

Inflation in Saudi Arabia:
Long and Short Run Determinants
محددات التضخم في المملكة العربية السعودية على
المدى القصير والبعيد

By

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ABSTRACT

This paper investigates the possible long run and short run relationships of various economic factors on Consumer Price Inflation in the Kingdom of Saudi Arabia using Bounds Testing approach as presented by Pesaran et al (2001) and Johansen (1998) multivariate cointegration method. Two economic models are presented in the study. The first model investigates the relationship between domestic Consumer Price Index and World Food Price Index, domestic Broad Money Supply (M2), Trade Weighted Dollar Index and 3 month Eurodollar interest rate using Bounds Test approach presented by Pesaran et al (2001). The second model investigates the relationship between domestic Consumer Price Index and World Commodity Price Index, domestic Broad Money Supply (M2), domestic Nominal Effective Exchange Rate and 3 month US Treasury Bill Rate/

The results obtained exhibit existence of long run relationship (cointegration) between domestic price inflation, global food and commodity prices, domestic money supply, domestic effective exchange rate and the foreign interest rate (US).

The study concludes that in the long run both world commodity and food prices and money supply exert a positive pressure on domestic prices whereas appreciation in Saudi Riyals value and foreign (USA) interest rate exert a negative pressure on local price inflation. In the short-run while other factors have similar effect as that of long-run, money supply is found to have minimal role.

Key Words: Pesaran et al (2001), Bounds Test

المخلص

تبحث هذه الدراسة في المدى الطويل و المدى القصير على امكانية ايجاد علاقة مع العوامل الاقتصادية المختلفة على أسعار المستهلك التضخم في المملكة العربية السعودية باوندز نهج الاختبار وقدمها Pesaran وآخرون (2001) ويوهانسن (1998) أسلوب التكامل المشترك متعدد المتغيرات. في هذه الدراسة يتم عرض نموذجين اقتصاديين في الدراسة. النموذج الأول يحقق في العلاقة بين مؤشر أسعار المستهلك المحلي ومؤشر أسعار الغذاء العالمي، عرض النقد المحلي بمفهومه الواسع (2M)، تجارة مؤشر الدولار المرجح و3 أشهر سعر الفائدة اليورو دولار باستخدام نهج اختبار (باوندز) قدمها Pesaran وآخرون (2001). النموذج الثاني يحقق في العلاقة بين مؤشر أسعار المستهلك المحلي ومؤشر أسعار السلع العالمية، عرض النقد المحلي بمفهومه الواسع (2M)، سعر الصرف الفعلي المحلي الاسمي و3 أشهر الخزنة الأمريكي بيل السعر النتائج المتحصل عليها هي وجود علاقة المدى الطويل (التكامل المشترك) بين التضخم المحلي السعر، مؤشر أسعار الغذاء العالمي وأسعار السلع الأساسية، وإمدادات المال المحلي، ومعدل الصرف الفعلي المحلية وسعر الفائدة الخارجية (الولايات المتحدة). وتلخص الدراسة إلى أنه في المدى الطويل على حد سواء السلع العالمية وأسعار المواد الغذائية والمعروض من النقود تمارس ضغط إيجابي على الأسعار المحلية في حين التقدير في قيمة الريال السعودي و(الولايات المتحدة الأمريكية) سعر الفائدة الأجنبية تمارس الضغط السلبي على التضخم في أسعار المحلية. اما بالنسبة الى قصيرة المدى بينما عوامل أخرى لها تأثير المدى الطويل، تم العثور على ان المعروض من النقود له الدور الأدنى.

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1. Introduction

Saudi Arabia is an open economy that has experienced rising inflation since 2007 with highest peak levels seen in 2008. The exact interaction of various factors contributing to inflation is a complex issue, however in light of existing literature some of the major factors are discussed below.

The main reason behind the price hike is the fixed peg of Saudi Riyal with the US dollar that came into force in 1986. While the fixed peg has provided stable monetary policy and cushion against exchange rate volatility, the recent depreciation of US dollar over the past six years against major international currencies had a negative effect on the local economy causing price hikes especially for imported goods. As major portion of Saudi Arabia's imports come from Europe or Japan (as compared to USA) coupled with absence of domestic alternatives the rise in import price causes domestic inflation (Onis and Ozmucur, 1990; Juselius, 1992; Metin, 1995; Lim and Papi, 1997; Bonato, 2007; Kandil and H. Morsy, 2009).

The other drawback of the pegged currency is that it paralyses the country's monetary policy. As a result Saudi Arabia is forced to cut interest rate in pursuit to US Federal Reserve which is not beneficial especially during times when inflation rates are already on the rise.

Upward trends of inflation in the world economy further contribute to inflation in the country. As Saudi Arabia heavily relies on imports from around the world, changes in world price level would directly affect the price level in the country (Keran, 1979; Jin, 2000; Kandil and H. Morsy, 2009).

Saudi Arabia stands as one of the major oil exporting countries in the world and relies heavily on revenues from oil exports. In 2006 oil export revenues comprised 80% to 90% of state revenues, and 46 percent of the country's gross domestic product (IMF, 2007). Increases in oil price therefore tend to increase money supply followed by economic growth with increased demand for money that contribute to inflation in the country (Iyoha, 1973; Keran, 1979; Darrat, 1985; Metin, 1995; Lim and Papi, 1997; Sekine, 2001; Khan and Schimmelpfening, 2006; Bonato, 2007; and Kandil and H. Morsy, 2009).

This paper investigates whether the price inflation in Saudi Arabia has a long-run relationship (cointegration) between world food prices, broad money supply, nominal effective exchange rate and bank interest rate. The technique used is Bounds Test method (Pesaran et al, 2001) using an Auto Distributed Lag Model (ARDL) and Johansen (1998) approach to cointegration using VECM model. The study also examines whether world food/commodity prices, domestic broad money supply, currency exchange rate and foreign (US) interest rate cause changes in the price level in Saudi Arabia using Granger Casualty Test.

1.1 Purpose and Motivation

This paper studies the presence of short and long-run relationships among Saudi Arabia's domestic price inflation, world food price, domestic broad money supply (M2), nominal effective exchange rate and foreign interest rate.

Early literature mainly focused on short run impacts of various factors on price inflation and using simple ordinary least square (OLS) regression method. Such studies may have lead to wrong conclusions about long term relationships giving spurious estimates (Caporale and Chui, 1999). Only recent studies use sophisticated economic techniques and distinguish between short and long run relationships with only a handful making use of the procedure of Bounds Testing that was most recently proposed by Pesaran et al (1996, 2001). In our study we have therefore used the Bounds Test approach by utilizing an unrestricted error correction version (UECM) of the Auto Regressive Distribution Lag Model (ARDL) as suggested by Pesaran et al (1996, 2001). We further reinforce our study by presenting a Vector Error Correction Model using Johansen (1998) approach to cointegration to justify the results.

Other research methods like Vector Error Correction Model (VECM) impose a pre-condition that requires all variables of study to be integrated to the same order. In practice this restriction is difficult to comply with, as most of the time series data available is either integrated at level $I(0)$ or at first level $I(1)$. Bounds Testing approach relieves this restriction and allows the use of integrated data comprised of either $I(1)$ or a mix of both $I(0)$ and $I(1)$ provided the dependant variable is $I(1)$. It is a matter of coincidence that all our variables of research are integrated at first difference $I(1)$. It is for this reason that we are able to use both techniques that involve Bounds Testing approach using ARDL and

Johansen (1998) multivariate cointegration using VECM.

For policy making purpose the possible presence of long-run relationships should be of prime interest. This is especially more true in case of Saudi Arabia as having a pegged currency to US dollar leaves the government with few tools to exert control over price inflation.

This study intends to highlight the key factors contributing to the domestic price inflation which should enable the government to tailor their policy accordingly in the appropriate direction.

1.2 Outline of Study

The rest of the paper is organized as follows;

Section 2 Brief review of existing literature.

Section 3 Model specification

Section 4 Data used and methodology employed

Section 5 Background Concepts

Section 6 ARDL Model Approach

Section 7 VECM Model Approach

Section 8 Comparative Analysis of Results

Section 9 Limitations of Study and Suggestions

Section 10 Conclusion

Section 11 References

Section 12 Appendix

2. Literature Review

There is vast amount of literature and economic research on inflation all over the world. Some of the most influential studies include Diz (1970), Vogel (1974), Darrat (1981), Thomas and Akkina (1982), Aljuhani (1990) and Salih (1993). However, it remains a fact that none of these studies is able to fully explain the complex phenomenon of inflation in any economy.

Studies of long-run relationships between non-stationary variables have been widely studies and researched under the pretext of cointegration using testing methods proposed by Clive Granger and Robert Engle in the 1980s. They maintain that two time series series containing unit roots can be considered cointegrated if some form of their linear combination is also stationary. This result has proved very helpful in selecting meaningful regression results in many studies. Despite being heavily emphasized over the last two decades Engle-Granger approach remained with some flaws and drawbacks. Johansen multivariate method emerged as comparatively better choice with good results for testing cointegration, and VEC Granger-causality test to determine the direction of relationships.

A recent study conducted by Hasan and Alogeel (2008) successfully demonstrates the effects of long and short run determinants of inflation in Kuwait and Saudi Arabia. Demand for money is generally believed to raise prices in an economy. An increase in the supply of money in an economy enables more goods to be purchased which increases aggregate demand that in turn raises price levels (Lipsey 1999). Empirical studies carried out by Darrat (1981), Al-Bassam (1990), Nagadi (1985), Al-Juhani (1990) indicate that US dollar interest rate influence demand for money in Saudi Arabia. This shows that US interest rate could affect price levels in Saudi Arabia.

According to Pigou (1949), inflation increases as a result of un-parallel increase in money income as compared to the income earning capacity thereby labeling increase in money stock as the primary cause of inflation. Pigou's views actually turned out into reality in Saudi Arabia which saw enormous increases in oil prices prompting economic growth and increase in money supply which in turn generated demand for money followed by price inflation. Various studies which conclude relationship between money supply growth and inflation include (Iyoha,1973; Keran, 1979; Darrat, 1985; Metin, 1995; Lim and Papi, 1997; Sekine, 2001; Khan and Schimmelpfening, 2006; Bonato, 2007; and Kandil and H.

Morsy, 2009)

Keran and Al-Malik (1979) and in a separate empirical study by Darrat (1981) and Hafiz and Darrat (1983) examine the inflation problem in Saudi Arabia and conclude that world inflation and money supply are the main causes of increase in domestic prices.

Saudi Arabia heavily relies on imported goods. The country is therefore vulnerable to fluctuations in the world price level which in turn impact its domestic inflation (Keran, 1979; Jin, 2000; Kandil and H. Morsy, 2009).

Barry (1980), concludes that during the period 1964 to 1972 excess monetary demand in Saudi Arabia was a result of growth in money supply, government expenditures and imported inflation.

Darrat (1985), bases his study on monetary approach to inflation in Saudi Arabia, Libya, and Nigeria with quarterly data from 1960-1979 and concludes that foreign interest rates and money growth are the main factors responsible for inflation.

Salih (1993), examines the role of the money supply and imported inflation on domestic inflation of Kuwait. His study concludes that money growth, exchange rate and imported inflation play a major role in domestic inflation.

Ghavam Masoodi and Tashkini (2005) and in a separate study Pahlavani and Rahimi (2009) both apply auto regressive distributed lag (ARDL) method to show that GDP, imported inflation, money supply and the exchange rate in Iran are the most significant factors that cause inflation.

Cheung (2009) state that for industrialized and developed countries commodity prices are responsible for inflation which affects commodity export countries comparatively more than the countries which are commodity importers.

Aljibrin (2006) in his study conclude that in oil exporting countries like Saudi Arabia inflation both in the short and long run is caused by growth of money and non-oil GDP whereas oil prices are responsible for inflation in the long run.

Kia (2006) use monetary model to explore internal and external factors including monetary and fiscal policies in Iran which contribute to inflation. He concludes that depreciating

currency in the long run causes price levels to rise whereas in the short run foreign interest rates and fiscal policy have a more profound effect on inflation.

3. Model Specification

Saudi Arabia has a pegged exchange rate with US dollar. This means value of Saudi Riyal and bank interest rates have to shadow US dollar and interest rates dictated by Federal Reserve. The recent depreciation of US dollar has put upward pressure on prices of imported goods especially from countries other than USA which account for 85% of the total imports of the country. The gradual reduction in interest rates by Federal Reserve since 2007 has compelled Saudi Arabian Monetary Authority (SAMA) to cut interest rates accordingly whereas an increase in interest rate was required to tackle rising inflation. The Riyal Dollar peg turned the domestic monetary policy ineffective and coupled with rising international food prices further aggravated the situation that resulted in high inflation.

Inflation is seen as monetary phenomenon and a function of monetary growth in the long run as per quantity theory. Due to the dollar peg SAMA has little control over its monetary policy. As a consequence the recent surge in oil prices and boosted oil revenues lead to increase in money supply with increased aggregate demand in the country causing inflation. Furthermore, Saudi government in an attempt to seek economic self dependence has been increasing spending over the past years. The overall effect of this increased expenditure on inflation is however dependant on the extent to which this expense is utilized to target demand (to increase inflation) as compared to increase in productive capacity (to reduce inflation). In order to avoid multi-colinearity between the variables of study we have analysed two different models.

The first model used in the study is described below;

$$CPI = f(WPI, MS, TWDI, IRED) \dots \dots \dots (A1)$$

Thus:

$$LCPI_t = \alpha_0 + \alpha_1 * LWPI_t + \alpha_2 * LMS_t + \alpha_3 * LTWDI_t + \alpha_4 * IRED_t + \epsilon_t \dots \dots \dots (A2)$$

Where CPI is inflation in Saudi Arabia measured in terms of consumer price index, WPI is the world food price index, MS is broad money supply in the country, TWDI is the trade weighted dollar index, and IRED is the 3 month Euro-Dollar bank interest rate and ϵ_t is the

error term in the form of white noise.

