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RESEARCH PAPE

Long Run Cointegration Relationship of Income with Petrol and High-Speed Diesel Prices

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ABSTRACT

This study focuses on finding the long run relationship among different income group-based index numbers, i.e. lower, higher and combined/average income groups with that of petroleum products prices, namely petrol and high-speed diesel (HSD). Another focus of the study is estimation of an equation to investigate the effect of petrol and HSD prices on different income groups, and to asses which income group is affected more by increase in prices of petroleum products for the period 2019-21. Correlogram, Augmented Dickey Fuller and Phillips-Perron tests are used to assess the nature of stationarity after which Johansen's cointegration test is used to assess the long run equilibrium relation. The long run cointegration equation helps in assessing the strength of petrol and HSD on increasing the consumer price index for different income groups. From the study, it is found that for lower income group HSD causes more change in the index number than that of petrol prices while for higher income group families the case is reverse. Whereas for combined income group high speed diesel revealed more changes than that of petrol.

Introduction

Oil prices play vital role in the economic activity of every country specifically for oil importing countries. The two mostly dependable areas on oil are industries and transportation. In country like Pakistan, approximately 60% of energy is produced by Petroleum Products. Thus, it is of major interest for everybody to know the impact of oil prices on different important indicators of economy. One of the most important economic indicators which plays vital role in national policy matters is inflation, which is defined as the increase in the prices of different commodities for a specific time period. The tool used to assess the inflation figure is Consumer Price Index (CPI). The percentage change in the CPI for one fiscal period over the other fiscal period is defined as inflation, e.g. if CPI for the period 2011-12, 2010-11 was 162.57 and 146.45, respectively then the percentage change, 11.01 is defined as inflation for the period 2011-12 (PBS, 2012). It is of interest to know that oil prices have a valuable weight in the compilation of CPI. Thus, it is of significant importance to find out the impact of petroleum products on inflation figure.

The Pakistan Bureau of Statistics (PBS), also known as Federal Bureau of Statistics in the past, is responsible for compilation and publication of Price Indices and different important statistics. The three major price indices are: Consumer Price Index (CPI), Sensitive Price Indicator (SPI), Whole sale Price Index (WPI). CPI is a significant measure of inflation used worldwide to reflect any change in the prices of basket of specified representative items, reflecting general patterns of common people's daily consumption.

The first ever CPI published by PBS was compiled with base period as 1948-49 for industrial workers, for which the data was collected from the cities of Sialkot, Lahore and Karachi. To have better coverage of the items and cities, the number of cities and items have been added and changed at each family budget survey for CPI. Uphill now CPI is compiled on the basis of following base years; 1959-60, 1969-70, 1975-76, 1980-81,2000-01 and 2007-08. According to the publication of Pakistan Bureau of Statistics, CPI based on base period 2007-08 covers 40 urban centers of Pakistan comprising 76 markets and 5 income groups.

CPI for the current base period, i.e. 2007-08, covers 487 items. The items are selected based on family budget survey conducted in 2007-08. Current CPI may be divided into 12 groups. The weights of commodity groups reveal that after food group the most highly weighted groups are housing, water, electricity, gas and other fuels and transportation with weights 34.84, 29.41 and 7.20 respectively. This is why the study of petroleum products is of major importance for many researchers and policy makers.

The methodology used for the computation of CPI uses the formula of Laspeyre's as given below:

$$I_n = \frac{\sum (Pn/Po)\ x\ Wi}{\sum Wi}\ x\ 100$$

Where, I_n= Consumer Price Index for the nth period, P_n= Price of an item in the nth period. P_o= Price of an item in the base period, Q_0 = Quantity of an item used in the based period, W_i = Weight of the ith item and $\sum W_i$= Total weight of all items.

WPI is computed on monthly basis while SPI is computed and published each week. These important indicators are used by different government departments for policy purposes. WPI and SPI also use the same formula of Laspeyers. WPI covers 463 items while SPI covers most essential 53 kitchen items (PBS, 2012). The world in aggregate is in the grip of rising inflation. Pakistan is not an exception. The general CPI for the month of March, 2013 reached to 175.82 (with base period 2007-08=100), whereas the Transport Index approached to 189.11 for the same period (PBS, 2013). It is said that inflation, if it goes beyond the double digit, is an indication of a weak economy.

