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# Analyzing The Dynamic Interactions Between Workers' Remittances And Inflation By Using Vector Auto Regressive (VAR) And Co- Integration Approach

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**Abstract:** Pakistan has benefited greatly from Pakistani remittances, which have been a significant source of foreign exchange. The consumer price index (CPI), the wholesale price index (WPI), and Pakistan's workers' remittances (WR) are all inflation indicators, but Pakistan's consumption-oriented economy makes it interesting to investigate the potential relationship—long-term or short-term—between the two. At the first step, the causality between WR and CPI and WR and WPI will be checked. This investigation will make use of the monthly CPI, WPI, and WR data from July 2008 to June 2017. The vector autocorrelation model is utilized for the short-term connection between the factors, while the Johansen strategy is utilized for the long-term relationship. According to the empirical findings, remittances from abroad have a significant positive effect on inflation. As a result, it is imperative that remittances from abroad be channeled into productive investments in order to boost economic growth and mitigate the inflationary effects of remittances in Pakistan.

**Keywords:** Inflation, worker's remittance, CPI (consumer price index), WPI (wholesale price index)

## Introduction:

The connection between the remittances of workers and expansion is a subject important to financial specialists and policymakers in nations with countless residents working abroad who send cash to their nation of origin. Workers' remittances allude to the cash sent by people who work in one nation and send it back to their nation of origin, while expansion is the expansion in the general price level of labor and products in an economy after some time. The connection between the two peculiarities is complicated in light of the fact that remittances can add to and moderate inflationary tensions in the beneficiary country. A few investigations propose that a high inundation of remittances can prompt expanded interest for labor and products, which can drive up prices and add to expansion. Nonetheless, remittances can likewise assist with settling the economy by giving a wellspring of unfamiliar trade and expanding the buying force of beneficiaries, counterbalancing inflationary tensions. Understanding the connection between workers' remittances and expansion is fundamental for policymakers as they endeavor to advance financial strength and development while limiting the unfavorable impacts of expansion on the populace.

A settlement is a financial exchange made by an unfamiliar laborer to a person in their nation of origin. This exchange of assets assumes a crucial part in offering monetary help to individuals dwelling in emerging nations. Remittances are many times seen as a critical kind of revenue for non-industrial countries and are contrasted with worldwide guide. In specific nations where an enormous number of individuals are utilized abroad, remittances comprise a significant part of the country's

monetary inflows. Thus, remittances assume a critical part in the financial improvement of such nations.

Remittances keep on fundamentally affecting family pay in Pakistan, with the country's settlement receipts consistently expanding over the long haul. As a matter of fact, as per the State Bank of Pakistan, remittances have flooded to an unsurpassed high of $31.9 billion in the financial year 2020-21. As most low-pay families need admittance to credit to support fundamental costs or useful ventures, an expansion in family pay is probably going to prompt an ascent popular for things like furnishings, machines, lodging, clinical consideration, training, cultivating, assembling, or retail deals. This change sought after may cause lopsided changes in relative prices, bringing about expanded price scattering. Furthermore, remittances can likewise raise generally expansion by influencing total interest through both immediate and backhanded impacts.

Expansion is the constant ascent in the general price level of labor and products in an economy over a period, prompting a decline in the buying influence of cash. National banks plan to limit expansion and forestall collapse, yet there is no agreement on the reason for expansion. The broadly acknowledged speculations incorporate interest pull expansion, which happens when the interest for labor and products surpasses their stockpile, cost-push expansion, which emerges when the expense of creation increments, and financial expansion, which results from an overabundance supply of cash in the economy, prompting an ascent in the prices of labor and products.

The Consumer Price Index (CPI) is a well-known proportion of the typical prices for a particular container of consumer labor and products. It is utilized to survey the typical cost for most everyday items and recognize expansion or collapse. On the other hand, the Wholesale Price Index (WPI) screens price changes in products before they arrive at the retail stage and is communicated as a rate change, showing the expansion level of a country. WPI might envelop various items in different nations, and a few countries might utilize other files, for example, the Maker Price Index. The impact of remittances sent by outsiders on their nations of origin's economies has been a subject of discussion, with clashing investigations introducing shifting effects.

## Literature Review:

It is contended that an expansion popular for things because of remittances can prompt somewhat greater costs. These changes popular, alongside supply price vacillations, can bring about unbalanced changes in relative prices, prompting an effect on the scattering of relative price changes. Moreover, remittances might increment expansion through their immediate and aberrant impacts on total interest. Our exploration adds to the current writing on the connection among's remittances and expansion. Through our examination of the effect of remittances on the economy, we improve our cognizance of this point as well as can gain proficiency with the extraordinary arrangement about the miniature and macroeconomic factors affected emphatically as well as adversely in connection with remittances"

Adams and Page, Acosta et al., and the World Bank agree that traveler remittances well affect the equilibrium between installments and monetary development in agricultural nations. These impacts come from the immediate effect of remittances on reserve funds and interest in human and actual capital, as well as their aberrant effect through utilization. The gainful effects of remittances likewise include the improvement of monetary establishments, the use of remittances as unfamiliar trade, and their part in decreasing credit limitations in nations where miniature funding isn't generally accessible. Remittances are seen as a main thrust for the improvement of monetary business sectors and money related strategies in emerging nations.

The concentrate by Guilano and Arranz recommends that remittances can further develop credit imperatives on poor

people, dispense capital, substitute for the absence of monetary turn of events, and speed up financial development. Iqbal and Sattar found that specialist remittances can forestall conversion scale, financial, and monetary approaches from going under pressure. While certain examinations recommend that remittances are chiefly utilized for utilization, others show that remittances can increment private venture and human resources speculation, producing a bigger effect on financial development through a multiplier impact.