The second model used in the study is described below;

$$\text{CPI} = f(\text{WCI}, \text{MS}, \text{NEER}, \text{IRUS}) \dots \dots \dots \text{(B1)}$$

Thus:

$$\text{LCPI}_t = \alpha_0 + \alpha_1 * \text{LWCI}_t + \alpha_2 * \text{LMSt} + \alpha_3 * \text{LNEER}_t + \alpha_4 * \text{IRUS}_t + \text{et} \dots \dots \dots \text{(B2)}$$

Where CPI is inflation in Saudi Arabia measured in terms of consumer price index, WCI is the world commodity price index, MS is broad money supply in the country, NEER is the nominal effective exchange rate of Saudi Arabia, and IRUS is the 3 month US Treasury Bill interest rate and et is the error term in the form of white noise.

The relationship between these factors could be stated as follows. Money supply increases liquidity and increased demand in the economy which in turn push prices high. Depreciating currency would tend to raise imported inflation irrespective of world price level. Further pressure would be felt by increases in world food or commodity prices. Higher foreign interest rates (3 month Euro-dollar rate or US Treasury Bill rate) would however tend to dampen inflation and price levels in the country.

4. Data and Methodology

All the variables of study are in natural log form except for the interest rate. The data for Saudi Arabia's consumer price index and broad money supply has been taken from annual and quarterly reports of Saudi Arabian Monetary Agency (2012) whereas the nominal effective exchange rate of the country was obtained from Bruegel database. The world food and commodity prices were taken from the database of Food and Agriculture Organisation (FAO) and International Monetary Fund respectively. The 3 month Euro Dollar and US Treasury Bill interest rates and the trade weighted dollar index were obtained from US Federal Reserve Economic Database.

This study is based on the quarterly time series data spanning over the period of January 1999 to December 2012. Broad money (M2) has been used as monetary aggregate (MS), which includes currency in circulation and the demand deposits (narrow money, M1) plus the savings, call deposits and time deposits. The proxy for the domestic price level is the consumer price index (CPI) whereas proxy for the world inflation is the world food price index (WPI) and world commodity price index (WCI). Similarly, the effective exchange rate has been proxied by the nominal effective exchange rate (NEER) and Trade Weighted Dollar Index (TWDI). The proxy for the foreign interest rate is taken as the 3 month Eurodollar deposit rate (IREDD) and 3 month US Treasury Bil rate (IRUS).

In our research we present two approaches to study the long-run relationship between Saudi Arabia's price inflation and its determinants. The first one is the autoregressive distributed lag (ARDL) model introduced by Pesaran and Shin (1999) and Pesaran, Shin, and Smith (1997, 2001) and the second one is the Johansen (1998) and Johansen and Juselius (1990) Maximum Likelihood Cointegration approach.

We apply the Pesaran et al (2001), ARDL model approach on the first model specification;

$$CPI = f(WPI, MS, TWDI, IREDD) \dots \dots \dots (A1)$$

$$LCPI_t = \alpha_0 + \alpha_1 * LWPI_t + \alpha_2 * LMSt + \alpha_3 * LTWDI_t + \alpha_4 * IREDD_t + \epsilon_t \dots \dots \dots (A2)$$

We apply the Johansen (1998) Cointegration model approach on the second model specification;

$$CPI = f(WCI, MS, NEER, IRUS) \dots \dots \dots (B1)$$

$$LCPI_t = \alpha_0 + \alpha_1 * LWCI_t + \alpha_2 * LMSt + \alpha_3 * LNEER_t + \alpha_4 * IRUS_t + \epsilon_t \dots \dots \dots (B2)$$

5. Background Concepts

In this section we introduce some background concepts to the various terms and methods used in the study which include stationarity and unit roots, lag selection, information criteria cointegration, Johansen test of multivariate cointegration, Bounds Test approach.

5.1. Stationarity and Unit Roots

The term stationarity to time series implies that the roots of the lag polynomial lies inside the unit circle and the series has a finite variance and constant mean. In contrast, a nonstationary time series implies that the mean, variance and the covariance of the series change over time. A simple way to analyse a nonstationary time series is to convert the series to a stationary series and apply the Box-Jenkins methodology. The series is converted by differencing until it becomes stationary. If a series is differenced 'k' times prior to its becoming stationary, then the series is regarded as integrated of the order 'k' and denoted as $I(k)$. In other words the same implies that the series contains 'k' number of unit roots.

Time series containing a unit root is regarded as non-stationary. The analysis of stationary time series requires the testing of unit roots in order to avoid spurious regression (Harris, 1995). Many time series in macroeconomic environment such as real exchange rate exhibit non-stationary behavior (Parikh and Kahn, 1997).

There are quite a handful of tests that can be used to test the unit roots in the data, the most famous ones being the Dicky Fuller (1979) test, Augmented Dicky Fuller (ADF) test, Kwiatkowski, Phillips, Phillips Perron test, Schmidt and Shin (KPSS) test. Out of these test the one that has gained considerable importance and is widely used is the Augmented Dicky Fuller test (Barr and Kahn, 1995, Madsen, 1997, Parikh and Kahn, 1997 and Mainardi, 2000). The main reason behind this is that ADF provided stable and reliable results and can handle complex series that the traditionally random walk models fail to address. Another reason could be the fact that ADF can be comparatively easily modeled into computer language and hence its inclusion in many commercial software packages such as Eviews, PcGive, Rats and SAS.

5.1.1 Dicky Fuller Test

The Dicky Fuller test involves testing of a null hypothesis that the series under study is non-stationary. This is tested against the alternative hypothesis that the series is stationary.

In this study, due to its suitability we adopt ADF test for the analysis of our data. Like most of the other econometric tests the ADF test is also sensitive to the lag order being used. It is therefore important to estimate the correct lag order prior to its use to obtain logical and reasonable output. The over inclusion of the number of lags initiates estimation of additional parameters which ends up in reduced degrees of freedom. This in turn reduces the power of the test to detect the unit root ending up in the detection of unit roots for some lags while missing the others. As a priori, since the true order of the autoregressive process is unknown, a reasonable estimate has to be made for the initial start. The strategy normally used for the estimation of the initial order is to randomly choose a relatively larger order of the autoregressive process. This ensures that the inference about the unit root is not biased due to the smaller size of order (Schwert, 1989). On the other hand the selection of excessively large order of the autoregressive process leads to deterioration in the properties of the discrete sample properties of the ADF test (Phillips and Perron 1988).

The second strategy makes use of the data itself to estimate the order of the autoregressive process. This involves the use of Hendry's General-to-Specific approach or information criteria methods such as Hannan and Quinn (1979), Schwarz (1978) and Akaike Dickey and Fuller (1979, 1981) to determine the stationarity of the autoregressive (AR) process. These tests are based on the null hypotheses that the AR process contains one unit root therefore the sum of the autoregressive coefficients is equal to one.

Schwert (1989) levels some criticism of the tests for unit roots developed by Dickey and Fuller (1979, 1981) and state that these tests are sensitive to the assumption that the data are generated by a pure auto-regressive (AR) process. He successfully demonstrated that the results of these tests may give ambiguous results if the underlying data contained moving average (MA) component. Under these conditions the resulting test statistics can be different from the distributions reported by Dickey and Fuller. Schwert (1989), therefore conclude that if the underlying data of the economic time series models contain MA components, Dickey-Fuller (1979, 1981) tests for unit roots may not be appropriate.

The Dickey and Fuller (1979) method is essentially based on the following three single-equation regression models to test for the presence of a unit root:

$$y_t = \alpha y_{t-1} + e_t \dots\dots\dots(1)$$

$$y_t = a + \alpha y_{t-1} + e_t \dots\dots\dots(2)$$

$$y_t = a + \alpha y_{t-1} + bT + e_t \dots\dots\dots(3)$$

Where,

‘y’ is the economic variable and ‘t’ is the time period 1,2,3,4,.....

‘y_{t-1}’ is the first lag of the economic variable with coefficient ‘α’

‘a’ is the intercept or drift

‘T’ is the time trend with coefficient ‘b’

‘e_t’ is the error term or white noise

As can be seen from the three models, the first equation represents a pure random walk model in which there is no intercept or trend. The second equation includes a deterministic element of intercept ‘a’ also called ‘drift’ variable, and the third equation includes two deterministic elements of an intercept term ‘a’ and a linear time trend ‘T’ variable.

In this study we have employed the random walk models without the inclusion of the deterministic elements of intercept or linear time trend variables.

In the Dicky Fuller test the parameter of interest in the coefficient of the first lag variable ‘α’ based on which the inference is made. If α = 0, then the time series is regarded as non-stationary and is believed to contain a unit root. This test involves estimating at least one of the equations above using ordinary least squares (OLS) regression in order to obtain the estimated value of ‘α’ and the associated standard error. The t-test statistic value of the regression equation is then calculated by taking the ratio of the coefficient ‘α’ and the corresponding standard error. The test reports the estimated t-statistic with the appropriate values reported in the table from where we can determine whether to accept or to reject the null hypothesis of α = 0, (non-stationary series). The calculated t-statistics are compared with a set of critical values at 1%, 5% and 10% significance. If the value of estimated t-statistics is less than the Dicky Fuller critical values then we reject the null hypothesis that the model has unit root, meaning that the time series is stationary. If however, the value of t-statistics is greater then we accept the null hypothesis that the time series has unit roots and it is non-stationary. This methodology remains the same and is applicable to all the three forms of the equations. However, it should be noted that the critical values of the t-statistics are sensitive to the inclusion or exclusion of the intercept or

time trend in the regression equation. Dickey and Fuller (1979) state that the critical values for $\alpha = 0$ are influenced by both the form of the regression equation and the sample size whereby increased sample sizes tend to make the value of t-statistics more negative.

5.1.2 Augmented Dicky Fuller Test

Despite its usefulness the traditional Dickey Fuller (1979) test suffered some drawbacks in which the most serious one was the existence of serial correlation or autocorrelation. Autocorrelation occurs when the time series is correlated to its own past values as a result of which the output values of the test may be incorrect and misleading. In order to tackle the issue of autocorrelation in the Dickey-Fuller test there exist two approaches for the modification of the test. The first method is based on the parametric approach also known as the Augmented Dicky Fuller (1981) or ADF test. And the second one is the is non-parametric approach referred to as the Phillip Perron or PP test.

The ADF test is essentially an extension of the traditional Dickey-Fuller test which include an auto-regressive (AR) process of known order containing no more than one unit root. The ADF test is a unit root testing procedure that employs augmented autoregression estimates. The null hypothesis of this test statistic states that the series is non-stationary while the alternative states the series is stationary. The original Dickey Fuller (DF) test assumed that the data are generated by a finite auto-regression model of order ‘N’ and therefore, the test was based on fitting an autoregressive model of the same order. In the ADF an additional term has been augmented to include the option of variable orders as represented in the three models represented below.

$$y_t = \alpha_1 y_{t-1} + \sum_{i=2}^N \beta_i y_{t-i} + e_t \quad \dots\dots\dots(4)$$

$$y_t = a_0 + \alpha_1 y_{t-1} + \sum_{i=2}^N \beta_i y_{t-i} + e_t \quad \dots\dots\dots(5)$$

$$y_t = a_0 + \alpha_1 y_{t-1} + \alpha_2 T + \sum_{i=2}^N \beta_i y_{t-i} + e_t \quad \dots\dots\dots(6)$$

Where,

‘y’ is the economic variable and ‘t’ is the time period 1,2,3,4,.....

' y_{t-1} ' is the first lag of the economic variable with coefficient ' α '

' y_{t-i+1} ' is the augmented variable with coefficient ' β '

' a ' is the intercept or drift

' T ' is the time trend with coefficient ' b '

' e_t ' is the error term or white noise

5.1.3 Phillip Perron Test

As state before an alternative test is the Phillip Perron or PP test. The origins of this procedure for testing of a unit root in a general time series go back to the study proposed by Phillips (1987). Phillips presented a non-parametric technique with respect to the nuisance parameters which enabled it to be applicable to a wide class of time series models containing a unit root. This procedure can be used for ARIMA models with heterogeneously as well as identically distributed innovations. The method offers considerable advantages when there are moving average (MA) components in the time series and, offers an alternative to the Dickey-Fuller procedure.

Phillips and Perron (1988) extend the original Phillips (1987) method to include the cases that also comprise of a drift and/or a linear trend in the specification. From a practical point of views these extensions are considered very important as most real time series contain a non-zero drift. Furthermore, it is not uncommon for an economic time series to contain deterministic linear time trend either along side with a deterministic drift or without a drift. It is therefore important that regression tests for unit roots allow for these possibilities which have been successfully addressed in the PP test.

In this study we have used both ADF test and the PP test to determine the order of integration of each time series of the economic variable under study for the two cointegrated bivariate models.

5.2. Cointegration

It is common to find empirical research in economics based on time series involving stochastic process. This involves extracting statistical inference form the relation building equations between economic variables. The term frequently encountered in analysing time series data is non-stationarity (Wei, 2006). Non-stationary data tends to move randomly

without a clear trend. As stated by (Pfaff, 2006), one major objective of our research is to test hypotheses and estimate relationships derived from economic theory among aggregated variables.

Traditionally large simultaneous equation models involving Ordinary Least Squares (OLS) regression assumed the economic variables to be stationary based on the statistical inference. This assumption is however flawed and it is not applicable to non-stationary processes as it leads to spurious results. In such a situation the results show in error statistically significant relationships between variables even though they are not related at all to each other. This issue has been a constant dilemma for the researchers until the introduction of the concept of “cointegration” by Granger in 1987. The technique of cointegration enables non-stationary stochastic variables to be arranged in a manner that can produce statistically and economically meaningful results. Cointegration represents long-run equilibrium between economic time series that are non-stationary, but a linear combination of them is stationary (Wei, 2006).

