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Analyzing Inflation in the Saudi Arabia: An Empirical Analysis Using GARCH Model

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Abstract

This study aims to analyze the causes of inflation in Saudi Arabia using GARCH mode. Inflation in Saudi Arabia is measured based on the growth rate of the Consumer Price Indexes (CPIs). Prior to 2000 Saudi economy witnessed low rates of inflation not exceeding 1%. Inflation sparked in 2018 due to VAT implementation. The empirical results of the study displayed the existence of the long-run equilibrium between the variables of the model. The regression results show that growth domestic product, government expenditure, money supply, and oil prices are statistically significant on inflation. Openness of the economy is not significant or has no effect on inflation. The study recommends appropriate fiscal and monetary measures to control inflation Saudi Arabia and enhance economic growth.

Keywords

Inflation, Cointegration, Money Supply, Oil Prices, Saudi Arabia, GARCH Model

1. Introduction

Since 1970 world inflation has witnessed remarkable fluctuations. According to Jongrim, Ayhan and Franziska (2016), these fluctuations mainly associated with cyclical fluctuations in the global economy or sharp movements in oil prices. After achieving low rate of inflation in gulf countries in 1990s, inflationary pressures have emerged in 2003 inflation due mainly to oil boom putting reducing inflation on the top agenda for the policy makers. Inflation in Saudi Arabia is measured based on the Consumer Price Indexes (CPIs), mainly calculated by the General Authority for Statistics. Alogeel and Hasan (2008) argued that "during the1980s and the 1990s, inflation in Saudi Arabia fluctuated between mild deflation and inflation, reaching 5 percent in 1991. Inflation remained steady during

the 2000s and started to hike in 2003, reaching 4.1 percent in 2007 and 10.5 percent in April 2008". They added that after achieving an impressive success in maintaining price stability in 1980s and 1990s, inflationary pressures have emerged since 2003 in gulf countries. However, prior to 2000 Saudi economy witnessed low rates of inflation not exceeding 1%. From 2013 to 2018, Saudi Arabia's inflation rates were generally low, controlled by government price controls and subsidies. In 2018, inflation started to rise mainly due to VAT implementation, higher international commodities prices and global supply constraints.

2. Literature Review

Understanding the causes of inflation has become for governments very important for decision in order to formulate effective policies which can control inflation without hampering economic growth. Economists generally do not agree on causes of inflation. This means that they are different opposing views on inflation. According to monetarist school, inflation is always and everywhere a monetary phenomenon. There for, monetarists believe that controlling money supply is very crucial to control inflation. Keynesian on the other hand, believes that inflation is caused by imbalances of aggregate. Both of these macroeconomics schools affect directly the way the governments create fiscal and monetary policies.

Alogeel and Hasan (2008) analyzed inflation in Saudi Arabia and Kuwait in the short run and long run. The study reveals that in the long run, higher inflation in trading partners countries is the main driving force for inflation in the two countries, with significant but lower contributions from the exchange rate pass-through effect and oil prices. They concluded that demand and money supply shocks affect inflation in the short run

Osman (2019) and others examined inflation the Causes of inflation in Saudi Arabia over the period (1980-2018). Their study reveals that inflation in Saudi Arabia is positively determined by broad money supply, oil prices, and real GDP in both the short and long run and is negatively determined by the stock price index.

Fareed, Rezghi and Sandoz (2023) analyzed inflation in gulf countries over the period 1987-2022/They stated that external factors play a major role in impacting inflation dynamics in the Gulf Cooperation Council (GCC) and trading partners' inflation has a significant impact on inflation in the GCC

Nazer (2016) investigated causes of inflation in the Saudi Arabia using a multiple regression model. He found positive statistical evidence between inflation and money supply, and import values, and a negative relation between inflation and real GDP. Nazer concluded that Saudi's inflation is mainly caused by the money supply and import prices

Alnefaee (2018) conducted Vector Error Correction Model (VECM) to study inflation in the short and long run in Saudi Arabi. His findings indicate that in the long run, inflation is positively influenced by money supply, domestic de-

mand and oil prices, and negatively influenced by exchange rate. Naseem (2016) studied the macroeconomics determinants of inflation in Saudi Arabia over the period 2000-2016. The findings of the study show that money supply, fixed exchange rate against U.S dollar, import value, export value, and oil prices have statistical significance on inflation in Saudi Arabia except unemployment that does not directly predict inflation rates in Saudi Arabia. Naseem (2016) concluded that effect of domestic factors on Saudi inflation eroded over the last 13 years as Saudi inflation become more globalized.