Zarate-Hoyos (2004) recommended that remittances might have a lower pay flexibility for the utilization of solid merchandise contrasted with families. This proposes that settlement shocks can diminish the overall price of strong products. This thought is upheld by the way that settlement moves are frequently designated towards explicit family utilization, for example, medical services uses, which can influence the utilization examples of settlement getting families and have suggestions at relative costs. The effect of remittances on macroeconomic factors, for example, price and swapping scale. The examinations by Amuedo-Dorantes and Pozo (2004) and Vargas-Silva (2009) found that remittances can prompt the enthusiasm for the genuine conversion scale. While the effect of remittances on prices has not been broadly contemplated, there is a positive connection among expansion and the conveyance of relative price changes. Remittances can be viewed as an element that can make sense of this relationship for the majority emerging nations. Iqbal, Nosheen, and Javed (2010) led research inferring that remittances can influence expansion rates through expanded interest for labor and products because of expanded buying power from the beneficiaries. This can come down on item prices to increment. Ripon Roy and Md. Mokhlesur Rahman (2014) directed an examination concentrate on that examined the discoveries of Narayan, Narayan, and Mishra's 2010 review. The last option concentrate on inspected the impacts of remittances and institutional factors on expansion in both short and long haul periods, utilizing a board informational collection of 54 emerging nations from 1995 to 2004. The outcomes uncovered that remittances lead to expansion in non-industrial nations, and this impact turns out to be more critical over the long haul. It merits thinking about whether these microeconomic effects can have any macroeconomic ramifications. Anum Nisar and Saira Tufail (2017) talked about the discoveries of Irfan's concentrate in 1983 which analyzed the connection among remittances and utilization, as well as the effect on expansion. The investigation discovered that remittances can increment utilization levels and result sought after pull expansion because of the ensuing expansion in total interest through financial extension.

The effect of remittances on expansion has been a subject of significant discussion among specialists. This writing survey looks at a few examinations led by different researchers to investigate the connection among remittances and expansion in various nations and settings. Irfan (1983) exhibits that remittances can possibly increment utilization levels and create request get expansion through money related development. The implantation of settlement assets into the economy increments total interest, accordingly applying up strain on prices. Zarate-Hoyos (2004) recommends that settlement shocks can prompt a decline in the overall price of sturdy merchandise. The lower pay versatility for utilization of families getting remittances contrasted with everyone adds with this impact. Narayan, Narayan, and Mishra (2010) utilize a demonstrating way to deal with break down the impacts of remittances and institutional factors on expansion in non-industrial nations. Their discoveries show that remittances add to expansion, with a more articulated influence saw over the long haul.

Ziesemer and Kahanec (2013) find that remittances emphatically influence expansion in center pay nations however not in low-pay nations. The fluctuating effect of remittances on expansion across pay bunches features the

significance of considering the financial setting while dissecting the relationship. Chami et al. (2015) contend that remittances can cause expansion by expanding the interest for non-tradable labor and products, prompting genuine swapping scale appreciation. The convergence of settlement reserves reinforces the homegrown money, making imported merchandise somewhat less expensive and expanding the interest for non-tradable labor and products. Hassan and Tariq (2016) concentrate on the effect of remittances on expansion in Pakistan and notice a beneficial outcome on expansion because of expanded total interest. Their discoveries feature the job of remittances in animating monetary movement and adding to inflationary tensions. Ullah and Shahzad (2016) look at the effect of remittances on expansion in Pakistan and track down a huge beneficial outcome in the short and long run. Their review gives experimental proof supporting the speculation that remittances can fuel expansion in Pakistan. Habib and Ahmad (2017) track down a genuinely huge impact of remittances on expansion in Pakistan. Their review gives observational proof supporting the thought that remittances can add to inflationary tensions in the country. Moyo and Chikodzi (2017) find that remittances can prompt expansion in Zimbabwe through expanded interest for labor and products and genuine swapping scale appreciation. The ascent sought after, combined with the enthusiasm for the genuine conversion standard, adds to inflationary tensions in Zimbabwe's economy. Ahmed et al. (2018) find that remittances can make expansion in Bangladesh due an expansion in cash supply and total interest. The extension of the cash supply coming about because of settlement inflows produces inflationary tensions in the Bangladeshi economy. Tadesse and Hailu (2019) concentrate on the impact of remittances on expansion in Ethiopia and track down a positive and critical effect in both the short and long run. Their discoveries recommend that remittances add to inflationary tensions in the Ethiopian economy. Islam and Saifullah (2019) examine the impact of remittances on expansion in Bangladesh and track down a positive and huge effect in both the short and long run. Their review gives additional proof supporting the thought that remittances add to expansion in the country.

## Data

Inflation is a critical consider the economy, prepared to do either settling or undermining it. Affected by different determinants can adversely affect the economy. In this research, we emphasized was on three factors: worker remittances, consumer price index (CPI), and wholesale price index (WPI). The consequences of inflation can be either ideal or troublesome relying upon these factors in a country's economy. To analyze their relationship and impact on inflation, we led tests utilizing data gathered from July 2008 to June 2017. The data was acquired from the State Bank of Pakistan site (www.sbp.org.pk).

## Methodology:

This chapter focuses on examining the determinants of inflation in Pakistan, with a specific emphasis on remittances. In addition to studying the overall determinants of inflation, the data is arranged in a way that addresses heteroskedasticity by using logarithmic transformations. The purpose of this transformation is to make the data more representative and facilitate further analysis. Once the data is converted into logarithms, various tests are conducted to obtain results. Three approaches are adopted to explore the variables in terms of their stationary and non-stationary behavior. Firstly, graphical representations are used to analyze each determinant. Then, Correlograms are applied to further examine the results. Finally, a unit root test is conducted on each determinant. Causality tests are statistical methods used to determine whether there is a causal relationship between the variables. VAR model used to examine the direction and strength of causal relationships between variables. Cointegration

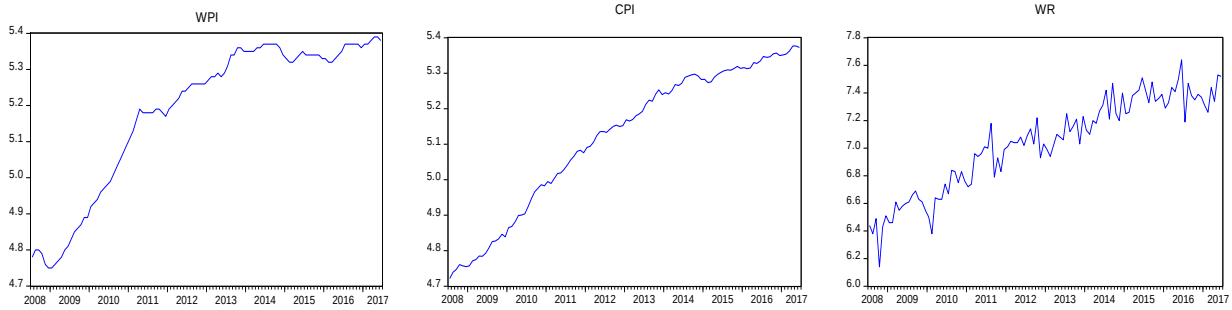
analysis enables the examination of long-term causal relationships between variables.