In the past data was differenced to convert it to stationary prior to its use in the OLS to test hypotheses of relationship between non-stationary variables. This method is correct for large samples but can give misleading results in samples with small number of observations. The problem further gets compounded in single equations where the use of integrated (non-stationary) data result in non-standard distribution of coefficients, residuals show serial correlation (autocorrelation), multiple cointegrating vectors emerge with weak exogeneity (Banerjee et al., 1993). These drawbacks of running OLS on non-stationary data are to a greater extent resolved by the technique of cointegration and estimation of error correction models (ECM) to establish short-run and long-run relationships among variables. This is more relevant to especially the cases where samples consist of small number of observations. The various methods of cointegration employed in contemporary econometrics are the Engle and Granger (1987) two-step estimation procedure, the Phillips-Ouliaris methods, Johansen (1998) procedure of multivariate cointegration and Bounds Test by Pesaran et al (2001).

In this study our main focus is to estimate the cointegrating models and highlight their use on different sets of data using Bounds Test approach by Pesaran et al (2001) and Johansen approach to multivariate cointegration.

5.3 Engle and Granger Method

Engle and Granger developed and presented the technique of cointegration in 1987. According to Granger's representation theorem, cointegrated variables serve as a link between the moving average, the autoregressive, and the error correcting term in a cointegrated system.

Engle and Granger (1987) further explain the steps required in determining whether the two variables are cointegrated of the same order comprise the following:

- a) Pre-test each variable to determine its order of integration
- b) Estimate the error-correction model (ECM)

According to Johansen (1988) if the variables are found to be integrated to the same order, then it must be tested whether these variables are cointegrated (Johansen, 1988).

5.3.1 Pre-testing of Variables

In the pre-testing phase the intention is to determine the order of integration of each variable. This is done using the Augmented Dickey-Fuller (ADF) unit root test to infer the number of unit roots (if any) in each of the variables under investigation. The testing procedure for the ADF unit root test is applied to the following model

$$\Delta y_t = \alpha + \beta T + \gamma y_{t-1} + \sum_{j=1}^p \delta_j \Delta y_{t-j} + e_{it} \quad \dots\dots\dots(7a)$$

Where ‘ α ’ is constant and ‘ β ’ is coefficient for linear time trend ‘T’

‘ γ ’ is the coefficient for one time period lagged value of economic variable ‘y’.

‘p’ is the lag order

$\Delta y_t = y_t - y_{t-1}$ is the first difference of economic variable

Δy_{t-j} are the changes in the lagged values and ‘ e_{it} ’ is the white noise.

After rejecting the null hypothesis of the unit root test we attempt to estimate the long-run equilibrium relationship in the form of an OLS regression .

$$\Delta y_t = \beta_0 + \beta_1 x_t + e_{it} \quad \dots\dots\dots(7b)$$

where β_0 is the intercept and β_1 is the slope and e_{it} is the error term.

The parameters in equation 7b are estimated from the equation

$$\beta_1 = \frac{\sum (x_t - \bar{x}_t) (y_t - \bar{y}_t)}{\sum (x_t - \bar{x}_t)^2} \dots\dots\dots(8)$$

where \bar{x} and \bar{y}_t are the mean of x_t and y_t respectively

The value of β_0 is however estimated from the equation;

$$\beta_0 = \bar{y}_t - \beta_1 \bar{x} \dots\dots\dots(9)$$

The estimated regression line then takes the form;

$$\hat{y} = \beta_0 - \beta_1 x \dots\dots\dots(10)$$

Enders (2004) state that if the variables cointegrate then the equation (10) gives super consistent estimators, which is indicates of strong linear relationship among the variables which can be tested in by adopting one of the following ways.

- (a) The value of β_1 falls between 0.5 and 1
- (b) The plot of x_t and y_t show coordinates in increasing or decreasing order

For testing integration, we test for unit roots on the residual sequence in the equation (7b) using the ADF test. The residual sequence, denoted by e_{it} represents a series of estimated values of the deviation from the long-run relationship which in turn is estimated from;

$$e_t = y_t - \bar{y}_t \dots\dots\dots(11)$$

where \bar{y}_t is predicted equation (10).

Testing for unit roots on residuals aims at determining whether these deviations are stationary or not. If they are stationary, then the series cointegrate. If the residuals are not stationary, there is no cointegration. The ADF test is performed on the following model

$$\Delta \hat{e}_t = a_1 \hat{e}_{t-1} + e_t \dots\dots\dots(12)$$

where $\Delta \hat{e}_t$ is the estimated first difference residual, and a_1 represents slope of the line and e_t are errors obtained in fitting both differenced residuals.

Since the e_t is the residual from a regression equation, it is not necessary to include the

intercept term in equation (12). In order to test the hypothesis on a_1 to determine whether the residuals are stationary, proceed as follows;

(i) Set both the null and alternative hypothesis as

$$H_0 : a_1 = 0 \dots\dots\dots (13)$$

$$H_1 : a_1 < 0 \dots\dots\dots (14)$$

(ii) Determine the test statistic using

$$F_{\hat{a}_1} = \hat{a}_1 / SE(\hat{a}_1) \dots\dots\dots (15)$$

where the value of $SE(\hat{a}_1)$ is the standard error of \hat{a}_1

(iii) Compare the calculated test statistic in equation (15) with the critical value from the Dickey-Fuller table in order to decide whether to accept or not to accept the null hypothesis.

(iv) If $F_{\hat{a}_1}$ is greater than the critical value, we accept the null hypothesis, H_0 .

The rejection of the null hypothesis H_0 implies that the residuals are not integrated or they are stationary. This further implies that the variables under study have a long-run relationship and are cointegrated.

Following the above we move on to the next step of estimating an error correction model (ECM) which we present in the following section.

5.3.2 Error Correction Model

An error correction model (ECM) is essentially a dynamic model in which the changes observed in a variable in any period of time are related to the previous period's deviation from the long-run equilibrium. Despite the fact that it is possible to estimate the long-run cointegrating relationship, represented in the form of $y_t = \beta x_t + e_t$ in practice the economic systems are seldom found to be in equilibrium. This is because they are often influenced by transitory or permanent institutional and/or structural changes. As the long-run equilibrium is rarely observed therefore it makes it more important to focus on short term dynamics and thereby the resulting short-run adjustments.

However, the short-run models are often associated with problems some of which are summarized below;

i) Multicollinearity: This term is used when the variables are exhibit high correlation with each other.

ii) Spurious correlation: This term is used when in actual practice there is no causal relation between the variables but the results show them highly correlated which is due to the influence of a third unseen factor.

These problems are solved by the introduction of an error-correction mechanism (ECM) formulation of the dynamic structure. In our study we set up the ECM of the following form:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^N \alpha_{1,i} \Delta y_{t-i} + \sum_{i=0}^N \alpha_{2,i} \Delta p_{t-i} + \sum_{i=0}^N \alpha_{3,i} \Delta q_{t-i} + \sum_{i=0}^N \alpha_{4,i} \Delta r_{t-i} + \sum_{i=0}^N \alpha_{5,i} \Delta s_{t-i} + \lambda ECT_{t-1} + e_t \dots\dots\dots(16)$$

Where, the coefficient ‘ λ ’ is the speed of adjustment with values of in between 0 and -1.

We can make the following interpretation from the estimated values of ‘ λ ’,

- Smaller values approaching -1 show high speed of adjustment towards equilibrium
- Larger values approaching 0 show slow speed of adjustment towards equilibrium
- Extremely small values eg. -2 show overshooting of economic equilibrium
- Positive values would indicate divergence from long-run equilibrium path

ECT is the error correction term comprised of the residuals that are obtained from the estimated cointegration model of general equation (17) stated below;

$$\Delta y_t = \alpha_0 + \sum_{i=1}^N \alpha_{1,i} \Delta y_{t-i} + \sum_{i=0}^N \alpha_{2,i} \Delta p_{t-i} + \sum_{i=0}^N \alpha_{3,i} \Delta q_{t-i} + \sum_{i=0}^N \alpha_{4,i} \Delta r_{t-i} + \sum_{i=0}^N \alpha_{5,i} \Delta s_{t-i} + \beta_1 y_{t-1} + \beta_2 p_{t-1} + \beta_3 q_{t-1} + \beta_4 r_{t-1} + \beta_5 s_{t-1} + e_t \dots\dots\dots(17)$$

The error correction term (ECT) can therefore be written as;

$$ECT_t = y_t - \gamma_1 p_t - \gamma_2 q_t - \gamma_3 r_t - \gamma_4 s_t + e_t \dots\dots\dots(18)$$

Where; $\gamma_1 = -(\beta_2 / \beta_1)$, $\gamma_2 = -(\beta_3 / \beta_1)$, $\gamma_3 = -(\beta_4 / \beta_1)$, $\gamma_4 = -(\beta_5 / \beta_1)$ are the coefficients

of ordinary least squares (OLS) obtained from equation 17.

The error correction model (ECM) is based on the following assumptions;

- Regression model is linear
- Normally distributed residuals
- Residuals without serial correlation
- The number of observations must not exceed the number of parameters to be estimated.
- Variables are not perfectly multi-collinear

Due to the above assumptions it becomes incumbent that the model is tested that the underlying assumptions are not violated. The tests normally conducted to achieve this are stated below;

- Normality test
- Heteroscedasticity test
- Serial correlation test
- Functional form or test for mis-specification

5.3.2.1 Normality test

The test most commonly used to test the normality of residuals is Jacque-Bera test which confirms whether the ECM is normally distributed or not. This method takes into account the difference in kurtosis and skewness of a variable compared to those of the normal distribution (Jarque and Bera, 1980).

In the Jacque-Bera test, we set the null and alternative hypothesis as follows:

H0: The variable is normally distributed.

H1: The variable is not normally distributed.

The test statistic is

$$JB = (N - K / 6) (S^2 + (K - 3)^2 / 4) \dots\dots\dots(19)$$

where N is the number of observations, k is the number of estimated parameters, S is the skewness

of a variable, and K is the kurtosis of a variable.

We reject the null hypothesis if the p-value is less than or equal to the level of significance of if the JB is greater than $\chi^2 (2)$.

5.3.2.2 Heteroscedasticity test

Heteroscedasticity emerges as a result when the sequence of random variables differ in variances. This simply means that during regression analysis the variance was found non-consistent.

In order to test for Heteroscedasticity we employ Lagrange Multiplier, also known as Engle's Arch LM test (Engle, 1982). The test is performed in the following sequence;

Test for Null Hypothesis

H0: There is no heteroscedasticity.

H1: There is heteroscedasticity.

The test statistic is stated as below;

$$LM_E = nR^2 \dots\dots\dots(20)$$

where 'n' is the number of observations, and R^2 is the coefficient of determination of the augmented residual regression. We reject the null hypothesis if the probability value is less than or equal to the level of significance and conclude that the presence of heteroscedasticity in the model.

5.3.2.3 Serial correlation test

Serial correlation also called autocorrelation is the cross-correlation of a variable with itself. Autocorrelation can result from a number of factor which include;

- nonstationarity of dependent and explanatory variable
- data manipulation (averaging, interpolation and extrapolation)
- incorrect functional form.

Ljung and Box (1978) suggested the use of Ljung-Box test to test the assumption that the residuals contain no autocorrelation up to any order k. The test procedure is as follows:

H0: There is no autocorrelation up to order k.

H1: Autocorrelation exists up to order k.

The test statistic is

$$Q_{LB} = T(T + 2) \sum_{j=1}^n r_j^2 / (T - j) \dots\dots\dots(21)$$

where T is the number of observations, 'n' is the highest order of autocorrelation for which to test,

and r_j^2 is the jth autocorrelation.

The null hypothesis is rejected if the p-value is less than or equal to the level of significance and conclude that there is autocorrelation up to the order of 'n'. The problem however facing the use of this type of test is in deciding the appropriate lag order (n). Ljung and Box (1978) suggested the maximum number of lags to use should be $T^{1/3}$ where T is the number of observations.

5.3.2.4 Mis-specification Test or Function Form Test

Misspecification can result due to a number of reasons which include the following;

- incorrect functional form
- inclusion of irrelevant variables
- exclusion of relevant variables.

Due to the mis-specification the regression results could end up in showing the following symptoms;

- Residuals not normally distributed
- Signs of serial correlation
- Regression results not matching the actual working of the economy
- Estimated parameter estimates are not robust

In order to test for any mis-specification in the regression model, Ramsey (1969) proposed the use of Ramsey's reset test. This test basically is based on likelihood test criteria that compares the likelihood function of original regression against an augmented regression.

5.1.3 Limitations of the Engle-Granger Method

Despite the fact that the Engle and Granger procedure is very useful and is easy to apply, it has several drawbacks.

a) The test requires the presence and distribution of variables on both sides of the equation to establish the long-run equilibrium regression. The independent variable or explanatory variable is placed on the right hand side while the dependent variable or exploratory variable on the left hand side of the model equation.

As demonstrated below that in the case of two variables, the Engle-Granger method can be used for cointegration by using the residuals from any of the following two regression equations.

$$y_t = \beta_{10} + \beta_{11} x_t + e_{1t} \dots\dots\dots(22)$$

$$x_t = \beta_{20} + \beta_{21} y_t + e_{2t} \dots\dots\dots(23)$$

But the problem comes when the sample size grows infinitely large. The test for a unit root in the residual e_{1t} of the first equation becomes equivalent to the test for a unit root in the residual e_{2t} of the second equation. The properties of large samples on which this result is derived does not match sample sizes usually available to economists. In general the available sample sizes are available to economists are much smaller than the required sample size assumed in the theory.

b) In the two-step estimation it is assumed that the same results will be attained if the variables are interchanged with each other in the analysis and irrespective of the chosen variable for normalisation.

But in actual practice this may not be true. As it is quite possible that the result of one regression indicate that the variables are cointegrated whereas reversing the order may indicate no cointegration at all. The test therefore suffers with this problem because ideally any test for cointegration should be indifferent to the choice of variable for the process of normalization.

c) Engle-Granger's procedure essentially involves a two-step estimator. The error correction term involving long-run coefficients derived from the first step is used as a regressor in the second step to estimate the short-run dynamics. In other words the coefficient in the regression model is obtained by estimating a regression equation using residuals from another regression. As a result should there exist any error in the first step, it will automatically get passed over into the second step, making the results unreliable.