3. Data and Mode Specification

This study is based on the annual time series data from 2000-2020 on the following variables:

- Inflation (P): is measured by an increase in the level of prices of the goods and over a certain period of time,
- GDP (gross domestic product at constant prices million SAR): Gross domestic product (GDP) is the measurement of the value of goods and services produced in a given country during a certain period of time. GDP is expected to affect inflation negatively. As GDP increases,
- Government expenditure (GOV million SAR): A rise in government spending can increase demand and hence push prices up
- Openness of the economy (open): Openness is the degree at which international transactions take place and affect size and growth. Openness is measured as the ratio of country total output, the sum of exports and imports to GDP. As an economy becomes more opens, it is more exposed to movements of international prices.
- Money supply (M3): M3 was traditionally used by economists to estimate the entire money supply. An increasing the money supply paving the way for a sharp rise in future price levels fueling inflation.
- Oil price (OILP): the price of oil has positively correlated with inflation.

The data on these variables were taken from Central Bank of Saudi Arabia and General Authority for Statistic. All the variables were log-transformed before to performing econometric analysis in order to minimized the effect of significant differences in their scale and interpret the estimated coefficient as elasticity of the dependent variable with respect to the independent variables.

In order to examine the sources of inflation in Saudi Arabia, the following econometric model is formulated

$$P_t = \beta_0 + \beta_1 \ln \mathrm{GDP}_t + \beta_2 \ln \mathrm{GOV}_t + \beta 3 \ln \mathrm{open}_t + \beta_4 \ln \mathrm{M3}_t + \beta_5 \ln \mathrm{OILP} + \varepsilon_t \quad (1)$$

Dependent Variable: P = Inflation.

Explanatory Variables:

GDP = Gross Domestic, GOV = government expenditure, open = openness, M3 = money supply, OILP = Oil price.

β_0 = the constant or the intercept. β_1, B_2, β_3, β_4, β_5 = are the parame-

ters/coefficients of the explanatory variables. While the expected signs of the parameters are: $\beta_2 > 0$, $\beta_3 >$, $\beta_4 > 0$, $\beta_5 > 0$, $\beta_1 < 0$.

The error term (ε) is assumed to be independently and identically distributed. The subscript (t) indexes time.

4. Methodology

Autoregressive conditionally heteroscedastic (ARCH) models were introduced by Engle (1982) and their GARCH (generalized ARCH) extension is due to Bollerslev (1986). The study relied on (GARCH) the generalized autoregressive conditional heteroskedasticity models. (GARCH) models are considered among the modern models in time series analysis and forecasting, as they are distinguished greatly from other autoregressive models in that other models such as (ARIMA) models, which require that the variance of the random term of the time series be constant. According to the assumptions of the ordinary least squares method, this matter may not be available in most financial and economic variables data such as stock prices, exchange rates and other financial variables. Therefore, we find that GARCH models can give a better explanation of the phenomena compared to other models. GARCH models are widely used in various branches of econometrics, especially in financial time series analysis.

5. Empirical Results

This section includes descriptive statistical analysis of the variables has been made to reflect their developments during the period under measurement, then unit root tests are performed using the Dickey-Fuller (ADF) to test the stationary of the variables, After that a cointegration test is performed in addition to the results of estimating the GARCH model to measure the sources of inflation in the Kingdom of Saudi Arabia.