Literature Review

According to Aurangzeb and Haq (2012), inflation is said to exist if the demand of daily use commodities is more than their production. They further state that deflation and increased supply of currency notes, deprived performance of agriculture sector, worldwide high oil prices, maximum use of ethanol fuel, hoarding and smuggling are also the main cause of high inflation. The study also revealed that as much the loan of the country increases, it increases the inflation rate. The rising prices of commodities, specifically of petroleum products, are causing economic hurdles for families with low income. In addition, the devaluation of currency is exaggerating the level of poverty in the country. Electricity shortages have badly affected many economic hubs and industries. Thus, potentially effective economic policies can help to deal with the intensifying inflationary movement and improve the exaggerated divisions of the economy, specially manufacturing and agriculture.

Malik (2008) investigated the challenges of high oil prices on the economy of Pakistan. As Pakistan is heavily dependent on imported fuels which is expected to increase causing inflationary pressure on the economy. Syed (2010) measured the impact of oil prices and other macro-economic variables like consumption, inflation and foreign direct investment, etc. on Gross Domestic Product (GDP) for Pakistan's economy. The main outcomes of the study indicated that oil prices and inflation have negative relationship with

GDP. Kiani (2011) studied the impact of high oil prices on the economic growth of Pakistan for the period 1990-2008 and found that increase in oil prices leads to inflation, budget deficit and puts downward pressure on exchange rates which as a result affects the consumption pattern of common man badly. Abdullah and Kalim (2012) tried to investigate the main factors contributing to food inflation based on Johansen's cointegration approach for the period 1972-2008, and revealed a long term relationship between inflation and factors like inflation expectations, support prices, etc. Ali et. al. (2012) investigated the effect of high speed diesel (HSD) prices on food inflation in Pakistan and found a significant relationship between the two factors. According to Economic Survey of Pakistan (2012), worldwide rise in commodities and fuel prices activated significant rise in domestic inflation. The report suggested that main factor responsible for the rise of non-food inflation was the increase in the prices of oil, gas and energy items. The ramble in the prices of petroleum products, such as, petrol, kerosene oil, HSD, gas, CNG and electricity tariff rates, etc., caused increase in cost of general daily use items, which as a result caused increase in the general level of inflation.

Material and Methods

The following section discussed various topics of econometric used for analysis of time series data, together with description about the source of data to be used for the purpose of study.

Data for this study purpose obtained from Pakistan Bureau of Statistics (PBS) on monthly basis, starting from July, 2000 to June, 2020. Data will be collected for consumer price index (CPI) for lower, higher and combined income groups, and petroleum products which includes petrol and HSD prices.

In this research, first of all the trend and nature of trend of data would be assessed with the help of correlogram. To see the effect of stationarity of the data a number of unit root tests are available. Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test used in this study to decide about the presence or absence of stationarity in the data. Once the time series become non-stationarity, co-integration would be studied to assess to study the long run relationship between index number and petroleum products. Cointegration regression equation used to see the significance of the coefficients in the long run and to see the significance of coefficients in the regression model, EViews (2019) used as statistical software for time series data analysis.

Results and Discussion

Graphical Presentation of Data

This section describes the graphical presentation of the data for the three indices series and two petroleum products for the period from july-2000 to June 2020. Correlogram approach is adopted to represent if there is any stationarity in the data. One of the problems in correlogram is to select appropriate lag length, but EViews 2019 software, automatically selects lag length. The lag length in the given graphical analysis is 36. However, a general approach is to calculate autocorrelation function up to one third the length of the understudy time series (Gujrati, 2004).