This problem of passing over of error from one step to the other can be successfully dealt with by using several methods that could avoid these defects. These methods include the Phillip-Ouliaris methods, Johansen's procedure, and the Stock and Watson maximum likelihood estimators. These tests rely to a great extent on the relationship between the rank of a matrix and its characteristic roots. They are flexible to use and provide the option to use the restricted versions of cointegrating vectors and the speed of adjustment parameters.

5.5 Johansen Multivariate Cointegration Test

Johansen's procedure is a vector cointegration test method. It is comparatively better choice over the Engle-Granger and the Phillips-Ouliaris methods in the sense that it can estimate more than one cointegration relationships in case the data set contains more than one time series. It builds its base of cointegrated variables onto the maximum likelihood estimation instead of relying on OLS estimation. It takes into consideration the relationship between the rank of a matrix and its characteristic roots. The derivation of the maximum likelihood estimation use sequential testing for determining the number of cointegrating vectors. Although, Johansen's procedure is an innovative approach it can nevertheless be regarded as a multivariate generalisation of process involved in the Dickey-Fuller test. The two likelihood ratios proposed by Johansen include;

5.5.1 Trace Test

In the Trace test the null hypothesis of 'r' cointegrating vectors is tested against the alternative hypothesis of 'n' cointegrating vectors. The test statistic are listed below;

$$J_{\text{trace}} = -T \sum_{i=r+1}^n \ln(1 - \hat{w}_i) \dots\dots\dots(24)$$

5.5.2 Maximum Eigenvalue Test.

In the maximum eigenvalue test tests the null hypothesis of r cointegrating vectors is tested against the alternative hypothesis of (r+1) cointegrating vectors. Its test statistics are listed below;

$$J_{\text{max}} = -T (1 - \hat{w}_{r+1}) \dots\dots\dots(25)$$

5.5.3 Limitations of Johansen Approach

Johansen's approach bears some weaknesses and drawbacks some of which are highlighted below.

The underlying assumption of Johansen approach is that the cointegrating vector remains constant during the period of study. In actual practice it is quite possible that the long-run relationships between the underlying variables may change over the course of time. There can be various reasons for this such as innovations in technology, economic meltdown, changes in demographics, people's lifestyle and preferences, policy or regime change and institutional developments. This is particularly more relevant in the case when the sample period is much longer. This issue has been taken into account by the studies carried out by Gregory and Hasen (1996), who propose tests for cointegration with one and two unknown structural breaks which are outside the scope of this study.

Despite the fact that Johansen approach is comparatively more advantageous as compared to the traditional Engle and Granger approach, the Johansen method itself suffers from some deficiencies. One of the limitations is that Johansen makes use of VAR systems. The VAR system treats all the variables symmetrically in the form of endogenous variables. As a result the output from Johansen's is complicated and not easy to interpret especially in terms of exogenous and endogenous variables. The second limitation is that in this method all the variables are modeled simultaneously. This can cause problems if any one of the variables is inappropriate and contains faults. For instance the underlying VAR may contain bias. In order to resolve this, one could put conditions on the faulty variable instead of having the unrestricted model. Furthermore, there is no doubt that a multidimensional VAR system consumes many degrees of freedom (Sørensen, 1997).

Another drawback is that the Johansen method is inefficient with regards to its transitivity property. It can fail to find a cointegrating relationship between two variables, that are not directly cointegrated with each other but through the fact that both are cointegrated with a third variable.

The Johansen method also bears sensitivity to the model specification of the VECM. The choice of deterministic components in the model can alter the output results considerably rendering the output unreliable. A simple decision therefore to include or exclude a linear trend component can turn a good model into an unfavorable one (Ahking 2002).

5.6 Vector Error Correction Granger Causality Test

The study of causal relationships between different time series generally involves two strategies as put forward by Kirchgässner and Wolters (2007). The first one is the bottom up

approach assuming that time series are formed independently without any link to each other. Granger (1969) further developed this strategy by applying causality test and attempted to find out the existence of any specific cases of time series that may be related to each other. The other one is the top down strategy whereby it is assumed that the generating process is dependent on each other and as a result the exercise is to find out whether some specific time series are generated independently.

4.3.5.1 Bottom Up Approach

Granger (1969) states that the causality between two weakly stationary time series of say x and y follow the sequence: 'x' Granger cause 'y' if and only if the relationship of an optimal linear prediction function leads to the following equation;

$$\sigma^2 (y_{t+1} | I_t) < \sigma^2 (y_{t+1} | I_t - \bar{x}_t) \dots\dots\dots (26)$$

Where I_t represents the information set that includes the two time series of X and Y, available at time t.

\bar{x}_t is the set of all present and past values of 'x' and where $\bar{x}_t = (x_t, x_{t-1}, \dots, x_{t-k})$

The term $\sigma^2 (\cdot)$ represents the variance of the relevant forecast error which indicates that the future value of 'y' could be predicted better within the current and past values of x available and with a smaller forecast error variance

Sargent (1976) derives the direct bivariate Granger procedure which is a simple procedure for testing the causality directly from Granger's definition of causality. This involves regressing two stationary variables, x and y, using the following equations:

$$Y_t = \sum_{i=1}^p \alpha_i y_{t-i} + \sum_{i=1}^p \beta_i X_{t-i} + U_t \dots\dots\dots (27)$$

$$X_t = \sum_{i=1}^p \delta_i y_{t-i} + \sum_{i=1}^p \gamma_i X_{t-i} + V_t \dots\dots\dots (28)$$

In order to find out whether X Granger causes Y a Wald test is used to test whether all of the lagged values of X in the Y equation are simultaneously equal to zero.

If the condition $\sum \beta \neq 0$ exists then we conclude that X Granger causes Y;

If the condition that both $\sum \delta \neq 0$ and $\sum \beta \neq 0$ is valid then it is concluded that there exists a bi-directional causality between Y and X.

The simple Granger procedure described above can easily be extended to a tri-variate model because it is possible that a third variable could affect the variables under consideration. If the information set represented by 'I_t' also contains the past information on a third variable 'Z' in addition to \bar{X}_t and \bar{Y}_t then the null hypothesis of X does not cause Y conditional on Z could be tested with a Wald test in a model where Y depends on lagged values of Y and Z.

6. ARDL Model Approach

Autoregressive Distributed Lag Model (ARDL) offers quite a few advantages (Pesaran and Shin 1997, Caporale and Chui, 1999, Catao and Falcetti, 2002, Shrestha, 2002) which are not possible with other cointegration techniques like Engle and Granger (1987) residual based approach and Johansen and Julius (1990) and Johansen (1992) maximum likelihood-based approach. First of all it does not require the pre-testing of unit roots. Second it can be applied on a mix of integrated data composed of variables integrated at I(0) or I(1). Third it can handle exogenous variables (Pesaran and Shin, 1997). Fourth, the short-and long-run relationships can be obtained by applying OLS to ARDL with an appropriate lag length. Fifth it gives better estimates for small samples (Danica Unevska, 2007).

Following Pesaran et al. (1997, 2001), an ARDL representation of equation (A2) can be written as:

$$\Delta LCPI_t = \alpha_0 + \sum_{i=1}^N \alpha_{1,i} \Delta LCPI_{t-i} + \sum_{i=0}^N \alpha_{2,i} \Delta LWPI_{t-i} + \sum_{i=0}^N \alpha_{3,i} \Delta LMS_{t-i} + \sum_{i=0}^N \alpha_{4,i} \Delta LTWDI_{t-i} + \sum_{i=0}^N \alpha_{5,i} \Delta IRED_{t-1} + \beta_1 LCPI_{t-1} + \beta_2 LWPI_{t-1} + \beta_3 LMS_{t-1} + \beta_4 LTWDI_{t-1} + \beta_5 IRED_{t-1} + e_t$$

.....(A3)

Where, Δ is the first difference operator, 'L' represents natural log operator, ' α_0 ' is the constant or drift component, and ' e_t ' is the white noise and 'N' is the number of observations and 't' is the time period. The coefficients β_1 to β_5 represent the long run relationship and α_1 to α_5 represent the short run impacts.

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6.1 Methodology: ARDL Model

The procedure for ARDL approach essentially involves four steps which include empirical testing of a) Stationarity of data, b) Cointegration between variables (for long-run and short-run dynamics) and c) Diagnostic Tests to check the overall condition of the research model. The diagnostic tests include tests for serial correlation, heteroskedasticity, normality of residuals and stability tests including tests for functional form/omitted variables and recursive estimates of residuals.

6.1.1 Stationarity

The first step in ARDL approach is to determine the non-stationarity of the data by determining the order of integration of each variable under study. The ARDL technique is not applicable if the order of the integration of the variables is greater than one. The checking for non-stationary data is crucial from another point of view is that it helps in avoiding spurious regression results, a problem often associated with the use of non-stationary data. Most commonly used methods to test for integration of data are Augmented Dicky Fuller (ADF) test and the Phillip Perron (PP) test which are essentially unit root tests. The major difference between PP and ADF test is that latter allows autocorrelation of the residuals. However, both tests often give similar and identical results. These tests involve testing of null hypothesis that the time series is integrated to the order of one (or non-stationary), usually denoted by I(1), against the alternative hypothesis, that the time series is stationary, denoted by I(0).

6.1.2 Cointegration: Long-Run Dynamics

In the second step we apply Bounds Test approach developed by Pesaran et al. (2001) to find out whether a long run relationship (cointegration) exists between the research variables. This approach essentially is based on Wald Test or F- statistics applied to Equation (A3) which involves testing the null hypothesis of no cointegration between the long run variables represented by the assumption $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$. This is then tested against the alternative hypothesis of cointegration represented by the assumption $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$

Since the Wald Test is sensitive to the order of lag we use Akaike Information Criteria (AIC) or Schwarz Bayesian Criteria (SBC) alongside the criteria for serial correlation

through LM autocorrelation test in order to establish the optimum lag length. The F-statistics calculated by the Wald Test is then compared against the two sets of critical values (lower bound and upper bound) provided by Pesaran et al. (2001) corresponding to the number of variables used and number of test observations. The lower bound critical value assumes that all the variables in the ARDL model are integrated at level (or I(0)), and the upper bound critical value assumes that all variables are integrated to the order of 1 (or I(1)). The null hypothesis of no cointegration is rejected if the value of calculated F-statistics is significant at 5% and greater than the relevant upper bound critical values. If however, the calculated F statistics is below the lower bound then the null hypothesis cannot be rejected which means there is lack of cointegration. If the values of F-statistics fall in between the lower and upper bounds then the test results are inconclusive and another method to test cointegration would be required. It is worth mentioning here that critical values suggested by Pesaran (2001) are applicable to large samples with number of observation greater than 500 (Narayan, 2004). Since our data is small and observations limited to approximately 52 we make use of critical values proposed by Narayan (2004) which are suitable for smaller size sample data in the range of 30 to 80 observations.

6.1.3 Cointegration: Short-Run Dynamics

In the third step we develop an unrestricted error correction model (UECM) based on the assumption made by Pesaran et al. (2001) to show the short-run dynamics between the study variables.. The error correction version of the ARDL model pertaining to the equation (A3) can be expressed as:

$$\Delta LCPI_t = \alpha_0 + \sum_{i=1}^N \alpha_{1,i} \Delta LCPI_{t-i} + \sum_{i=0}^N \alpha_{2,i} \Delta LWPI_{t-i} + \sum_{i=0}^N \alpha_{3,i} \Delta LMS_{t-i} + \sum_{i=0}^N \alpha_{4,i} \Delta LTWDI_{t-i} + \sum_{i=0}^N \alpha_{5,i} \Delta IRED_{t-i} + \lambda ECT_{t-1} + et \dots\dots\dots(A4)$$

Where, the coefficient ‘ λ ’ is the speed of adjustment and ECT is the error correction term comprised of the residuals that are obtained from the estimated cointegration model of equation (3). The error correction term (ECT) can therefore be written as;

$$ECT_t = LCPI_t - \gamma_1 LWPI_t - \gamma_2 LMS_t - \gamma_3 LTWDI_t - \gamma_4 IRED_t + et \dots\dots\dots(A5)$$

Where; $\gamma_1 = -(\beta_2 / \beta_1)$, $\gamma_2 = -(\beta_3 / \beta_1)$, $\gamma_3 = -(\beta_4 / \beta_1)$, $\gamma_4 = -(\beta_5 / \beta_1)$ are the coefficients of ordinary least squares (OLS) obtained from equation 3.

The coefficients of the differenced lagged variables (α) provide the short run dynamics where as the coefficient ‘ λ ’ of the lagged error correction term represent the speed of adjustment to equilibrium under transient short term disturbances. The value of ‘ λ ’ is expected to fall between zero and -1 and implies the existence of cointegration.

6.1.4 Diagnostic Testing

In the final stage we check the performance of the model by conducting a series of diagnostic tests which include tests for serial correlation, heteroskedasticity, normality and stability tests comprising functional form and recursive estimates. The serial correlation between the variables is checked by Breusch-Godfrey’s Lagranges Multiplier (LM) test for auto-correlation (χ^2_{AUTO}), For heteroskedasticity we employ Breusch-Pagan Godfrey’s ARCH test (χ^2_{ARCH}) along with White’s test (χ^2_{WHITE}). The normality of residuals is checked by Jarque Bera test (χ^2_{NORM}). For stability of the model, we employ Ramsey’s regression specification test (χ^2_{RESET}) to check the function form as a result of omitted variables. Further stability checks are employed by recursive estimates of residuals using cumulative sum of recursive residuals (CUSUM) and cumulative sum of square of residuals (CUSUMSQ).

6.2 Empirical Results: ARDL Model

6.2.1 Stationarity: ADF and PP Tests

In order to check the non-stationarity of the variables we have employed both tests ADF and PP at level and at first difference of the variable. The tests further include options for intercept and intercept and trend for both level and first difference variables.. As the test results are sensitive to the lag length being used, we can determine the optimum lag length using a model selection procedure based on the Schwarz Bayesian Information Criterion (SBC) or the Akaike Information Criteria (AIC). In this study we employ AIC criteria for optimum lag selection as it gives smaller standard error (Pesaran and Pesaran 1997, Sherestha, 2006, Aalexioou and Toro, 2006). The statistical results to check the stationarity of the data with ADF and PP tests are reported in Table A1 with chosen selection marked with ‘*’, ‘**’ and ‘***’ respective to 1%, 5% and 10% significance. Both tests ADF and

PP conclude that all variables are stationary (I(0)) at the first difference level.