## Data Analysis:

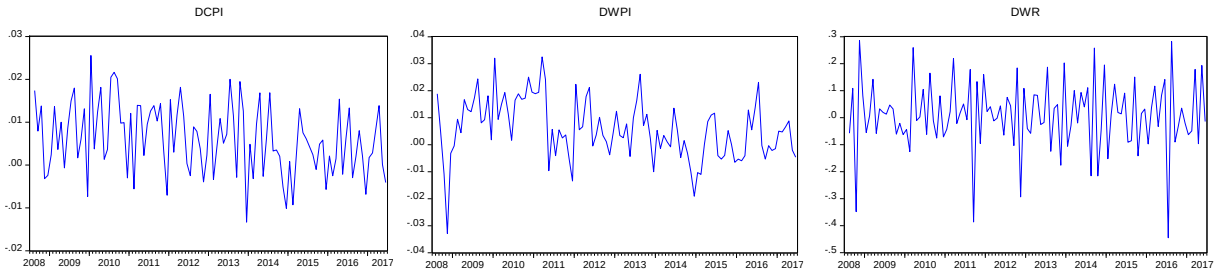
We chose three ways to explore our variables in term of their stationary as well as non-stationary behavior. Firstly we conducted graphical representation on each determinant then we analyzed results further we applied Correlogram on each determinant as well as unit root test.

## Graphical representation:

The graphic representations are used for evident imagination of statistical quantities they allow to analyze them deeper. Above are the graphs of CPI, WPI and WR. The graphic representations are used for evident imagination of statistical quantities they allow to analyze them deeper. Above are the graphs of CPI, WPI and WR:




These graphs shows fluctuations at every interval like in CPI from year 2008 the till 2017 the graph line is moving with spikes that shows the non-stationary behavior of the data and in contrast the graph of WPI have more trends and fluctuations than CPI so it has also non-stationary behavior so as the WR graph which also have high spikes and contain non-stationary behavior in the data. For analysis the data should be in the form of stationary and in case of conversion from non-stationary to stationary series be taking difference over a finite number of times by adding lag system in the data. After conversion is done the graph spikes or the Fluctuation is settled down in an equal manner and data is said to be in stationary form. Above are the graphs of stationary data.




## Correlogram:

The correlogram analysis of CPI, WPI, and WR series from 2008 to 2017 indicates non-stationary due to a gradual decline in auto-correlation values. To facilitate further analysis like co-integration, the data needs to be converted to a stationary form. The conversion process involves creating lag series (DWPI, DCPI, and DWR) through a statistical package (e-views) and applying a general equation for non-stationary to stationary data conversion. The results of stationary and non-stationary data is in annexure.

## Unit root test:

A unit root test determines if a time series variable is non-stationary, with the null hypothesis assuming the presence of a unit root. The test examines whether the data has a unit root (indicating non-stationarity) or not (indicating stationarity) based on probability results. In this case, the null hypothesis was accepted, indicating a unit root and non-stationary data. To convert the data to a stationary form, a general equation was applied using a lag series, with the number of lags determining the equation's form. The required tables of stationary and non-stationary data are in annexure.

With the data converted into stationary form, tests can be performed to determine the relationship between the determinants, whether it is one-way or two-way dependency. One-way dependency implies a unidirectional relationship, while two-way dependency indicates mutual interdependence. The causality test, specifically the Granger causality test, was conducted to examine the relationship between the variables.

**Granger causality test:**

The Granger causality test, proposed in 1969, determines if one time series can be used to forecast another, based on the ability to predict future values using prior values. We examined the relationship between worker remittance (WR), consumer price index (CPI), and wholesale price index (WPI). The test results indicated that WR has a causal effect on CPI, but not vice versa, as the null hypothesis was rejected for WR causing CPI, while it was accepted for CPI causing WR.

**Causality Test of WR and CPI**

| Null Hypothesis: | Obs | F-Statistic | Prob. |
|---|---|---|---|
| DWR does not Granger Cause DCPI | 105 | 4.17026 | 0.0182 |
| DCPI does not Granger Cause DWR | | 1.17306 | 0.3136 |

**Causality Test of WR and CPI**

| Null Hypothesis: | Obs | F-Statistic | Prob. |
|---|---|---|---|
| DWPI does not Granger Cause DWR | 105 | 0.14085 | 0.8688 |
| DWR does not Granger Cause DWPI | | 4.35739 | 0.0153 |

The causality test reveals that wholesale price index (WPI) and Consumer price index does not affect worker remittance (WR), as the probability exceeds the significance level (0.05), accepting the null hypothesis for their relationship. Conversely, the null hypothesis for WR causing WPI and CPI is rejected, as the calculated probability is below the significance level. Therefore, it can be concluded that WR has a causal effect on WPI and CPI, but not vice versa.

After causality test we will move forward to next level that is we will apply vector autoregressive (VAR) technique to make all the variables endogenous by removing distinction between exogenous and endogenous variables.

**Vector Autoregressive (VAR) models:**

In economics, simultaneous equation models arise when variables serve as both explanatory and explained variables. Sims (1980) argued against differentiating between endogenous and exogenous variables when there is simultaneity among variables. As a result, all variables should be treated as endogenous, leading to the development of vector autoregressive (VAR) models where each equation has the same set of regressors in its general reduced form.