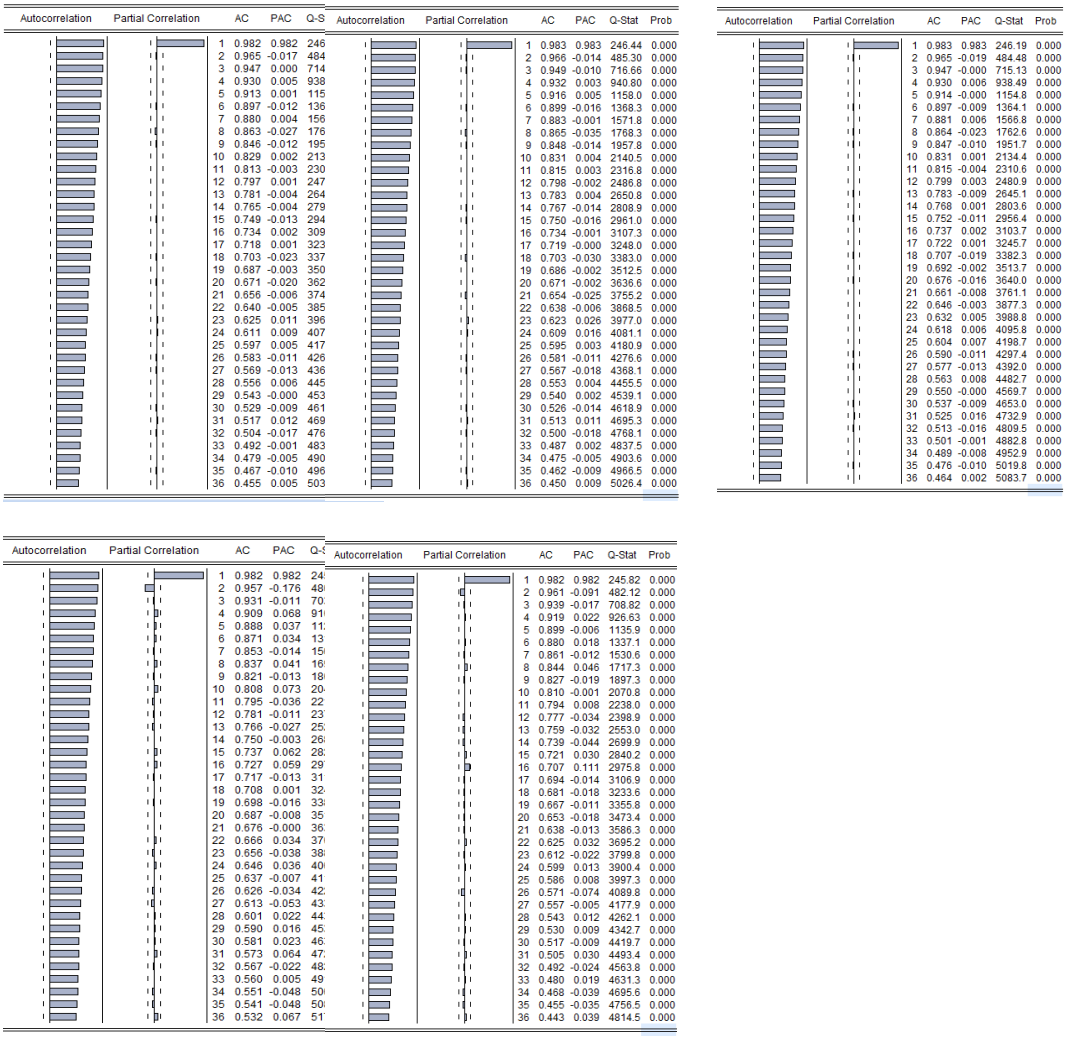


Figure: Correlogram for Combined and Individual Index Number

The autocorrelation coefficients (ACF) for combined index number, lower income group-based index number, higher income group-based index number, Petrol Prices and HSD Prices in above figures starting from a very high value of ACF and then shows a linear decline which indicates non stationarity in the index number based on combined income group, lower income group-based index number, higher income group-based index number, Petrol Prices and HSD Prices for the period starting from July, 2000 to June, 2020 and concluded that above series exhibit the pattern of non-stationarity.

To overcome the problem of non-stationarity, first difference of the given series is taken, and it is observed that all series converges to stationary time series.