The ARDL technique proposed by Pesaran et al (2001) allows use of mixed integrated data of I(0) and I(1) data, Johansen multivariate technique using VECM required all data to be integrated at the same level. Since all our variables are integrated I(1) as shown in Table A1 we able to proceed with the ARDL model approach to find out the long and short term relationships between the study variables.

6.2.2 Cointegration: Long-Run Dynamics

6.2.2.1 Lag Selection

Once the order of integration is established we start the ARDL procedure by first estimating the F-statistics using Wald Test assuming the same number of lags of the first differenced variables in equation (A3). The test results are very sensitive to the lag length being employed (Bahmani-Oskooee & Brooks, 2007). We therefore use SBC and AIC criteria to select the optimum lag. In order to further confirm the test results we employ additional Lagranges's Multiplier (LM) test which is based on the null hypothesis of the absence of serial correlation in the residuals. The LM test gives Chi Square statistics for each individual lag with relevant probability values. The chosen lag length is the one with probability values greater than 5% (least significant) which correspond to the absence of serial correlation in the residuals. The test results for the optimum lag selection are given in Table A2. Based on these test results AIC criteria recommends lag 4 but with marginal probability for LM test. We therefore select lag 5 as it has higher LM probability values indicating less likelihood of containing serial correlation in the residuals.

Table A1: ADF and PP Unit Root Test Results

RESULTS OF AUGMENTED DICKY FULLER TEST				
VARIABLES	LEVEL		FIRST DIFFERENCE	
	INTERCEPT	INTERCEPT AND TREND	INTERCEPT	INTERCEPT AND TREND
LCPI	4.568	-1.470	-2.500	-3.525**
LWPI	-0.265	-2.604	-4.276*	-4.213*
LMS	1.250	-2.580	-5.770*	-5.880*
LTWDI	-0.746	-2.076	-5.330*	-5.278*
IRED	-0.079	-0.907	-4.30*	-4.30*
RESULTS OF PHILLIPS PERRON TEST (NEWLY WEST BANDWIDTH AND BARTLETT KERNEL)				
VARIABLES	LEVEL		FIRST DIFFERENCE	
	INTERCEPT	INTERCEPT AND TREND	INTERCEPT	INTERCEPT AND TREND
LCPI	2.356	-1.340	-2.230	-3.66**
LWPI	-0.499	-2.910	-3.795*	-3.656**
LMS	1.117	-2.574	-5.780*	-5.900*
LTWDI	-0.871	-2.409	-5.118*	-5.051*
IRED	-0.730	-1.500	-4.257*	-4.27*
*, **, *** refer to marginal significance at 1%, 5% and 10%				

Table A2: Optimum Lag Selection Test Criteria Results

Lag No	AIC	SC	LM TEST	PROB
1	-18.536	-17.399*	47.047	0.005
2	-19.025	-16.942	43.173	0.013
3	-19.229	-16.198	16.215	0.908
4	-19.254*	-15.277	31.829	0.163
5	-18.938	-14.014	16.236	0.908*
* Lag selection by respective criteria. Bold figures show selection based on LM test				

6.2.2.2 Wald Test

Following the selection of optimum lag, the existence of long-run relationship between the

variables of study in Equation (A3) is estimated by performing an OLS regression. We then proceed to estimate the F-statistics by conducting a Wald Test. This is done by imposing a restriction of being equal to zero to the coefficients of the one period lagged level variables. The test results are stated in Table A3. The calculated F-statistics is then compared against the critical values given by Pesaran et al (2001) if the sample size is larger than 500 observations. For smaller size samples ranging between 30 to 80 observations it is more appropriate to use critical values presented by Narayan (2004). Since our sample size is 52 observations we choose to follow the critical values proposed by Narayan (2004) that are included in Table A4.

Table A3: Wald Test Results

Wald Test:			
Test Statistic	Value	df	Probability
F-statistic	4.928864	(5, 16)	0.0064
Chi-square	24.64432	5	0.0002

Table A4: Critical Values for Wald Test at 5% Significance

Reference	Lower Bound	Upper Bound
Narayan (2004) Case II, (k=5, n=50)	2.67	3.781
Pesaran et al (2001) Table C1(i) Case 1	2.14	3.34

k = no of variables and n = no of observations

It is evident from the test results of Table A3 that the value of the estimated F-statistics of

4.92 is significant at 99% confidence level and greater than the critical upper bounds values of 3.781 and 3.34 as proposed by Pesaran et al (2001) and Narayan (2004) respectively as stated in Table A4. This suggests strong evidence of long-run relationship or cointegration between the studied economic variables.

6.2.2.3 Parsimonious Model

After the confirmation of cointegration with Wald Test, it is prudent to seek for a parsimonious model related to the long-run inflation using Akaike Information Criteria where the lag length for each variable can have a different value. The recommendations of Pesaran and Shin (1997) and Narayan (2004) for maximum order of lags in the ARDL approach is two for annual data and four for the quarterly data. As this study is based on quarterly data we decide to employ 5 lags to avoid serial correlation in our analysis to estimate ARDL(p, q, r, s, t). The total number of regressions to be estimated are $(N+1)^k$ where 'N' is the maximum number of lag order 'k' is the number of variables in the equation. In our equation N=5 and k=5 making total number of regressions equation to be estimated is 7776. For this purpose we use PcGive v13.3 software program from Oxmetrics from which we obtain the parsimonious model of ARDL(5,0,3,0,5) relevant to Equation (A3) using 5 lags for the price inflation based on AIC criteria. The equation thus obtained for the parsimonious model is stated below;

$$\begin{aligned} \text{DLCPI} = & C(1)*\text{DLCPI1} + C(2)*\text{DLCPI2} + C(3)*\text{DLCPI5} + C(4)*\text{DLMS3} + C(5)*\text{DIRED} + \\ & C(6)*\text{DIRED3} + C(7)*\text{DIRED5} + C(8)*\text{LCPI1} + C(9)*\text{LWPI1} + C(10)*\text{LMS1} + \\ & C(11)*\text{LTWDI1} + C(12)*\text{IRED1} \dots\dots\dots (A6) \end{aligned}$$

We once again perform ordinary least square regression on this model and state the summary of results for the long-run coefficients normalised to the lagged value of CPI in Table A5. The coefficients of world food price index, domestic broad money supply, trade weighted dollar index and 3 month Eurodollar interest rate all have the expected sign as suggested by economic theories and are statistically significant. The long-run model of Equation (A2) for the price inflation can thus be re-written as;

$$\text{LCPI}t = 0.5*\text{LWPI}t + 0.179*\text{LMS}t - 0.57*\text{LTWDI}t - 0.02*\text{IRED}t \dots (A7)$$

The results confirm that in the long run there is positive pressure on Saudi Arabia's inflation rate due to positive trends in world food prices/inflation and domestic money

supply. Appreciation in the value of Saudi Riyal (or US\$) and increases in foreign interest rate, however, tend to exert a negative pressure thereby reducing domestic prices and inflation. The results show that changes in exchange rate and world food price have comparatively more impact on domestic price inflation in Saudi Arabia followed by money supply and to a lesser extent by interest rate.

Table A5: OLS Regression Results of Equation (3), ARDL(5,0,3,0,5)

Long Run Coefficients		Normalised to LCPI1
LCPI1**	-0.045	
LWPI1**	0.022	0.500
LMS1*	0.008	0.179
LTWDI1**	-0.026	-0.570
IREDD1***	0.001	0.020

*, **, *** refer to marginal significance at 1%, 5% and 10%

6.2.3 Cointegration: Short-Run Dynamics

The short-run behavior of the variables is estimated by including an Error Correction Term (ECT) as represented by Equation (A4). Any variable that undergoes short lived changes or shocks tend to disturb the long-run equilibrium. These disturbances however decay with the passage of time and the long-run equilibrium is reinstated. The speed with which this equilibrium returns to its original position is captured by the coefficient of the first lagged period value of the Error Correction Term (ECT). Once again we make use of the PvGive v13.3 software to obtain a parsimonious model from Equation (A4) using 5 lags to determine the short-run dynamics. The model proposed by the software is ARDL(3,2,3,1,5) as represented in Equation A8 below;

$$DLCPI = C(1)*DLCPI1 + C(2)*DLCPI2 + C(3)*DLCPI3 + C(4)*DLWPI2 + C(5)*DLMS3 + C(6)*DLTWDI1 + C(7)*DIRED + C(8)*DIRED5 + C(9)*ECT1.....(A8)$$

We then run the OLS regression on this parsimonious model and report the results in Table A6. The results show that the estimated lagged error correction term (ECT1) is negative and statistically significant which confirms the existence of long run relationship between the variables. The absolute value of the error correction term is 0.024 which means that

only 2.4% of the deviation of the long run equilibrium of price inflation returns to its equilibrium value in one time period of a quarter year. This speed of adjustment is very slow as it would take nearly 10 years to return to its original equilibrium position.

Table A6: OLS Regression Results of Equation (4), ARDL(3,2,3,1,5)

Dependent Variable: DLCPI		Method: Least Squares			
Sample (adjusted): 2000Q1 2012Q4		Included observations: 52 after adjustments			
Variable	Coefficient	Std. Error	t-Statistic	Prob.	
DLCPI1	0.491	0.122	4.030	0.000	
DLCPI2	-0.620	0.136	-4.546	0.000	
DLCPI3	0.291	0.109	2.658	0.011	
DLWPI2	0.026	0.009	2.812	0.008	
DLMS3	0.079	0.020	3.867	0.000	
DLTWDI1	-0.031	0.017	-1.832	0.074	
DIREDD	-0.003	0.001	-2.609	0.013	
DIREDD5	-0.003	0.001	-2.773	0.008	
ECT1	-0.024	0.006	-4.205	0.000	
R ² = 0.841		R ² adj = 0.81	F = 23.59 (0.0)	SE=0.004	DW=2.081

6.2.4 Diagnostic Tests: ARDL Model

In the final stage we check the suitability of the resulting parsimonious model with a series of diagnostic tests which include Breusch-Godfrey's Lagranges Multiplier (LM) test for auto-correlation (χ^2_{AUTO}), Jarque Bera test for normality (χ^2_{NORM}), Breusch-Pagan Godfrey's ARCH tests for heteroskedasticity (χ^2_{ARCH}) along with White's test (χ^2_{WHITE}) and Ramsey's regression specification test (χ^2_{RESET}) to check the function form as a result of omitted variables. The relevant diagnostic test results are shown in Table A8 whereas a summary of the short and long run coefficients is included in Table A9.

Table A8: Diagnostic Test Results of ECM

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.323623	Prob. F(5,36)	0.8954
Obs*R-squared	2.146605	Prob. Chi-Square(5)	0.8285
Heteroskedasticity Test: ARCH			
F-statistic	1.749975	Prob. F(5,39)	0.1462
Obs*R-squared	8.245979	Prob. Chi-Square(5)	0.1432
Heteroskedasticity Test: White			
F-statistic	0.58652	Prob. F(9,40)	0.8001
Obs*R-squared	5.829104	Prob. Chi-Square(9)	0.7569
Scaled explained SS	4.424587	Prob. Chi-Square(9)	0.8813
Ramsey RESET Test Omitted Var: Powers of fitted values from 2 to 3			
	Value	df	Prob
F-statistic	1.025783	(2, 39)	0.368
Likelihood ratio	2.563367	2	0.2776
Ramsey RESET Test Omitted Var: Powers of fitted values from 2 to 4			
	Value	df	Prob
F-statistic	1.065344	(3, 38)	0.3752
Likelihood ratio	4.037789	3	0.2574
Ramsey RESET Test Omitted Var: Powers of fitted values from 2 to 5			
	Value	df	Prob
F-statistic	1.065344	(3, 38)	0.3752
Likelihood ratio	4.037789	3	0.2574

Table A9: Estimated Long-Run and Short-Run Coefficients

ELASTICITIES OF INDEPENDENT VARIABLES (ARDL)		
VARIABLE	LONG RUN [^]	SHORT RUN
LWPI	0.499**	0.026*
LMS	0.179*	0.079*
LTWDI	-0.570**	-0.031***
IREC	0.020***	-0.006**
ECT1	-0.024*	

[^] Normalised to LCPI1

*, **, *** refer to marginal significance at 1%, 5% and 10%

The diagnostic tests confirm that the model is robust and reliable. The χ^2 statistics of Breusch-Godfrey's Lagranges Multiplier (LM) test for auto-correlation, Breusch-Pagan Godfrey's ARCH tests and White's test for hetro-skedasticity and Jarque-Bera test for normality of residuals show significance levels greater than 5%. This means the acceptance of the null hypothesis that the variables are not serially correlated are homo-skedastic and the residuals are normally distributed. The F-statistics of Ramsey RESET test for functional form, show significance levels greater than 5% thereby accepting the null hypothesis of no omitted variables.

The result of Jarque-Bera test showing normality of residuals is presented in Figure A1. Further we perform tests for the cumulative sum of residuals (CUSUM) and cumulative sum of squares of residuals (CUSUMSQ) to confirm the stability of the long-run coefficients. The results of the tests are shown in graphical form in Figure A2 and Figure A3 below which show that the residuals in general remain within the critical lines of 5% significance. In perspective to the above test results we can safely conclude that the specification of the model is correct.