The VAR model is useful for studying the relationship between multiple time series variables, such as inflation and worker remittances in Pakistan, allowing analysis of their short-run dynamics and interdependence. It enables examination of how past values of inflation and remittances impact their current and future values, considering the simultaneous interaction between the variables. The model

helps investigate the lagged effects and contemporaneous relationships between inflation and remittances, exploring if changes in one variable have immediate effects on the other in the short term. Overall, the VAR model provides insights into the dynamic interactions and short-run relationships between inflation and worker remittances in Pakistan. The results of vector autoregressive model is in annexure.

After implementing the vector autoregressive (VAR) model, the data on worker remittance (WR), consumer price index (CPI), and wholesale price index (WPI) were analyzed using the co-integration method to assess their long-run relationship.

Date: 07/27/17 Time: 15:17
Sample (adjusted): 2008M12 2017M06
Included observations: 103 after adjustments
Trend assumption: Linear deterministic trend
Series: WR CPI
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.220087 | 32.60826 | 15.49471 | 0.0001 |
| At most 1 * | 0.065751 | 7.005221 | 3.841466 | 0.0081 |

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Here the test results shows the two way relationship between WR and CPI as well as between WR and WPI. Also the test confirms the presence of long run relationship. The results reveal that remittances have a positive impact on the inflation i.e. with increase in remittances, the purchasing price of the consumer increase, therefore the demand increases which lead to an increase in overall price level eventually effecting annual percentage of inflation.

## Conclusion:

This study aims to investigate the relationship, whether long run or short run, between inflation indicators such as the Consumer Price Index (CPI) and Wholesale Price Index (WPI), and

## Co-integration:

A long run equilibrium relationship between the variables having same or different order of integrations is said to be a co-integrating relationship. When there are more than two variables there is possibility of more than one co-integrating relationship. JJ approach allows this possibility and uses maximum Eigen value and trace matrix to test the number of co-integrating relationships among the variables. Following are the results of WR and CPI and WR and WPI:

Date: 07/27/17 Time: 15:20
Sample (adjusted): 2008M12 2017M06
Included observations: 103 after adjustments
Trend assumption: Linear deterministic trend
Series: WR WPI
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.135784 | 22.02474 | 15.49471 | 0.0045 |
| At most 1 * | 0.065646 | 6.993713 | 3.841466 | 0.0082 |

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

workers' remittances (WR) in Pakistan. Various tests were conducted on the data to understand the changes in inflation resulting from different relationships among the factors. The study also explores the impact of these variables on inflation, both in the long run and short run. The short run relationship was examined using a VAR model, revealing a one-way relationship between the variables. The long run relationship was analyzed using co-integration techniques, confirming the presence of a lasting connection among the variables. Given the significance of inflation in the economy, changes in inflation directly affect the country's economic stability. Consequently, it is recommended that the government implement

measures to effectively utilize these valuable funds.

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## Correlogram (Non- Stationary):

CPI

Date: 07/27/17 Time: 12:37
Sample: 2008M07 2017M06
Included observations: 108

| | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|
| 1 | 0.973 | 0.973 | 105.13 | 0.000 |
| 2 | 0.947 | -0.007 | 205.54 | 0.000 |
| 3 | 0.920 | -0.016 | 301.26 | 0.000 |
| 4 | 0.894 | 0.004 | 392.57 | 0.000 |
| 5 | 0.868 | -0.023 | 479.42 | 0.000 |
| 6 | 0.841 | -0.032 | 561.70 | 0.000 |
| 7 | 0.812 | -0.030 | 639.34 | 0.000 |
| 8 | 0.784 | -0.016 | 712.43 | 0.000 |
| 9 | 0.756 | -0.023 | 781.01 | 0.000 |
| 10 | 0.728 | -0.013 | 845.20 | 0.000 |
| 11 | 0.699 | -0.033 | 904.96 | 0.000 |
| 12 | 0.669 | -0.023 | 960.36 | 0.000 |
| 13 | 0.640 | -0.005 | 1011.6 | 0.000 |
| 14 | 0.613 | 0.005 | 1059.1 | 0.000 |
| 15 | 0.584 | -0.034 | 1102.6 | 0.000 |
| 16 | 0.556 | -0.009 | 1142.5 | 0.000 |
| 17 | 0.529 | 0.000 | 1179.0 | 0.000 |
| 18 | 0.500 | -0.051 | 1212.0 | 0.000 |
| 19 | 0.472 | 0.006 | 1241.8 | 0.000 |
| 20 | 0.444 | -0.033 | 1268.4 | 0.000 |
| 21 | 0.417 | -0.004 | 1292.1 | 0.000 |
| 22 | 0.390 | -0.001 | 1313.1 | 0.000 |
| 23 | 0.363 | -0.032 | 1331.5 | 0.000 |
| 24 | 0.335 | -0.025 | 1347.5 | 0.000 |
| 25 | 0.309 | -0.005 | 1361.1 | 0.000 |
| 26 | 0.284 | 0.010 | 1372.8 | 0.000 |
| 27 | 0.260 | 0.009 | 1382.7 | 0.000 |
| 28 | 0.238 | -0.002 | 1391.1 | 0.000 |
| 29 | 0.216 | -0.005 | 1398.1 | 0.000 |
| 30 | 0.192 | -0.045 | 1403.8 | 0.000 |
| 31 | 0.170 | -0.015 | 1408.2 | 0.000 |
| 32 | 0.145 | -0.053 | 1411.5 | 0.000 |
| 33 | 0.121 | -0.019 | 1413.8 | 0.000 |
| 34 | 0.097 | -0.010 | 1415.3 | 0.000 |
| 35 | 0.073 | -0.024 | 1416.2 | 0.000 |
| 36 | 0.050 | -0.017 | 1416.6 | 0.000 |