5.1. Descriptive Statistics

The results for the main descriptive statistics of the data used in the research are shown in **Table 1** and **Figure 1**. The descriptive statistics includes the mean, median, maximum, minimum, standard deviation, Jarque-Bera, and probability of each variable. It is clear from the table and the figure that the average of GDP at Constant Prices in Saudi Arabia amounted to 1,567,284 SAR Million during 2000-2020 and the maximum value registered in 2019 and the minimum amount registered in 2001. For government spending, the average value was 656667.5 million Riyal and the maximum value amounted to 1,093,272 in 2017 and the minimum value was 233,500 million Riyal in 2002. Money supply increased from 318989.3 million Riyal in 2000 to reach its highest value in 2000 amounted to 2,149,267 million Riyal. In terms of Jarque-Bera, the test investigates whether data samples have skewness or kurtosis matching a normal distribution. Relating to the current study, the test statistics for (GDP, GOV, M3, OILP, P), are all (p-value) greater than 0.05. This is an indication that the variables are normally distributed.

Table 1. Descriptive statistics.

	GDP	GOV	M3	OILP	OPEN	*P*
Mean	1567284	656667.5	1158707	61.59238	0.6177	**2.655905**
Median	1664440	653885.0	1080370	61.10000	0.6762	**3.700000**
Maximum	2751831	1093272.	2149267	110.2200	0.8309	**6.100000**
Minimum	679163.0	233500.0	318989.3	23.06000	0.0431	**−1.110000**
Std. Dev.	622790.1	323844.9	621367.5	28.67800	0.2392	**2.249052**
Skewness	0.359054	0.023292	0.048397	0.353506	−1.569	**−0.258892**
Kurtosis	2.583127	1.476715	1.519610	1.941826	4.243	**1.748785**
Jarque-Bera	0.603279	2.032246	1.925807	1.417149	9.969	**1.604435**
Probability	**0.739605**	**0.361996**	**0.381783**	**0.492345**	**0.0068**	0.448334
Observations	21	21	21	21	21	21

Source: Authors' Calculations (E-views 12).