Figure A1: Jarque Bera Test for Normality

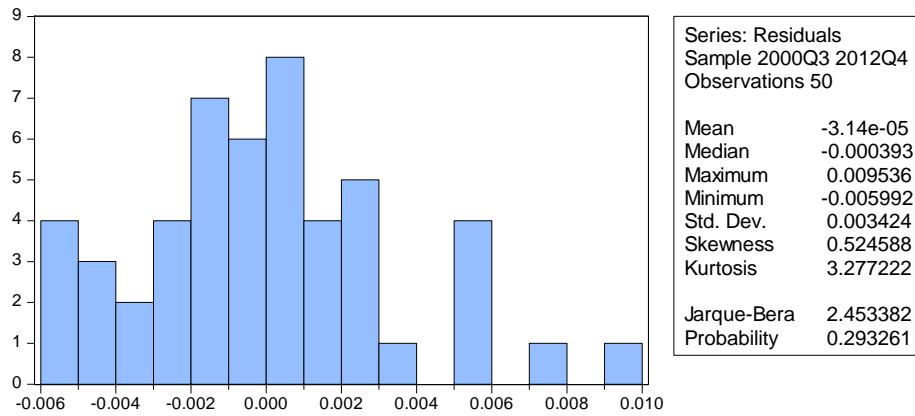


Figure A2: Cumulative Sum of Residuals (CUSUM)

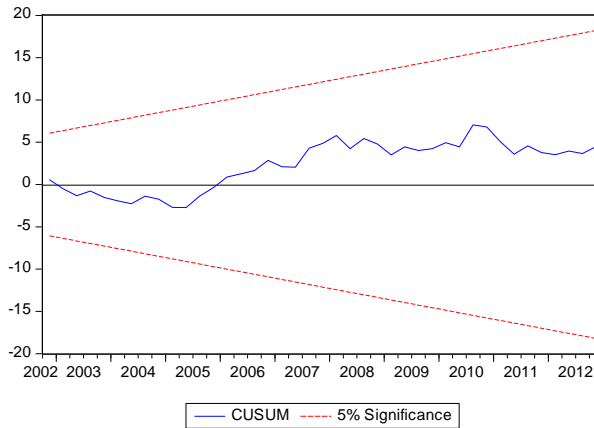
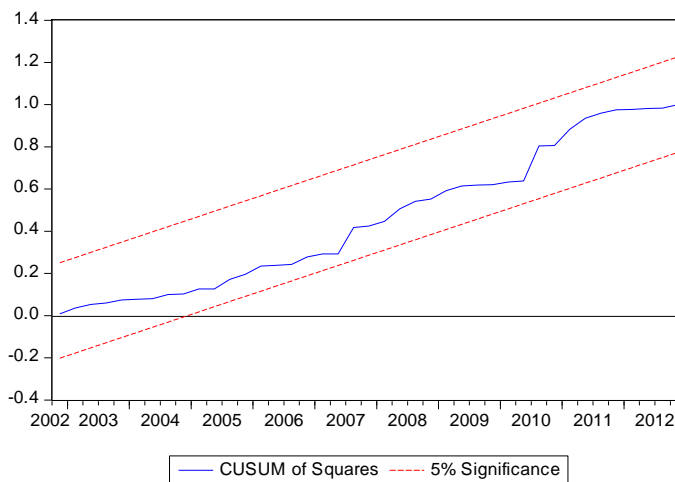


Figure A3: Cumulative Sum of Squares of Residuals (CUSUMSQ)



7. VECM Model Approach

The concept of error correction model (ECM) was first introduced by Phillip (1954) which was later used by Sargan (1964) and Davidson et al (1978) in their economic analysis. Later the same concept was adopted in the Granger representation theorem which states that if two or more integrated time series are cointegrated then they can be represented by an error correction term and if two or more time series share an error correction term they can be regarded as cointegrated (Engle and Granger 1987). The concept of ECM is generally used in econometric analysis to avoid spurious regression (Lauridsen 1998). The inclusion of error correction term in the cointegration equation takes into account the adjustments that are made in the long-term equilibrium caused by the shocks resulting from the short-term changes in the variables. The time paths of the affected variables tend to depend upon the magnitude of deviation from the long-run equilibrium (Anders, 2004). The error correction term represents the percentage of correction to any disturbance in the long-run equilibrium in one time period. It therefore gives the speed of correction at which any imbalance caused by short-run changes returns to its long-run equilibrium. The ECM approach therefore captures the interaction of short-run dynamics affecting the long-run dynamics of the economic variables.

This study involves analysis based on the VECM model for cointegration. Since all our data is non-stationary at level and integrated to the order I(1) which is a pre-requisite we can use VECM approach to cointegration. The method essentially involves a restricted vector autoregression (VAR) model which is designed for cointegrated and non-stationary variables. It is assumed that the variables undergo linear adjustment process over the period of time and converge towards the long-run equilibrium. Engle and Granger (1987), state that the changes in the dependent variable are a function of disequilibrium caused in the long-run relationship which is comprised of the error correction term (ECT) and other explanatory variables. The variables that best serve VECM are the ones that are first differenced stationary and cointegrated (Hendry and Juselius (2000)).

The general model used in this study is described below;

$$\text{CPI} = f(\text{WCI}, \text{MS}, \text{NEEX}, \text{IRUS}) \dots \dots \dots \text{(B1)}$$

Thus:

$$LCPI_t = \alpha_0 + \alpha_1 * LWCIt + \alpha_2 * LMS_t + \alpha_3 * LNEEX_t + \alpha_4 * IRUS_t + et \dots\dots(B2)$$

Where CPI is inflation in Saudi Arabia measured in terms of consumer price index, WCI is the world commodity price index, MS is broad money supply in the country, NEEEX is the nominal effective exchange rate of Saudi Riyal, and IRUS is the 3 month US Treasury Bill interest rate and et is the error term or white noise.

7.1 Methodology: VECM

The methodology involved in the VECM approach involves testing for non-stationarity of data, testing for cointegration and direction of casualty and diagnostic testing of the model. For stationarity we have used Augmented Dicky Fuller (ADF) Test and Phillip Perron Test (PP). For cointegration we us Johansen approach to multivariate cointegration. The direction of casualty is determined by Granger Casualty Test.

7.1.1 Stationarity : ADF and PP Tests

Since all our variables are first difference stationary using ADF and PP tests as shown in Table B1 we proceed to the next step of establishing cointegration responsible for the long-run equilibrium.

7.1.2 Cointegration: Johansen Approach

The findings of (Madlala and Kim, 1998) conclude that if there is at least one cointegration relationship among the variables of interest then some causal relationship exists among the variables. If the data is found integrated then Engle and Granger (1987), recommend use of Granger causality test based on Johansen multivariate vector error correction model (VECM) as compared to first difference VAR model. We present below the error correction model used in our study;

$$\Delta LCPI_t = \alpha_0 + \sum_{i=1}^N \alpha_{1,i} \Delta LCPI_{t-i} + \sum_{i=0}^N \alpha_{2,i} \Delta LWCI_{t-i} + \sum_{i=0}^N \alpha_{3,i} \Delta LMS_{t-i} + \sum_{i=0}^N \alpha_{4,i} \Delta LNEEX_{t-i} + \sum_{i=0}^N \alpha_{5,i} \Delta IRUS_{t-i} + \lambda ECT_{t-1} + et \dots\dots(B3)$$

Where, the coefficient ‘ λ ’ is the speed of adjustment and ECT is the error correction term derived from residual of the equation B2.

This study is based on the Johansen (1998) and Johansen and Juselius (1990) Maximum Likelihood Cointegration Approach to multivariate analysis. This approach requires a VAR model with a specified lag length to test for the number of cointegrating relationships between the variables. It is based on the assumption that for cointegrated series even if two series are non stationary there still exists some long run relationship linking both series so that it is stationary. Johansen approach is sensitive to lag length for which we use AIC or SBC criteria to determine the optimum number of lags. In this study we opt for AIC criteria.

Johansen (1998) and Johansen and Juselius (1990) Maximum Likelihood Cointegration Approach involves two tests; the Trace Test and the Maximum Eigenvalue Test. We can use either of these for the estimation of the number of cointegrating vectors. The results of the two tests can often give conflicting estimates though. The Trace test is a joint test where the null hypothesis is tested for the number of cointegrating vectors to be less than or equal to r . The alternative hypothesis is that the number of cointegrating vectors is greater than r . The Maximum Eigenvalue test on the other hand employs separate tests for each eigenvalue with null hypothesis that ‘ r ’ cointegrating vectors exist. This is tested against the alternative hypothesis that $r + 1$ number of cointegrating vectors exist. Trace test and the Johansen’s Maximum Eigenvalue Test indicate the cointegrating vectors or equations in the model and reject the null hypothesis of no cointegration at 5% significance level.

In this study we use Eviews 7 software to conduct Johansen (1998) test for cointegration and Granger Causality Test. We opt to choose Maximum Eigenvalue Test for our analysis of results to establish the rank order and determine the number of cointegrating equations in our analysis.

7.1.3 Granger Causality

The cointegration test only reveals the fact that the variables have a long-run relationship. It does not state the direction of relationship whether it is from dependant variable to independent variable or vice versa. In order to establish the direction of relationship we employ Granger Casualty Test. This test involves analysing the direction of casualty between the first difference variables. The reason for using the difference values is that the

current changes in the dependant variable (price inflation) are actually a result of the changes in the past or lagged values of the independent variables. This method appears to be one of the earliest methods developed to capture the casual relationship from the time series data. It is essentially based on the dynamics of the “cause and effect” phenomenon with underlying assumption that “cause” occurs prior to its “effect” In economic literature it is often stated as X Granger causes Y when the variable X is responsible for causing changes in variable Y.

In this study we use Eviews 7 software to conduct Granger Causality Test using 4 number of lags. The test results are summarized in Table B4. The Granger causality test results reveal that there is two-way causality.

7.2 Empirical Results: VECM

7.2.1 Stationarity: ADF and PP Test

As explained in section 5.1.1 we use ADF and PP Tests to check the non-stationarity of the variables. We employ AIC criteria for optimum lag selection as it gives smaller standard error (Pesaran and Pesaran 1997, Sherestha, 2006, Aalexiouu and Toro, 2006). The statistical results to check the stationarity of the data with ADF and PP tests are reported in Table B1 with chosen selection marked with ‘*’, ‘**’ and ‘***’ respective to 1%, 5% and 10% significance. Both tests ADF and PP conclude that all variables are stationary at the first difference or integrated (1).

Johansen multivariate technique using VECM requires all data to be at the same level and integrated I(1). Since all our variables are integrated at first differnce I(1) as shown in Table B1 we proceed with the Johansen test for cointegration using VECM to find out the long and short term relationships between the study variables.

Table B1: ADF and PP Unit Root Test Results

RESULTS OF AUGMENTED DICKY FULLER TEST				
VARIABLES	LEVEL		FIRST DIFFERENCE	
	INTERCEPT	INTERCEPT AND TREND	INTERCEPT	INTERCEPT AND TREND
LCPI	4.568	-1.470	-2.500	-3.525**
LWCI	-1.307	-2.407	-5.182*	-5.142*
LMS	1.250	-2.580	-5.770*	-5.880*
LNEER	-0.947	-2.443	-5.045*	-4.998*
IRUS	-0.821	-1.109	-3.395*	-3.361*
RESULTS OF PHILLIPS PERRON TEST (NEWLY WEST BANDWIDTH AND BARTLETT KERNEL)				
VARIABLES	LEVEL		FIRST DIFFERENCE	
	INTERCEPT	INTERCEPT AND TREND	INTERCEPT	INTERCEPT AND TREND
LCPI	2.356	-1.340	-2.230	-3.660**
LWCI	-1.290	-2.731	-5.202*	-5.127*
LMS	1.117	-2.574	-5.780*	-5.900*
LNEER	-1.176	-2.692	-4.790*	-4.729*
IRUS	-1.483	-1.981	-3.493*	-3.458*
*, **, *** refer to marginal significance at 1%, 5% and 10%				

7.2.2 Optimum Lag Selection

Johansen multivariate technique using VECM is very sensitive of the order of lag being used in the analysis. We therefore perform an optimum lag selection test using the software Eviews 7 with automatic lag selection of the VAR model. The test results are stated in Table B2. We opt to use AIC criteria based on which we select lag 4 in our analysis.

Table B2: Optimum Lag Selection Test Criteria Results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	109.657	NA	1.23E-08	-4.025	-3.837	-3.953
1	516.558	719.902	5.16E-15	-18.713	-17.588	-18.282
2	566.698	79.067	2.02E-15	-19.68	-17.616*	-18.889*
3	591.99	35.019	2.14E-15	-19.691	-16.69	-18.541
4	629.117	44.267*	1.54e-15*	-20.158*	-16.218	-18.647

* 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

VAR Lag Order Selection

Endog var: LCPI LWCI LMS LNEER IRUS

Sample: 1999Q1 2012Q4

Included observations: 52

7.2.3 Johansen Cointegration Test Result

In the first part the test results of Johansen Cointegration Test using maximum Eigenvalue test are presented in Table B3. The proposed rank order for lag 4 with the option of intercept only in cointegrating equation and test VAR, reveal that there is only one cointegrating equation selected at 5% level of significance. The test results are included in Table B3.