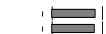
WPI

Date: 07/27/17 Time: 12:38
Sample: 2008M07 2017M06
Included observations: 108

| | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|
| 1 | 0.975 | 0.975 | 105.65 | 0.000 |
| 2 | 0.950 | -0.025 | 206.88 | 0.000 |
| 3 | 0.924 | -0.038 | 303.49 | 0.000 |
| 4 | 0.896 | -0.053 | 395.15 | 0.000 |
| 5 | 0.864 | -0.093 | 481.19 | 0.000 |
| 6 | 0.831 | -0.036 | 561.53 | 0.000 |
| 7 | 0.797 | -0.031 | 636.17 | 0.000 |
| 8 | 0.762 | -0.021 | 705.18 | 0.000 |
| 9 | 0.727 | -0.026 | 768.64 | 0.000 |
| 10 | 0.693 | -0.006 | 826.80 | 0.000 |
| 11 | 0.658 | -0.020 | 879.83 | 0.000 |
| 12 | 0.623 | -0.024 | 927.88 | 0.000 |
| 13 | 0.590 | 0.006 | 971.34 | 0.000 |
| 14 | 0.558 | 0.011 | 1010.6 | 0.000 |
| 15 | 0.525 | -0.023 | 1045.9 | 0.000 |
| 16 | 0.494 | -0.016 | 1077.4 | 0.000 |
| 17 | 0.463 | -0.009 | 1105.4 | 0.000 |
| 18 | 0.431 | -0.049 | 1129.9 | 0.000 |
| 19 | 0.401 | 0.016 | 1151.4 | 0.000 |
| 20 | 0.371 | -0.027 | 1169.9 | 0.000 |
| 21 | 0.342 | -0.009 | 1185.9 | 0.000 |
| 22 | 0.313 | 0.004 | 1199.4 | 0.000 |
| 23 | 0.285 | -0.022 | 1210.8 | 0.000 |
| 24 | 0.257 | -0.033 | 1220.2 | 0.000 |
| 25 | 0.229 | -0.013 | 1227.7 | 0.000 |
| 26 | 0.204 | 0.015 | 1233.7 | 0.000 |
| 27 | 0.179 | 0.010 | 1238.4 | 0.000 |
| 28 | 0.157 | 0.012 | 1242.1 | 0.000 |
| 29 | 0.136 | 0.016 | 1244.9 | 0.000 |
| 30 | 0.116 | -0.013 | 1247.0 | 0.000 |
| 31 | 0.097 | -0.016 | 1248.4 | 0.000 |
| 32 | 0.078 | -0.020 | 1249.4 | 0.000 |
| 33 | 0.061 | 0.009 | 1250.0 | 0.000 |
| 34 | 0.045 | 0.005 | 1250.3 | 0.000 |
| 35 | 0.028 | -0.049 | 1250.4 | 0.000 |
| 36 | 0.011 | -0.035 | 1250.4 | 0.000 |

WR

Date: 07/27/17 Time: 12:40
Sample: 2008M07 2017M06
Included observations: 108



| | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|
| 1 | 0.902 | 0.902 | 90.329 | 0.000 |
| 2 | 0.882 | 0.369 | 177.59 | 0.000 |
| 3 | 0.858 | 0.144 | 260.93 | 0.000 |
| 4 | 0.792 | -0.219 | 332.49 | 0.000 |
| 5 | 0.775 | 0.079 | 401.74 | 0.000 |
| 6 | 0.759 | 0.157 | 468.79 | 0.000 |
| 7 | 0.730 | 0.046 | 531.42 | 0.000 |
| 8 | 0.703 | -0.116 | 590.08 | 0.000 |
| 9 | 0.712 | 0.195 | 650.99 | 0.000 |
| 10 | 0.665 | -0.132 | 704.62 | 0.000 |
| 11 | 0.657 | 0.049 | 757.53 | 0.000 |
| 12 | 0.660 | 0.086 | 811.42 | 0.000 |
| 13 | 0.592 | -0.252 | 855.24 | 0.000 |
| 14 | 0.591 | 0.049 | 899.42 | 0.000 |
| 15 | 0.554 | -0.073 | 938.64 | 0.000 |
| 16 | 0.521 | 0.070 | 973.73 | 0.000 |
| 17 | 0.499 | -0.082 | 1006.2 | 0.000 |
| 18 | 0.469 | -0.079 | 1035.3 | 0.000 |
| 19 | 0.432 | -0.040 | 1060.2 | 0.000 |
| 20 | 0.406 | 0.018 | 1082.4 | 0.000 |
| 21 | 0.395 | 0.034 | 1103.7 | 0.000 |
| 22 | 0.338 | -0.121 | 1119.5 | 0.000 |
| 23 | 0.344 | 0.082 | 1136.1 | 0.000 |
| 24 | 0.305 | -0.111 | 1149.2 | 0.000 |
| 25 | 0.264 | 0.001 | 1159.2 | 0.000 |
| 26 | 0.253 | -0.051 | 1168.5 | 0.000 |
| 27 | 0.216 | 0.063 | 1175.3 | 0.000 |
| 28 | 0.192 | -0.048 | 1180.8 | 0.000 |
| 29 | 0.172 | 0.012 | 1185.3 | 0.000 |
| 30 | 0.144 | -0.081 | 1188.4 | 0.000 |
| 31 | 0.113 | 0.052 | 1190.4 | 0.000 |
| 32 | 0.102 | -0.008 | 1192.0 | 0.000 |
| 33 | 0.090 | 0.104 | 1193.3 | 0.000 |
| 34 | 0.066 | 0.017 | 1194.0 | 0.000 |
| 35 | 0.080 | 0.024 | 1195.0 | 0.000 |
| 36 | 0.040 | -0.103 | 1195.3 | 0.000 |