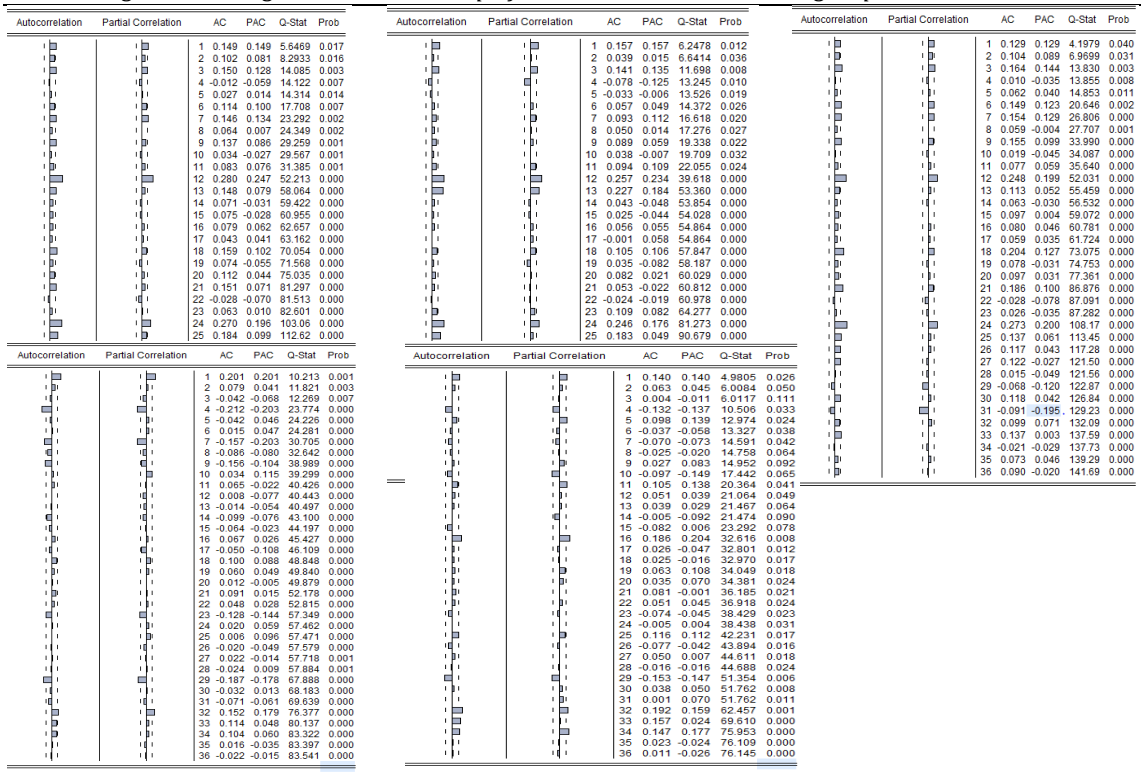


Figure: Correlogram after 1st difference of Combined and Individual Index Number

The spikes in the ACF after taking first difference of combined income group-based index number, lower income group-based index number, higher income group-based index number, Petrol Prices and HSD Prices in the above figures show tendency of the spikes towards center, which indicates stationarity in the data set for combined income group-based index number, lower income group-based index number, higher income group-based index number, Petrol Prices and HSD Prices for the period starting from July, 2000 to June, 2020 are stationary at first difference.

Unit Root Test

Based on EViews software, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are used to check unit root in the given series of indices and petroleum products, which by default selected the the lag length of 15 for ADF test. Both intercept and trend is used in the analysis for detecting the presence of unit root problem.