Table B3: Maximum Eigenvalue Test

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.702	61.822	33.877	0.000
At most 1	0.386	24.877	27.584	0.107
At most 2	0.333	20.675	21.132	0.058
At most 3	0.229	13.274	14.265	0.071
At most 4	0.045	2.324	3.841	0.127

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

In the second part of Johansen's test we estimate the coefficients of the one period lagged error correction term and its constituents along with the coefficients of the one period lagged differenced variables of equation B3. The value of these coefficients and their signs indicate the extent and the direction of changes in the dependant variable caused by independent variables. The coefficient of one period lagged value of error correction term however estimates the speed with which these changes return to their normal value in one period time. The coefficients of the one-period lagged variables in the error correction model represent the long-run effects whereas the coefficients of the difference variables represent the short-run effects. The error correction term in equation B3 estimated by the Johansen VECM test for 4 lags and with intercept only in cointegrating equation and test VAR is presented below assuming one cointegrating equation in the model.

$$\text{ECT}(-1) = \text{LCPI}(-1) - 0.054 * \text{LWCI}(-1) - 0.477 * \text{LMS}(-1) + 0.001 * \text{LNEER}(-1) - 0.0213 * \text{IRUS}(-1) + 8.462 \dots \dots \dots (\text{B4})$$

Once the error correction term is obtained in the next step we run an OLS on equation (B3) using the error correction term of Equation (B4) to find out the coefficients of all the variables in the equation. From the regression results a further parsimonious model is then obtained by deleting the insignificant variables and sequentially re-running the OLS on the remaining significant variables. The parsimonious model thus derived is given in Equation B5.

$$\begin{aligned} \text{D}(\text{LCPI}) = & \text{C}(1) * \text{ECT1} + \text{C}(2) * \text{D}(\text{LCPI}(-2)) + \text{C}(3) * \text{D}(\text{LCPI}(-3)) + \text{C}(4) * \text{D}(\text{LCPI}(-4)) + \\ & \text{C}(5) * \text{D}(\text{LWCI}(-1)) + \text{C}(6) * \text{D}(\text{LWCI}(-2)) + \text{C}(7) * \text{D}(\text{LWCI}(-3)) + \text{C}(8) * \text{D}(\text{LMS}(-3)) + \\ & \text{C}(9) * \text{D}(\text{LMS}(-4)) + \text{C}(10) * \text{D}(\text{LNEER}(-2)) + \text{C}(11) * \text{D}(\text{LNEER}(-4)) + \text{C}(12) * \text{D}(\text{IRUS}(-1)) + \\ & \text{C}(13) * \text{D}(\text{IRUS}(-3)) + \text{C}(14) * \text{D}(\text{IRUS}(-4)) + \text{C}(15) \dots \dots \dots (\text{B5}) \end{aligned}$$

A summary of the long-run coefficients obtained from the error correction term of equation B(4) and short-run coefficients obtained from the parsimonious model of equation (B5) is included in Table B4.

Table B4: Estimated Long and Short Run Coefficients

ELASTICITIES OF INDEPENDENT VARIABLES (VECM)		
VARIABLE	LONG RUN^	SHORT RUN
LWCI	0.0541	0.0695***
LMS	0.475	0.054**
LNEER	-0.001	-0.003**
IRUS	0.02	-0.015**
ECT1	-0.056*	

*, **, *** refer to marginal significance at 1%, 5% and 10%

7.2.4 Granger Causality Test Result

The Granger Causality Test show that world commodity prices and domestic inflation in Saudi Arabia do have an influence on each other and show a two way causality. This is evident from the fact that the probability values are less than 5% based on which the null hypothesis of no Granger causality cannot be rejected. On the other hand domestic money supply and nominal effective exchange rate appear to Granger cause domestic inflation (p value less than 5%) whereas the reverse is not true (p value higher than 5%). The test results point out that there is no causality between foreign (US) interest rate and domestic inflation.

Table B5: Granger Causality Test

Pairwise Granger Causality Tests Sample: 1999Q1 2012Q4	Date: 04/23/13 Time: 21:30 Lags: 4			
Null Hypothesis:	Obs	F-Statistic	Prob.	
DLWCI does not Granger Cause DLCPI	51	2.91415	0.0325	
DLCPI does not Granger Cause DLWCI		3.04566	0.0272	
DLMS does not Granger Cause DLCPI	51	2.45865	0.0601	
DLCPI does not Granger Cause DLMS		1.19152	0.3286	
DLNEER does not Granger Cause DLCPI	51	2.02377	0.1085	
DLCPI does not Granger Cause DLNEER		1.02664	0.4047	
DIRUS does not Granger Cause DLCPI	51	1.73584	0.1601	
DLCPI does not Granger Cause DIRUS		0.3141	0.8669	

7.2.5 Diagnostic Test Results: VECM

In the final stage we check the suitability of the resulting parsimonious model of equation (B6) with a series of diagnostic tests which include Breusch-Godfrey's Lagrange Multiplier (LM) test for auto-correlation (χ^2_{AUTO}), Jarque Bera test for normality (χ^2_{NORM}), Breusch-Pagan Godfrey's ARCH tests for heteroskedasticity (χ^2_{ARCH}) along with White's test (χ^2_{WHITE}) and Ramsey's regression specification test (χ^2_{RESET}) to check the function form as a result of omitted variables. The relevant diagnostic test results are shown in Table B6 whereas a summary of the short and long run coefficients is included in Table B7.

Table B6: Diagnostic Test Results of ECM

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.545921	Prob. F(4,33)	0.7032
Obs*R-squared	3.165328	Prob. Chi-Square(4)	0.5305
Heteroskedasticity Test: ARCH			
F-statistic	0.413344	Prob. F(4,42)	0.798
Obs*R-squared	1.780129	Prob. Chi-Square(4)	0.7761
Heteroskedasticity Test: White			
F-statistic	0.773975	Prob. F(13,37)	0.681
Obs*R-squared	10.90368	Prob. Chi-Square(13)	0.6189
Scaled explained SS	7.001303	Prob. Chi-Square(13)	0.9021
Ramsey RESET Test Omitted Var: Powers of fitted values from 2 to 3			
	Value	df	Prob
F-statistic	2.207341	(2, 35)	0.1251
Likelihood ratio	6.058305	2	0.0484
Ramsey RESET Test Omitted Var: Powers of fitted values from 2 to 4			
	Value	df	Prob
F-statistic	1.563077	(3, 34)	0.2163
Likelihood ratio	6.58924	3	0.0862
Ramsey RESET Test Omitted Var: Powers of fitted values from 2 to 5			
	Value	df	Prob
F-statistic	2.336792	(4, 33)	0.0758
Likelihood ratio	12.71909	4	0.0127

Table B7: Estimated Long-Run and Short-Run Coefficients

ELASTICITIES OF INDEPENDENT VARIABLES (VECM)		
VARIABLE	LONG RUN^	SHORT RUN
LWCI	0.0541	0.0695***
LMS	0.475	0.054**
LNEER	-0.001	-0.003**
IRUS	0.02	-0.015**
ECT1	-0.056*	

*, **, *** refer to marginal significance at 1%, 5% and 10%

The diagnostic tests confirm that the model is robust and reliable. The χ^2 statistics of Breusch-Godfrey's Lagranges Multiplier (LM) test for auto-correlation, Breusch-Pagan Godfrey's ARCH tests and White's test for hetro-skedasticity and Jarque-Bera test for normality of residuals show significance levels greater than 5%. This means the acceptance of the null hypothesis that the variables are not serially correlated are homo-skedastic and the residuals are normally distributed. The F-statistics of Ramsey RESET test for functional form, show significance levels greater than 5% thereby accepting the null hypothesis of no omitted variables.

The result of Jarque-Bera test showing normality of residuals is presented n Figure B1. Further we perform tests for the cumulative sum of residuals (CUSUM) and cumulative sum of squares of residuals (CUSUMSQ) to confirm the stability of the long-run coefficients. The results of the tests are shown in graphical form in Figure B2 and Figure B3 below which show that the residuals in general remain within the critical lines of 5% significance. In perspective to the above test results we can safely conclude that the specification of the model is correct.

Figure B1: Jarque Bera Test for Normality

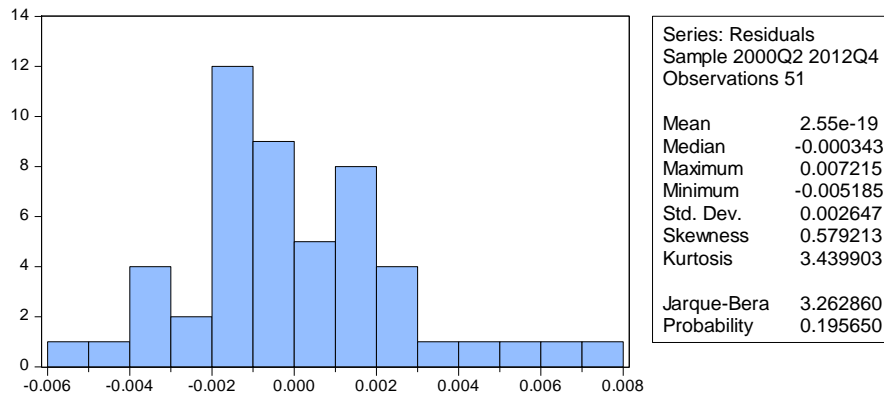


Figure B2: Cumulative Sum of Residuals (CUSUM)

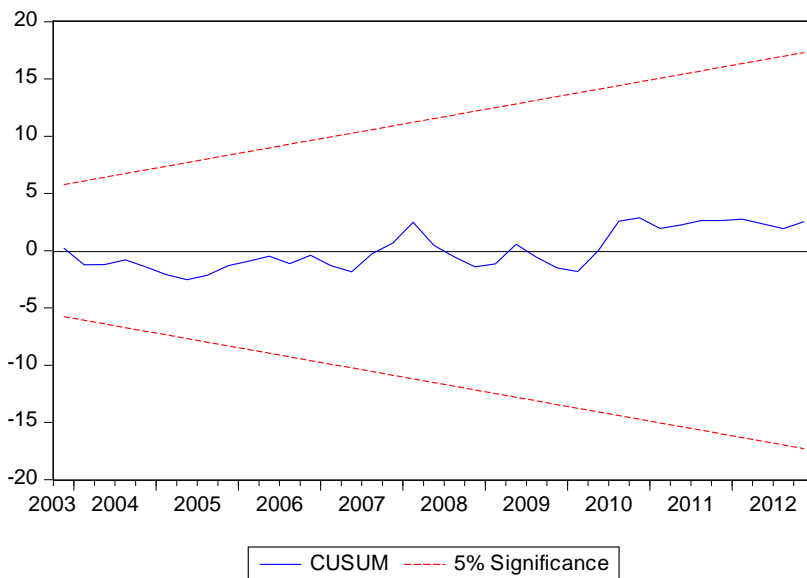
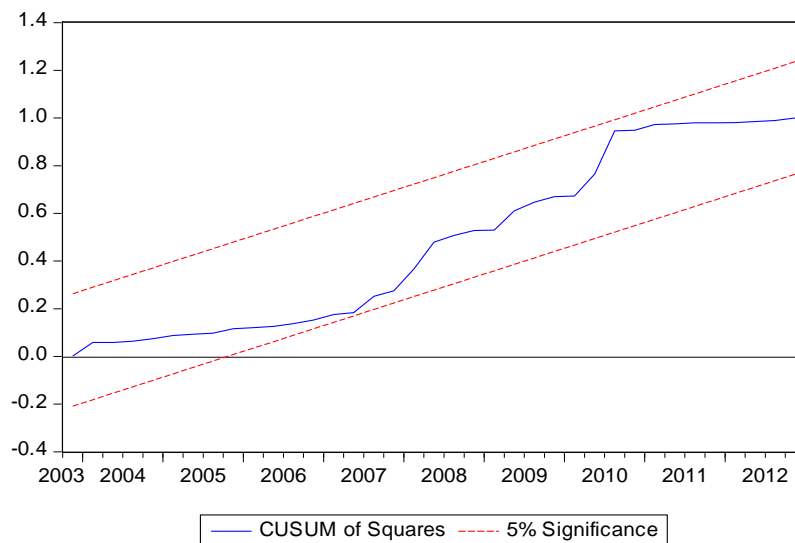


Figure B3: Cumulative Sum of Squares of Residuals (CUSUMSQ)



8. Critical Analysis of Results

As demonstrated in the previous sections this study involves the exploration of relationship between the price inflation in the Kingdom of Saudi Arabia and some economic factors which include world food and commodity prices, domestic broad money supply (M2), Saudi Arabia's effective exchange rate and foreign interest rate. Two approaches were used in the study one that of ARDL presented by Pesaran et al (2001) and the other Johansen (1998) approach to multivariate cointegration. The results obtained from both models show predominantly similar results. In general the results have shown compliance with the economic theory. The world inflation in terms of world food and commodity prices and the domestic broad money supply have been found to have a positive impact on the domestic price inflation. The nominal effective exchange rate of the local currency however, has shown a negative impact on the domestic inflationary pressure implying that appreciation in local currency would reduce price inflation in the country.

8.1 World Inflation

The effect of world inflation is captured in the variables of world food prices and world commodity prices. The world food prices and commodity prices have been found to exert a positive pressure on domestic prices both in the long-run and in the short-run. The effects of world food prices, however, have been found to exceed that of world commodity prices in the long-run. The results show that the world food prices impact domestic inflation approximately 10 times more than the world commodity prices. This is evident from the fact that the long-run coefficient of LWCI (world commodity prices) is 0.0541 while that of LWPI (world food prices) is approximately 0.5. This means that a 1% change in the world commodity prices creates 0.054% change in the domestic price inflation while a 1% change in the world food prices would create 0.5% change keeping other factors constant.

Our results for the ARDL model for the impact of world food price causing 0.5% increase in domestic prices is consistent with the results reported by Basher and Elsamadisy (2011) who estimate 0.62% increase and Hasan and Alogeel (2008) who give a figure of 0.83% increase in domestic prices due to 1% increase in foreign prices.

8.2 Money Growth

The effect of money supply which also represents the demand for money in Saudi Arabia is found to have a tremendous influence on the domestic prices especially in the long-run. This is partly due the fact that the money supply in the economy encompassed various other

channels that are responsible for imported inflation. These channels include differential in the foreign interest rate especially the USA to which the domestic currency is pegged and which could result in capital inflows and outflows to name but a few. Increases in money supply in the long-run and short-run have been found to increase the domestic inflation as reported by both of the applied models. The results however, differ in the extent to which the money supply influences domestic prices. As per ARDL technique in the long-run 0.18% change in the domestic CPI is observed as compared to 0.475% reported by Johansen VEC model resulting from 1% change in the domestic money supply.

The output from the ARDL model and Johansen VEC model suggesting figures of 0.18% and 0.475% respectively regarding the increase in domestic price levels due to 1% increase in domestic broad money supply are consistent with the results obtained by Basher and Elsamadisy (2011) the results of whose study come up with a value of 0.24%.