## Correlogram (Stationary):

CPI

Date: 07/27/17 Time: 12:58
Sample: 2008M07 2017M06
Included observations: 106

| | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|
| 1 | -0.464 | -0.464 | 23.465 | 0.000 |
| 2 | -0.128 | -0.438 | 25.276 | 0.000 |
| 3 | 0.257 | -0.049 | 32.645 | 0.000 |
| 4 | -0.208 | -0.180 | 37.519 | 0.000 |
| 5 | -0.034 | -0.233 | 37.653 | 0.000 |
| 6 | 0.169 | -0.094 | 40.925 | 0.000 |
| 7 | -0.071 | -0.022 | 41.511 | 0.000 |
| 8 | -0.149 | -0.237 | 44.118 | 0.000 |
| 9 | 0.223 | -0.069 | 50.002 | 0.000 |
| 10 | -0.086 | -0.061 | 50.880 | 0.000 |
| 11 | -0.212 | -0.335 | 56.299 | 0.000 |
| 12 | 0.439 | 0.105 | 79.729 | 0.000 |
| 13 | -0.281 | -0.078 | 89.447 | 0.000 |
| 14 | 0.035 | 0.093 | 89.598 | 0.000 |
| 15 | 0.210 | 0.207 | 95.158 | 0.000 |
| 16 | -0.337 | -0.085 | 109.60 | 0.000 |
| 17 | 0.047 | -0.141 | 109.88 | 0.000 |
| 18 | 0.183 | -0.069 | 114.25 | 0.000 |
| 19 | -0.019 | 0.182 | 114.29 | 0.000 |
| 20 | -0.237 | -0.145 | 121.80 | 0.000 |
| 21 | 0.280 | -0.009 | 132.37 | 0.000 |
| 22 | -0.109 | -0.005 | 133.99 | 0.000 |
| 23 | -0.242 | -0.270 | 142.08 | 0.000 |
| 24 | 0.423 | -0.102 | 167.03 | 0.000 |
| 25 | -0.177 | 0.043 | 171.45 | 0.000 |
| 26 | -0.077 | -0.011 | 172.29 | 0.000 |
| 27 | 0.222 | -0.004 | 179.41 | 0.000 |
| 28 | -0.205 | 0.052 | 185.57 | 0.000 |
| 29 | -0.014 | 0.015 | 185.60 | 0.000 |
| 30 | 0.119 | 0.003 | 187.73 | 0.000 |
| 31 | -0.067 | -0.057 | 188.40 | 0.000 |
| 32 | -0.071 | 0.000 | 189.19 | 0.000 |
| 33 | 0.176 | -0.087 | 194.07 | 0.000 |
| 34 | -0.127 | -0.052 | 196.65 | 0.000 |
| 35 | -0.130 | -0.034 | 199.38 | 0.000 |
| 36 | 0.349 | -0.019 | 219.28 | 0.000 |

WPI

Date: 07/27/17 Time: 12:59
Sample: 2008M07 2017M06
Included observations: 106

| | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|
| 1 | -0.320 | -0.320 | 11.139 | 0.001 |
| 2 | -0.071 | -0.193 | 11.691 | 0.003 |
| 3 | 0.033 | -0.065 | 11.811 | 0.008 |
| 4 | -0.056 | -0.092 | 12.164 | 0.016 |
| 5 | -0.100 | -0.177 | 13.303 | 0.021 |
| 6 | -0.031 | -0.182 | 13.412 | 0.037 |
| 7 | 0.125 | 0.006 | 15.231 | 0.033 |
| 8 | -0.106 | -0.112 | 16.544 | 0.035 |
| 9 | 0.002 | -0.107 | 16.544 | 0.056 |
| 10 | -0.064 | -0.207 | 17.026 | 0.074 |
| 11 | 0.085 | -0.068 | 17.894 | 0.084 |
| 12 | 0.026 | -0.013 | 17.974 | 0.116 |
| 13 | 0.025 | 0.011 | 18.049 | 0.156 |
| 14 | -0.040 | -0.095 | 18.251 | 0.196 |
| 15 | 0.135 | 0.108 | 20.547 | 0.152 |
| 16 | -0.251 | -0.212 | 28.551 | 0.027 |
| 17 | 0.153 | 0.064 | 31.548 | 0.017 |
| 18 | -0.059 | -0.099 | 32.003 | 0.022 |
| 19 | 0.054 | 0.060 | 32.389 | 0.028 |
| 20 | -0.113 | -0.171 | 34.097 | 0.025 |
| 21 | 0.106 | 0.068 | 35.614 | 0.024 |
| 22 | 0.086 | 0.071 | 36.623 | 0.026 |
| 23 | -0.238 | -0.107 | 44.441 | 0.005 |
| 24 | 0.218 | 0.052 | 51.056 | 0.001 |
| 25 | -0.138 | -0.095 | 53.758 | 0.001 |
| 26 | 0.057 | -0.016 | 54.227 | 0.001 |
| 27 | -0.042 | -0.012 | 54.487 | 0.001 |
| 28 | -0.052 | -0.179 | 54.877 | 0.002 |
| 29 | -0.007 | -0.121 | 54.884 | 0.003 |
| 30 | 0.090 | -0.021 | 56.118 | 0.003 |
| 31 | -0.093 | -0.122 | 57.437 | 0.003 |
| 32 | 0.036 | -0.137 | 57.642 | 0.004 |
| 33 | 0.115 | 0.009 | 59.726 | 0.003 |
| 34 | -0.079 | -0.145 | 60.729 | 0.003 |
| 35 | -0.035 | -0.080 | 60.926 | 0.004 |
| 36 | 0.130 | -0.028 | 63.692 | 0.003 |

WR

Date: 07/27/17 Time: 13:03
Sample: 2008M07 2017M06
Included observations: 106

| | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|
| 1 | -0.715 | -0.715 | 55.715 | 0.000 |
| 2 | 0.202 | -0.631 | 60.218 | 0.000 |
| 3 | 0.127 | -0.302 | 62.005 | 0.000 |
| 4 | -0.179 | -0.091 | 65.621 | 0.000 |
| 5 | 0.052 | -0.151 | 65.922 | 0.000 |
| 6 | 0.036 | -0.265 | 66.072 | 0.000 |
| 7 | 0.036 | 0.040 | 66.221 | 0.000 |
| 8 | -0.236 | -0.319 | 72.740 | 0.000 |
| 9 | 0.384 | -0.136 | 90.185 | 0.000 |
| 10 | -0.300 | 0.042 | 100.95 | 0.000 |
| 11 | -0.019 | -0.369 | 100.99 | 0.000 |
| 12 | 0.359 | -0.046 | 116.67 | 0.000 |
| 13 | -0.465 | -0.103 | 143.33 | 0.000 |
| 14 | 0.328 | -0.011 | 156.73 | 0.000 |
| 15 | -0.114 | -0.042 | 158.36 | 0.000 |
| 16 | -0.021 | -0.102 | 158.41 | 0.000 |
| 17 | 0.032 | 0.058 | 158.55 | 0.000 |
| 18 | 0.033 | 0.078 | 158.69 | 0.000 |
| 19 | -0.065 | 0.052 | 159.25 | 0.000 |
| 20 | -0.068 | -0.176 | 159.87 | 0.000 |
| 21 | 0.308 | 0.015 | 172.63 | 0.000 |
| 22 | -0.438 | -0.011 | 198.79 | 0.000 |
| 23 | 0.339 | -0.023 | 214.64 | 0.000 |
| 24 | -0.083 | -0.046 | 215.60 | 0.000 |
| 25 | -0.127 | 0.039 | 217.88 | 0.000 |
| 26 | 0.185 | 0.039 | 222.80 | 0.000 |
| 27 | -0.134 | -0.027 | 225.39 | 0.000 |
| 28 | 0.048 | -0.074 | 225.73 | 0.000 |
| 29 | 0.013 | 0.128 | 225.76 | 0.000 |
| 30 | 0.002 | 0.026 | 225.76 | 0.000 |
| 31 | -0.064 | 0.092 | 226.38 | 0.000 |
| 32 | 0.058 | 0.075 | 226.90 | 0.000 |
| 33 | 0.054 | 0.052 | 227.36 | 0.000 |
| 34 | -0.227 | -0.105 | 235.59 | 0.000 |
| 35 | 0.337 | -0.002 | 253.91 | 0.000 |
| 36 | -0.313 | -0.125 | 269.95 | 0.000 |