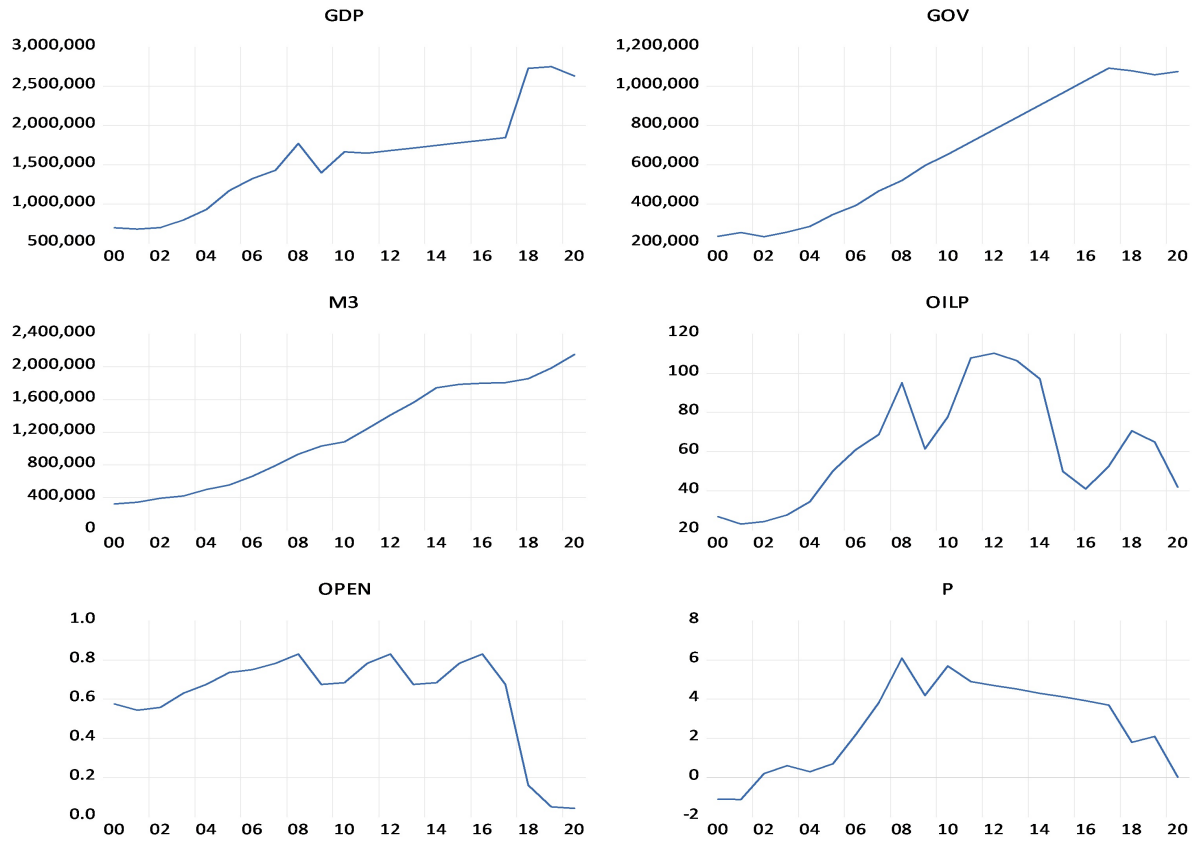

Figure 1. Time series plots of the variables. Source: Authors' Calculations (E-views 12).

5.2. Unit Root Tests

The practical application of the (GARCH) methodology requires revealing the extent of the stability of the series of the variables with the aim of examining the properties of the time series for all variables and ensuring the extent of their sta-

tionary, as the condition of stationary is a basic condition for time series analysis to reach logical results in order to know the stability of the time series and determine the degree of integration. Among the most important tests used is the Extended Dickey-Fuller (ADF) test.

Table 2. ADF unit root test.

Variable	Intercept			Trend and Intercept		
	ADF statistics	***p*-value**	**Stationary order**	**ADF statistics**	***p*-value**	**Stationary order**
GDP	−5.228	0.0005	**I(1)**	−5.070	0.0036	**I(1)**
GOV	−5.363	0.005	**I(2)**	−4.741	0.0088	**I(2)**
M3	−4.010	0.0073	**I(2)**	−4.077	0.0004	**I(2)**
P	−4.035	0.0074	**I(1)**	−4.252	0.0192	**I(1)**
OPEN	−4.848	0.017	**I(2)**	−3.973	0.0352	**I(2)**
OILP	**−3.538**	**0.0183**	I(1)	**−3.760**	**0.0427**	I(1)

Source: Authors' Calculations (E-views 12).

It is clear from Table 2 and based on the Dickey test (ADF) that all variables are not stationary at their levels. Therefore, the unit root tests were re-conducted again for these variables. The results indicated the presence of stationary for the variables (Gross Domestic (GDP), inflation (P), oil price (OIL)) in the first differences. This means that they are integrated of the first order I(1). While we find the variables (money supply (M3), government expenditure (GOV), openness (OPEN)) stabilized in the second difference, this means that it is integrated from the second order I(2) at a significance level of 5%.

5.3. Lag Selection

Estimating the lag length of VAR is an important economic exercise in empirical studies. The AIC, SBC and likelihood ratio (LR) criteria were utilized to select the optimal lag length of vector autoregressive (VAR). Table 3 presents lag order selection result on the variables considered in this study. lags(1) are selected for this study.

Table 3. VAR lag order selection criteria.

Lag	Log L	LR	FPE	AIC	SBC	Q
0	**−824.46**	**NA**	**4.78e+32**	**92.2737**	**92.57053**	92.31466
1	−688.1	166. 7*	8.90e+27*	81.125*	83.20139*	81.4103*

Source: Authors' Calculations (E-views 12). Note. *indicates optimal lag length.

5.4. Co-Integration Test

After ensuring the stability of the time series of variables, the co-integration test

is conducted using Johansen methodology (1988).

Johansen's methodology in its starting point in the (VAR) model of order p is given by the following equation:

$$y_t = \mu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t,$$

The Johansen co-integration test is considered a test of the rank of the matrix (r), and then the following cases can be obtained:

- If the rank of the matrix is equal to zero (Rank, $r = 0$), then this matrix is zero and all variables have unit roots, and the variables are not co-integrated with each other.
- If the rank of the matrix is perfect ($n = r$), then all variables do not have unit roots, that is, they are stable variables.
- If the rank of the matrix is equal to one ($r = 1$), then there is one cointegration vector.
- If the rank of the matrix is ($< r < n_1$), this indicates the presence of several co-integrated vectors.