Table 1
Unit Root Test for Stationarity at LEVEL

Index Number	Test	Test Statistic value	C.V at 1%	C.V at 5%	C.V at 10 %	Result
Combined	ADF	2.536228	-3.99504	-3.42783	-3.137268	Non-Stationary
	PP	3.007294				Non-Stationary
Q1 (lower income group)	ADF	1.627932	-3.99504	-3.42783	-3.137268	Non-Stationary
	PP	2.003275				Non-Stationary
Q2 (lower income group)	ADF	2.705567	-3.99504	-3.42783	-3.137268	Non-Stationary
	PP	3.326911				Non-Stationary
Petrol Prices	ADF	-2.959442	-3.995189	-3.427902	-3.13731	Non-Stationary
	PP	-2.430828				Non-Stationary
HSD Prices	ADF	-0.03446	-3.99504	-3.42783	-3.137268	Non-Stationary
	PP	-0.254732				Non-Stationary

The above table 1 shows that calculated values of test statistic based on ADF test and PP test for for combined income group-based index number, lower income group-

based index number, higher income group-based index number, Petrol Prices and HSD Prices for the period starting from July, 2000 to June, 2020 at Level i.e., taking no difference at 1%, 5% and 10 % level of Significance. As all the C. V are large enough therefore that there exists a unit root which implies that the combined index number series is non-stationary

Table 2
Unit Root Test for Stationarity at 1st Order Difference

Index Number	Test	Test Statistic value	C.V at 1%	C.V at 5%	C.V at 10 %	Result
Combined	ADF	-14.71396	-3.995189	-3.42790	-3.13731	Stationary
	PP	-14.73979				Stationary
Q1 (lower income group)	ADF	-14.28298	-3.995189	-3.427902	-3.13731	Stationary
	PP	-14.21045				Stationary
Q2 (lower income group)	ADF	-15.15503	-3.995189	-3.427902	-3.13731	Stationary
	PP	-15.15555				Stationary
Petrol Prices	ADF	-12.09057	-3.995189	-3.427902	-3.13731	Stationary
	PP	-11.39025				Stationary
HSD Prices	ADF	-13.70992	-3.995189	-3.427902	-3.13731	Stationary
	PP	-13.56908				Stationary

To make the time series as stationary, which is one of the basic assumptions of the long run relationship, the first order difference of the time series and the stationarity checked by the ADF test and PP test. The above table depict the results of the Unit root analysis after taking first order difference. The above table 2 shows that calculated values of test statistic based on ADF test and PP test for combined income group-based index number, lower income group-based index number, higher income group-based index number, Petrol Prices and HSD Prices for the period starting from July, 2000 to June, 2020 at Level i.e., taking 1st difference at 1%, 5% and 10 % level of Significance. As the results of EViews indicates that that there exists no unit root problem for three time series variables and times series become stationary at first order difference.

Johansen Test of Cointegration

It is important to decide in advance about the lag length for Johansen test of cointegration, but since the analysis is done by EViews statistical software, which automatically selects suitable lag length. As the analysis is performed for each index number separately based on income groups, i.e. lower, higher and combined (average), Petrol and HSD Prices. Therefore, separate three tests of cointegration are performed. The Johansen test uses two methods, $\lambda trace$ and λmax statistic to find cointegration between variables. And thus, it is the only criteria used in this analysis to decide about the long run equilibrium relationship.

Table 3 below indicates the result of Johnson Cointegration test used to test the presence of equilibrium relationship between variables. For this purpose, λ trace Statistic and λ max Statistic obtained from the output. In the null hypothesis, the r = 0, r = 1 and r = 2 indicate test that there is no cointegrating (long run) relationship exists among all three time series data (combined index number, petrol and HSD prices), one time series and two time series respectively.