## Appendix:

## Unit Root Test (Non-Stationary):

### CPI

Null Hypothesis: CPI has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -3.158978 | 0.0253 |
| Test critical values: | 1% level | -3.492523 | |
| | 5% level | -2.888669 | |
| | 10% level | -2.581313 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CPI)
Method: Least Squares
Date: 07/27/17 Time: 14:38
Sample (adjusted): 2008M08 2017M06
Included observations: 107 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| CPI(-1) | -0.011829 | 0.003745 | -3.158978 | 0.0021 |
| C | 0.066608 | 0.019174 | 3.473948 | 0.0007 |

### WPI

Null Hypothesis: WPI has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -1.993861 | 0.2892 |
| Test critical values: | 1% level | -3.493129 | |
| | 5% level | -2.888932 | |
| | 10% level | -2.581453 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(WPI)
Method: Least Squares
Date: 07/27/17 Time: 14:40
Sample (adjusted): 2008M09 2017M06
Included observations: 106 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| WPI(-1) | -0.009407 | 0.004718 | -1.993861 | 0.0488 |
| D(WPI(-1)) | 0.437962 | 0.087051 | 5.031353 | 0.0000 |
| C | 0.051814 | 0.024613 | 2.105173 | 0.0377 |

### WR

Null Hypothesis: WR has a unit root
Exogenous: Constant
Lag Length: 12 (Automatic - based on SIC, maxlag=12)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -1.740980 | 0.4075 |
| Test critical values: | 1% level | -3.500969 | |
| | 5% level | -2.892200 | |
| | 10% level | -2.583192 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(WR)
Method: Least Squares
Date: 07/27/17 Time: 14:41
Sample (adjusted): 2009M08 2017M06
Included observations: 95 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| WR(-1) | -0.057551 | 0.033057 | -1.740980 | 0.0855 |
| D(WR(-1)) | -0.619456 | 0.103078 | -6.009596 | 0.0000 |
| D(WR(-2)) | -0.214513 | 0.123377 | -1.738210 | 0.0851 |
| D(WR(-3)) | -0.203531 | 0.123888 | -1.642866 | 0.1043 |
| D(WR(-4)) | -0.401808 | 0.125808 | -3.193822 | 0.0020 |
| D(WR(-5)) | -0.341677 | 0.130354 | -2.621147 | 0.0105 |
| D(WR(-6)) | -0.287882 | 0.132164 | -2.178221 | 0.0323 |
| D(WR(-7)) | -0.285695 | 0.131628 | -2.167316 | 0.0331 |
| D(WR(-8)) | -0.344883 | 0.129208 | -2.669327 | 0.0092 |
| D(WR(-9)) | -0.069559 | 0.128052 | -0.543204 | 0.5885 |
| D(WR(-10)) | -0.222991 | 0.123484 | -1.805821 | 0.0747 |
| D(WR(-11)) | -0.153004 | 0.121468 | -1.259646 | 0.2114 |
| D(WR(-12)) | 0.249226 | 0.105917 | 2.351696 | 0.0211 |
| C | 0.443519 | 0.237415 | 1.868114 | 0.0654 |

## Unit Root Test (Stationary):

### CPI

Null Hypothesis: D(DCPI) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -13.84060 | 0.0000 |
| Test critical values: | 1% level | -3.494378 | |
| | 5% level | -2.889474 | |
| | 10% level | -2.581741 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DCPI,2)
Method: Least Squares
Date: 07/27/17 Time: 14:48
Sample (adjusted): 2008M11 2017M06
Included observations: 104 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(DCPI(-1)) | -2.129430 | 0.153854 | -13.84060 | 0.0000 |
| D(DCPI(-1),2) | 0.452481 | 0.089783 | 5.039737 | 0.0000 |
| C | -0.000238 | 0.000871 | -0.273131 | 0.7853 |

### WPI

Null Hypothesis: D(DWPI) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -10.35729 | 0.0000 |
| Test critical values: | 1% level | -3.494378 | |
| | 5% level | -2.889474 | |
| | 10% level | -2.581741 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DWPI,2)
Method: Least Squares
Date: 07/27/17 Time: 14:50
Sample (adjusted): 2008M11 2017M06
Included observations: 104 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(DWPI(-1)) | -1.612193 | 0.155658 | -10.35729 | 0.0000 |
| D(DWPI(-1),2) | 0.204212 | 0.095454 | 2.139381 | 0.0348 |
| C | 1.31E-05 | 0.001012 | 0.012918 | 0.9897 |

