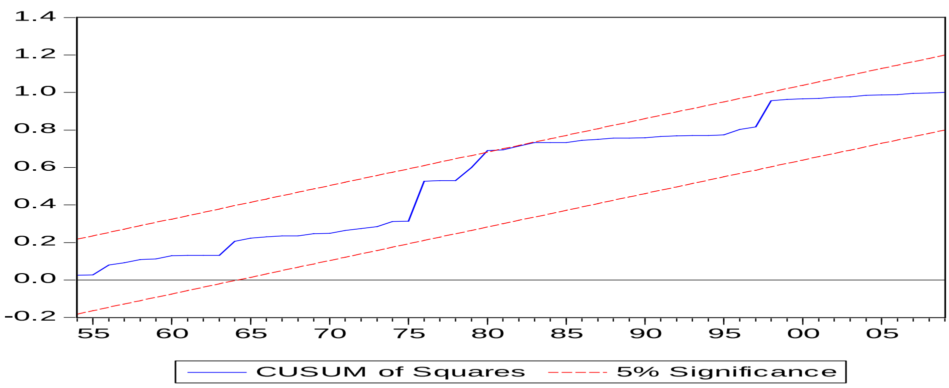
Dependent Variable = $\Delta \ln CPI_t$

Figure-1 Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

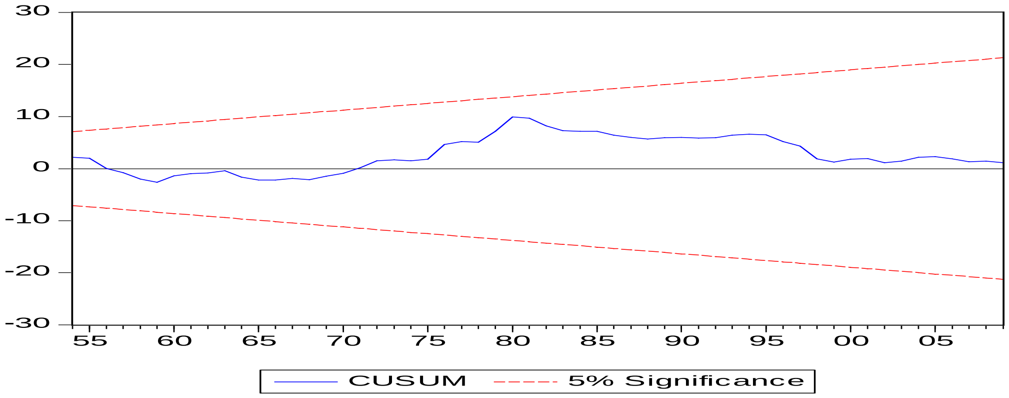
Figure-2 Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

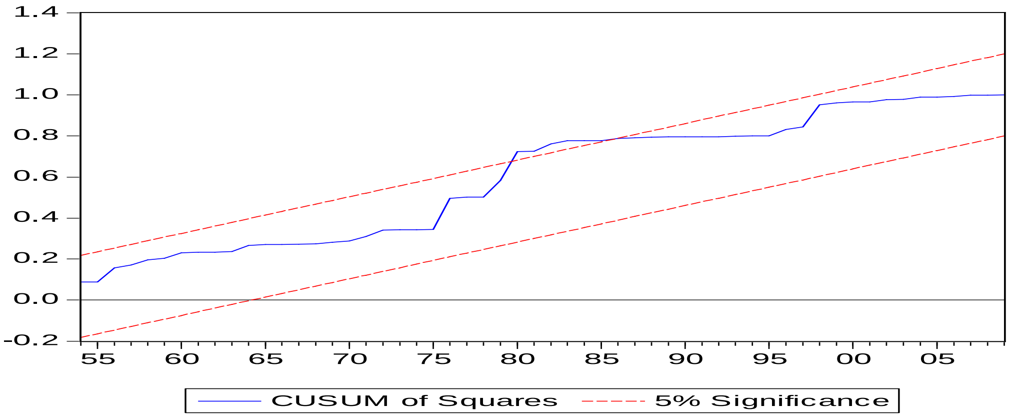
Dependent Variable = $\Delta \ln WPI_t$

Figure-3 Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Figure-4 Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Table-4: Chow Breakpoint Stability Test

Chow Breakpoint Test = 1980			
F-statistic	0.4222	Prob. F(3,53)	0.7378
Log likelihood ratio	1.3936	Prob. Chi-Square(3)	0.7070
Wald Statistic	1.2668	Prob. Chi-Square(3)	0.7370

Figure-5: Generalized Impulse Response Function