Table 3
Johanson Cointegration Test

TRACE AND EIGEN VALUE STATISTICS						
	Statistics	**Null Hypothesis**	**Alt. Hypothesis**	**Eigen value**	**Trace Statistic**	**C.V at 5%**
Combined, Petrol and HSD Prices	λ trace	r = 0	r > 0	0.163993	64.94187	29.79707
		r = 1	r > 1	0.060943	20.69977	15.49471
		r = 2	r > 2	0.020708	5.16865	3.841466
	λ max	r = 0	r > 0	0.163993	44.24211	21.13162
		r = 1	r > 1	0.060943	15.53111	14.2646
		r = 2	r > 2	0.020708	5.16865	3.841466
Q1 (lower income group), Petrol and HSD Prices	λ trace	r = 0	r > 0	0.114412	49.95611	29.79707
		r = 1	r > 1	0.060392	19.94474	15.49471
		r = 2	r > 2	0.018286	4.558497	3.841466
	λ max	r = 0	r > 0	0.114412	30.01137	21.13162
		r = 1	r > 1	0.060392	15.38624	14.2646
		r = 2	r > 2	0.018286	4.558497	3.841466
Q5 (Higher income group), Petrol and HSD Prices	λ trace	r = 0	r > 0	0.188307	72.58029	29.79707
		r = 1	r > 1	0.063302	21.04783	15.49471
		r = 2	r > 2	0.019625	4.895541	3.841466
	λ max	r = 0	r > 0	0.188307	51.53246	21.13162
		r = 1	r > 1	0.063302	16.15229	14.2646
		r = 2	r > 2	0.019625	4.895541	3.841466

It is observed that the values obtained od the both test statistics i.e., **λ trace and λ max** are greater than the critical values at 5% level of significance, thus leading to the conclusion that there exists long run relationship between more than zero variables. Similarly for the second hypothesis i.e. Ho: r =1 against H1: r > 1 and Ho: r =2 against the H1: r > 2 The computed values of trace statistic and max eigen value statistic leads to the rejection of null hypothesis, thus it may be concluded that there exist cointegration relationship among combined index number, petrol prices and HSD prices at 5% level of Significance.

Cointegrating Equation

To study which income group is more vulnerable to the changes in the prices of petroleum products, i.e. petrol and diesel. For this, long run cointegration regression is used, which yielded the following estimated equations. The first Cointegration regression equation represents higher income group-based index number (Q5) regressed on the prices of Petrol and HSD as given below:

Response Variable	**Cointegration Equation**
Higher Income Group Based Index Number	$Q5 = 30.7263 + 0.7716 * PETROL + 0.6435 * HSD$
Lower Income Group	$Q1 = 31.9558 + 0.6303 * PETROL + 0.7867 * HSD$
Combine Income Group	$Qc = 32.2141 + 0.6963 * PETROL + 0.7029 * HSD$

It reveals that petrol causes more change in the index for higher income group than that of HSD. Contrary to the above estimated equation the results for lower income group are reverse. It is obvious from the result that the index number for lower income group-based families is affected more by HSd prices as compare to petrol prices. The equation for combine income shows that HSD causes more change in the index for combined income group than that of petrol.

Conclusion

The main aim of the study is to find out the long run relationship between consumer price index for lower, higher and combined income group with that of the prices of petrol and HSD prices. For the said purpose monthly data was collected from PBS for 20 years. The data was analyzed with the help of correlogram and unit root tests, which suggested presence of unit root, while the first difference of the available series revealed stationarity. ADF and PP tests were used to assess the presence of stationarity. After confirming for non-stationary, Johansen's cointegration test was used to see the long run equilibrium relationship between consumer price index and petroleum products which revealed significant relationship between the variables of interest. After this cointegration regression equation was used to assess the strength of each variable on consumer price index. The results for lower income group suggested higher impact of HSD prices on index number than that of petrol prices, while the case was totally opposite in higher income group, which showed that petrol prices were more affecting increase in consumer price index for higher income group families than that of HSD prices. The case of combined income group showed that overall HSD prices were causing more increase in the combined income group than that of petrol prices.

Recommendations

Future research should extend the present study by incorporating data beyond June 2020 to examine the long-run relationship between income and petrol and high-speed diesel prices in Pakistan. Researchers may include additional macroeconomic variables, such as inflation, exchange rates, interest rates, and economic growth, to obtain a more comprehensive understanding of these relationships. The application of advanced time series techniques, including the ARDL bounds testing approach, and Vector Error Correction Model (VECM), may provide further insights into long-run equilibrium and short-run dynamics.

Future studies should also investigate the direction of causality between income and fuel prices. Furthermore, structural breaks and major economic events, such as changes in government policies and international oil price fluctuations, should be considered. Finally, the findings may assist policymakers in formulating effective fuel pricing, income support, and economic stabilization policies in Pakistan.

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