### WR

Null Hypothesis: D(DWR) has a unit root
Exogenous: Constant
Lag Length: 10 (Automatic - based on SIC, maxlag=12)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -7.695733 | 0.0000 |
| Test critical values: | 1% level | -3.500969 | |
| | 5% level | -2.892200 | |
| | 10% level | -2.583192 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DWR,2)
Method: Least Squares
Date: 07/27/17 Time: 14:51
Sample (adjusted): 2009M08 2017M06
Included observations: 95 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(DWR(-1)) | -12.92507 | 1.679511 | -7.695733 | 0.0000 |
| D(DWR(-1),2) | 10.50039 | 1.636998 | 6.414415 | 0.0000 |
| D(DWR(-2),2) | 9.159510 | 1.533053 | 5.974684 | 0.0000 |
| D(DWR(-3),2) | 7.914391 | 1.378704 | 5.740458 | 0.0000 |
| D(DWR(-4),2) | 6.600539 | 1.204138 | 5.481546 | 0.0000 |
| D(DWR(-5),2) | 5.314619 | 1.016362 | 5.229064 | 0.0000 |
| D(DWR(-6),2) | 4.120610 | 0.819684 | 5.027079 | 0.0000 |
| D(DWR(-7),2) | 3.017927 | 0.621703 | 4.854294 | 0.0000 |
| D(DWR(-8),2) | 1.957883 | 0.430180 | 4.550822 | 0.0000 |
| D(DWR(-9),2) | 1.158540 | 0.247341 | 4.683979 | 0.0000 |
| D(DWR(-10),2) | 0.492502 | 0.095084 | 5.179672 | 0.0000 |
| C | -0.002356 | 0.009270 | -0.254113 | 0.8000 |

## Vector autoregressive model (VAR):

Vector Autoregression Estimates
Date: 07/27/17 Time: 14:54
Sample (adjusted): 2009M08 2017M06
Included observations: 95 after adjustments
Standard errors in ( ) & t-statistics in [ ]

| | DWR | DCPI |
|---|---|---|
| DWR(-1) | -0.588743 | 0.007788 |
| | (0.07842) | (0.00679) |
| | [-7.50721] | [ 1.14688] |
| DWR(-4) | -0.148578 | 0.007624 |
| | (0.07878) | (0.00682) |
| | [-1.88597] | [ 1.11761] |
| DWR(-7) | -0.168510 | -0.006073 |
| | (0.09186) | (0.00795) |
| | [-1.83444] | [-0.76355] |
| DWR(-8) | -0.321264 | -0.008831 |
| | (0.09876) | (0.00855) |
| | [-3.25287] | [-1.03265] |
| DWR(-12) | 0.341999 | 0.003474 |
| | (0.07848) | (0.00680) |
| | [ 4.35756] | [ 0.51122] |
| DCPI(-1) | -1.515930 | 0.029628 |
| | (1.14718) | (0.09934) |
| | [-1.32144] | [ 0.29826] |
| DCPI(-4) | -0.600253 | -0.049002 |
| | (1.21888) | (0.10554) |
| | [-0.49246] | [-0.46428] |
| DCPI(-7) | 1.517361 | 0.102498 |
| | (1.22042) | (0.10568) |
| | [ 1.24331] | [ 0.96992] |
| DCPI(-8) | 1.015841 | -0.039823 |
| | (1.13213) | (0.09803) |
| | [ 0.89728] | [-0.40623] |
| DCPI(-12) | 1.571093 | 0.434708 |
| | (1.15759) | (0.10024) |
| | [ 1.35721] | [ 4.33682] |
| C | 0.003545 | 0.002831 |
| | (0.01705) | (0.00148) |
| | [ 0.20787] | [ 1.91739] |
| R-squared | 0.596970 | 0.271348 |
| Adj. R-squared | 0.548991 | 0.184603 |
| Sum sq. resids | 0.612144 | 0.004590 |
| S.E. equation | 0.085366 | 0.007392 |
| F-statistic | 12.44214 | 3.128133 |
| Log likelihood | 104.8224 | 337.2460 |
| Akaike AIC | -1.975209 | -6.868337 |
| Schwarz SC | -1.679497 | -6.572625 |
| Mean dependent | 0.009525 | 0.005947 |
| S.D. dependent | 0.127114 | 0.008186 |

Vector Autoregression Estimates
Date: 07/27/17 Time: 14:56
Sample (adjusted): 2009M08 2017M06
Included observations: 95 after adjustments
Standard errors in ( ) & t-statistics in [ ]

| | DWR | DWPI |
|---|---|---|
| DWR(-1) | -0.617293 | 0.015147 |
| | (0.07504) | (0.00831) |
| | [-8.22587] | [ 1.82327] |
| DWR(-4) | -0.237250 | 0.001089 |
| | (0.09014) | (0.00998) |
| | [-2.63207] | [ 0.10908] |
| DWR(-5) | -0.240874 | 0.005610 |
| | (0.09214) | (0.01020) |
| | [-2.61423] | [ 0.54993] |
| DWR(-12) | 0.397956 | 0.002454 |
| | (0.07490) | (0.00829) |
| | [ 5.31344] | [ 0.29599] |
| DWPI(-1) | -1.214275 | 0.441022 |
| | (0.90301) | (0.09997) |
| | [-1.34470] | [ 4.41155] |
| DWPI(-4) | 1.838782 | 0.039654 |
| | (1.02760) | (0.11376) |
| | [ 1.78940] | [ 0.34857] |
| DWPI(-5) | -0.798038 | -0.008701 |
| | (0.97597) | (0.10805) |
| | [-0.81769] | [-0.08053] |
| DWPI(-12) | 2.115422 | 0.075102 |
| | (0.82966) | (0.09185) |
| | [ 2.54976] | [ 0.81766] |
| C | 0.002272 | 0.002288 |
| | (0.01186) | (0.00131) |
| | [ 0.19165] | [ 1.74355] |
| R-squared | 0.589422 | 0.265763 |
| Adj. R-squared | 0.551229 | 0.197462 |
| Sum sq. resids | 0.623608 | 0.007643 |
| S.E. equation | 0.085154 | 0.009427 |
| F-statistic | 15.43263 | 3.891059 |
| Log likelihood | 103.9411 | 313.0229 |
| Akaike AIC | -1.998760 | -6.400483 |
| Schwarz SC | -1.756813 | -6.158536 |
| Mean dependent | 0.009525 | 0.005868 |
| S.D. dependent | 0.127114 | 0.010523 |