8.3 Exchange Rate

The effect of effective exchange rate of Saudi Arabian currency has been studied by the use of nominal effective exchange rate (NEER) in the ARDL model. Since the Saudi Riyal is pegged to the US dollar we expect the same results to be obtained by use of US trade weighted dollar index (TWDI) which we have used in the Johansen VEC model. The results of both models show that the effective exchange rate tends to exert a negative impact on the domestic prices thereby dampening the inflationary pressures in the short and long run. It has been found that the effect of nominal effective exchange rate has been minimal as compared to that of US trade weighted dollar index in the long-run.. A 1% increase in US trade weighted dollar index causes 0.57% decrease in the domestic prices while a similar change in the Saudi Arabia's nominal effective exchange rate produces only a negligible change of 0.001%. in the domestic inflation in the long-run.

Our results of 0.57% decrease in the domestic price level under the influence of 1% increase in domestic exchange rate (US trade weighted dollar index) as reported by ARDL model are consistent with the findings of Basher and Elsamadisy (2011) whose study results show a figure of 0.70% for the same. In contrast however, Hasan and Alogeel (2008) come up with a moderate result of only 0.20%. which they consider as comparable to the effects in developed countries (Goldberg and Campa 2010) or emerging market economies (Mihaljek and Klau, 2008)

8.4 Interest Rate

In this study we try to find out the effect of foreign interest rates on the domestic inflation in Saudi Arabia. As stated before due to US dollar peg the interest rates in Saudi Arabia generally follows the same trend as that dictated by the Federal Reserve in the USA.

In this study we have analysed two sets of data variables to proxy the foreign interest rates. In the ARDL model we use 3 month Eurodollar interest rate while in the Johansen VEC model we employ the 3 month US treasury bill rate. As expected both of our models give similar results showing that the increase in foreign interest rates tend to increase domestic inflation and vice versa in the long-run. However, in the short-run the foreign interest rates have shown a reverse effect of reducing the domestic inflation.

We are of the opinion that these results should be treated with caution owing to two well proven facts. The first and the foremost is that the mechanics of imported inflation dictates that any changes in the foreign interest rate also affect the changes in the domestic money supply through the interest rate parity implied by the exchange rate parity. This effect is accommodated in the analysis by the variable of domestic money supply, since a change in the interest rate differential between the anchor and pegging country would result in a change in the level of domestic money supply. This could take place through different channels such as the effect of capital flows on domestic money supply. The other reason to be cautious about the estimated coefficients for the foreign interest rate is the results of Granger causality test. While other variables have been shown to Granger cause domestic CPI the foreign interest rate (US Treasury Bill rate) tends not to show any such influence on the domestic prices. Instead the results show that the interest rate Granger causes world commodity prices (WCI). This means that while the changes in interest rate may not appear to directly influence the domestic inflation the pass through may take place other routes like the world commodity prices or through the capital flow mechanisms. Since in our study we have included the variable for domestic broad money supply we would therefore focus on the outcome of the money supply growth on the domestic price inflation which also encompasses the effects of any change in foreign interest rates.

8. 5 Speed of Correction

The speed of correction or the speed of convergence to the long-run equilibrium position is captured by the coefficient of the error correction term (ECT) as presented in the preceding sections. As expected the coefficient of speed of correction is found negative with a significant value at 5% level in both of our studied models. As suggested by Basher and Elsamadisy (2011) the error correction parameter becomes easier to interpret when we transform it to the half-life. We use the following formula for this purpose to convert both of the estimated error correction parameters respective to the two studied models of ARDL and Johansen VEC model to their half life spans.

$$\text{Half Life} = \ln(0.5) / \ln(1 + \text{Coefficient of Error Correction Term})$$

We obtain the half life values of 27.38 and 12.02 respectively for ARDL model and Johansen VEC model. Since we are using quarterly data, it implies that as per ARDL approach it would take about 6.8 years for 50% of a shock to the long-run equilibrium to dissipate. And as per Johansen VEC approach it would take approximately 3 years time for the same shock level to the long-run equilibrium to vanish. The resulting speed of correction for both of our models therefore appears to be very slow.

9. Limitations and Suggestions

The limitations of this study have been found related to the availability and quality of data for analysis and methodology.

As far as limitations on data are concerned, in general few data series are available for the Middle East region and even if they are available they tend to be covering only the last 15 to 18 years. In order to undertake comparative study similar set of data is generally required for the same time period span. Unfortunately, while complete data is available for a few countries it does not exist for majority of the region which makes it difficult for any researcher to undertake a comprehensive and detailed study of this part of the world. Moreover the base year to which the data is available may frequently change without any indication over this period making it difficult to get a consistent time series.

Other factor that is of concern is the quality of data. Since the Middle East is a developing region without well established procedures and rules the quality and reliability of data may not be as good as that of developed nations. Lack of audit and control coupled with the bureaucratic form of government and unaccountability may further compound the problem.

There are lack of tools and techniques to deal with complex econometric issues. The econometric software packages are either expensive or not free to the academic research. Economical commercial packages like E-Views 7.0 allow only limited number (max 10) variables to be tested with the Johansen approach. Increase in the number of research variables could open more doors and opportunities to explore long-term relationships.

The methodology of Johansen approach used in the study, potentially has limited quality of study. The cointegration methods in general and the Johansen VEC method in particular suffer from both inherent weaknesses and deficiencies particularly when dealing with the detection of long-run relationships between two variables that are cointegrated through a cointegrating relationship with a third common variable. It is difficult to test hypothesis by imposing restrictions on the cointegrating coefficients and it requires a strong theoretical background to interpret the results. The Johansen approach also fails to detect possible non-linear cointegration between variables. It is therefore recommended to repeat the study with different linear and non-linear methods. Further techniques need to be developed to account for the global macroeconomic shocks including the possibility of the meltdown of the global economic system.

10. Conclusion

The purpose of this research has been to empirically analyze the relationship between Saudi Arabia's price inflation and the selected economic variables of study in the long and short term. We have inferred several important results from the analysis.

First, the money growth has been found as a significant determinant of inflation in short and long-run. This implies that Saudi Arabia can benefit from having its own independent monetary policies rather than the imported monetary policy from the US Federal Reserve. The problem becomes further complicated when viewed in perspective to the dynamics of the exchange rate which has been found to play a key role in the determination of inflation in the long-run. An independent monetary policy would allow the Saudi Arabia's central banks to use their own exchange rate policies to rectify any deviations from the long-run price equilibrium.

The results also show that domestic prices in Saudi Arabia being an importer country are affected by foreign prices due to world inflation. The fact that world food and commodity prices positively contribute to the domestic price levels provide further support for using exchange rate policies to mitigate the impacts of global price shocks.

The empirical results of the study show a very slow (3 to 7 years) speed of correction under the pegged exchange rate scheme. It can be expected that with a sovereign monetary policy the speed of convergence would accelerate to a reasonable level.

11. References

- Al-Bassam, K. A., (1990), "Money Demand and Money Supply in Saudi Arabia: An Empirical Analysis." Unpublished Ph.D. Dissertation, University of Leicester, February 1990.
- Aljebrin, Mohammad, (2006). Analysis of inflation determinants in developing oil-export based economies, Doctoral dissertation, Colorado State University.
- Aljuhani, Eid A., (1990), Money Market, Price Fluctuations and the Role of the Monetary Authority in Saudi Arabia, Ph.D. Dissertation, Colorado State University, U.S.A.
- Barry, Zain Alabdeen Abdullah, (1980), "Inflation in Saudi Arabia: 1964 to 1978", Unpublished Ph.D. Dissertation, University of Colorado at Boulder, U.S.A.
- Bonato L (2007). Money and inflation in the Islamic Republic of Iran. IMF working paper, 7: 119 (Washington: International Monetary Fund). Available on Internet (URL: www.imf.org/external/pubs/ft/wp/2007/wp07119.pdf).
- Cheung C (2009). Are commodity prices useful leading indicator of inflation? Bank of Canada discussion Paper, p. 25. Available on Internet (URL: <http://www.bankofcanada.ca/en/res/dp/2009/dp09-5.pdf>).
- Darrat A (1993). Inflation in Saudi Arabia: An econometric investigation. J. Econ. Stud., 12(4): 44-51.
- Darrat, A. (1985), "Inflation in Saudi Arabia and Econometric Approach", Journal of Econometric Studies, 4 (12).
- Darrat, Ali F., (1981), "A Monetarist Approach to Inflation for Saudi Arabia." Unpublished Ph.D. Dissertation, Indiana University, June 1981.
- Dickey, D. A., and Fuller, W. A.. (1979). Distribution of the Estimator for Autoregressive Time Series with Unit Root, Journal of the American Statistical Association, 74, 427-431.
- Dickey, D. A., and Fuller, W. A.. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root, Econometrica, 49, 1057-1072.
- Diz, A.C., (1970), "Money and Prices in Argentina", 1935-62, in D. Meiseiman (ed.), Varieties of Monetary Experience, Chicago: University of Chicago Press.
- Engle, R and Granger, CWJ 1987, Cointegration and error correction: representation; estimating and testing, Econometrica, Vol. 55, pp. 251-276.
- Engle, R and Yoo BS 1987, Forecasting and testing in co integrated systems, Journal of Econometrics, Vol. 35, pp. 143-159.
- Ghavam Masoodi, Z. and Tashkini, A., (2005). The Empirical Analysis of Inflation in Iran. Quarterly Business Research Letter. No. (36). 75-105.

- Granger CWJ 1986, Development in the study of co integrated variables. Oxford Bulletin of Economics and Statistics, Vol. 48, pp. 213-228.
- Iyoha MA (1977). Inflation and openness in less developed economies: A cross-country analysis: Reply. *Econ. Dev. Cult. Change*, 26(1):153-155.
- Jin J (2000). Openness and growth: An interpretation of empirical evidence from East Asian countries. *J. Int. Trade Econ. Dev.*, 9(1): 5-17.
- Johansen S. (1995), *Likelihood-Based Inference in Co-integrated Vector Autoregressive Models*, Oxford University Press, Oxford.
- Johansen S.. (1988). Statistical analysis of Cointegration vectors, *Journal of Economic Dynamics and Control*, 12, 231-54.
- Johansen S. (1991), Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Regressive Models, *Econometrica*, 59, 1551-1580.
- Johansen S. (1995), "Determination of Cointegration Rank in the Presence of Linear Trend", *Oxford Bulletin of Economics and Statistics*, 54(3), 383-97.
- Johansen, S and Juselius K 1990, Maximum likelihood estimation and interference on cointegration with application to the demand for money, *Oxford Bulletin of Economics and Statistics*, Vol. 52, pp. 169-210.
- Juselius, K. (1992), "Domestic and Foreign Effects on Prices in an Open Economy: The Case of Denmark", *Journal of Policy Modeling*, 14(4), 401-28.
- Kandil, M. and H. Morsy (2009), "Determinants of Inflation in GCC", IMF Working Paper 09/82, (Washington: International Monetary Fund), Available on Internet (URL No.- www.imf.org/external/pubs/ft/wp/2009/wp0982.pdf).
- Keran, M., and A. Al Malik (1979), Monetary Sources of Inflation n Saudi Arabia", *Federal Reserve Bank of San Francisco-Economic Review*, Winter Issue Supplement. Available on Internet (URL No.- http://www.frbsf.org/publications/economics/review/1979/econrev_79-1supp_1-27.pdf)
- Khan MS, Schimmelpfenning A (2006). Inflation in Pakistan: Money or wheat. IMF Working Paper, 6: 60. (Washington: International Monetary Fund). Available on Internet (URL: www.imf.org/external/pubs/ft/wp/2006/wp0660.pdf).
- Kia, Amir, (2006). Deficits, debt financing, monetary policy and inflation in developing countries: Internal or external factors? Evidence from Iran. *Journal of Asian Economics*, 17, 897-903.

Lim, C. H. and L. Papi (1997), "An Econometric Analysis of Determinants of Inflation in Turkey" IMF Working Paper 97/170, (Washington: International Monetary Fund). Available on Internet (URL No.- www.imf.org/external/pubs/ft/wp/wp97170.pdf)

Lipsey R., (1999), Economics, Addison-Wesley. USA.

Metin, K. (1995), "An Integrated Analysis of Turkish Inflation", Oxford Bulletin of Economics and Statistics", 57 (4), 412-22.

Nagadi, Ahmed H., (1985), "Demand for Money in Saudi Arabia", Unpublished Ph.D. Dissertation, Claremont Graduate School, U.S.A.

Narayan, P.K. 2004. "Reformulating Critical Values for the Bounds F-statistics Approach to Cointegration: An Application to the Tourism Demand Model for Fiji." Discussion Papers, ISSN 1441-5429. Department of Economics, Monash University, Victoria, Australia.

Onis, Z. and S. Ozmuur (1990), "Exchange Rates, Inflation and Money Supply in Turkey: Testing the Vicious Circle Hypothesis", Journal of Development Economics, 32 (1), 133-54.

Pesaran M.H., Y. Shin, and R.J. Smith (2001), "Bound Testing Approaches to the Analysis of Level Relationships", Journal of Applied Econometrics, 16 (February) 289-326.

Pesaran, M. H. & Shin, Y. 1997. "Autoregressive Distributed Modeling Approach to Cointegration Analysis." Available at <http://www.eprg.org.uk/faculty/pesaran/ardl.pdf>.

Pesaran, M.H., Shin, Y. & Smith, R.J. 1999. "Bounds Testing Approaches to the Analysis of Long Run Relationships." Available at <http://www.econ.cam.ac.uk/faculty/pesaran/pss1.pdf>

Pigou, A. C., (1949), The Veil of Money, London: Macmillan.

Salih, Siddig A., (1993), "Determinants of Inflation in Oil-Exporting Developing Countries: An Empirical Investigation 1970-1990", Applied Economics, 25, pp. 439-445.

Sekine, T. (2001), "Modeling and Forecasting Inflation in Japan", IMF Working Paper 01/82, (Washington: International Monetary Fund). Available on Internet (URL No.- www.imf.org/external/pubs/ft/wp/2001/wp0182.pdf).

Thomas, L.B.; Jr., and K.R. Akkina, (1982), "Recent Inflation in Ten Industrial Nations: Some Tests Using a Monetarist Model", Review of Business and Economic Research, 18, pp. 60-73.

Vogel, R.C., (1974), "The Dynamic of Inflation in Latin America, 1950-1969", American Economic Review, 64, pp. 102-114

12. Appendix