This test is preferable to the Engel-Granger cointegration test, since it is suitable for small samples, as well as in the case of the presence of more than two variables.

Table 4. Johansen Test of Co-integration.

Hypothesized	Eigenvalue	Trace Statistic	Critical 5% Value	Prob.**
None*	0.968184	127.5281	69.81889	0.0000
At most 1*	0.826446	68.91598	47.85613	0.0002
At most 2	0.669386	39.14449	29.79707	0.0032
At most 3	0.565513	20.32885	15.49471	0.0086
At most 4*	0.303874	6.157827	3.841465	0.0131

Source: Authors' Calculations (E-views 12).

The result of Johansen co-integration test is displayed in Table 4. It is clear from the result of the (Trace test) test between the study variables that there is co-integration at the 5% level of significance, where the values of probability is less than the level of significance (0.05), which means that these time series rush to long-term equilibrium again after any deviation resulting from a temporary shock, meaning that these variables do not diverge from each other in the long run.

5.5. GARCH Model Estimation

Table 5 states the PGARCH (1, 1) model estimation results. The regression results report that (GDP, GOV, M3, OILP) are statistically significant on inflation rate. It can be noticed that the variable growth domestic product, money supply, government expenditure and Oil price reserves the probability of Z-stat is less than (0.05). Meanwhile the openness (OPEN) variable has the probability of Z-stat

more than (0.05), which means it is not significant or has no effect on inflation. The coefficient of growth domestic product (GDP) has a negative and significant effect on inflation variable as indicated by a coefficient value of (−2.157063) which implies that a 1% increase in growth domestic product would reduce inflation by (2.2%) assuming all other factors unchanged. The coefficient of determination (Adjusted R-squared), whose value is (0.588747), indicates (59%) of the variations in the dependent variable have been explained by variations in growth domestic product, money supply, government expenditure and Oil price. This result indicates the goodness of fit of the GARCH model in explaining the sources of inflation in the Kingdom of Saudi Arabia.

Table 5. PGARCH(1, 1) model estimation.

Dependent Variable : LOG(P)				
Variables	Coefficients	Std.Error	Z-stat	*P*-value
LOG (GDP)	−2.157063	0.784361	−2.750088	0.0060
LOG (M3)	0.560461	0.012302	45.55820	0.0000
LOG (OPEN)	−0.151134	0.253368	−0.596503	0.5508
LOG (GOV)	2.469909	0.842671	2.931047	0.0034
LOG (OILP)	1.565016	0.516763	3.028496	0.0025
R-squared	0.680136			
Adjusted R-squared	0.588747			

Source: Authors' Calculations (E-views 12).

5.6. Stability and Diagnostic Tests of PGARCH (1, 1) Model

Tables 6-8 and Figure 2 generally passes the several diagnostic tests for GARCH model. These tests reveal that the model has achieved desire econometric properties and the model has the best goodness of fit of the GARCH model and valid for reliable interpretation. Correlogram-Q-statistic test which is used to test for the presence of Serial Autocorrelation indicates that the residuals are not serially correlated as we can see in Table 6 that the *p*-value for all lags is greater than 5% level of significance so we cannot reject the null hypothesis that is the model has no serial correlation. ARCH test for Heteroskedasticity (see Table 7) shows that the residuals have not heteroskedasticity problem as the *p*-value (0.3414) is greater than five percent level of significance, the null hypothesis (There is no ARCH effect) is not rejected and the model does not have any ARCH effect. Similarly, the Regression Specification Error Test Nyblom confirms no miss-specification and we cannot reject the null hypothesis (No power in non-linear combinations - No miss-specification) as the *p*-value for all variables is greater than 5% level of significance. Figure 2 shows the Jarque-Bera normality test. The *p*-value (0.4157) is greater than the five percent level of significance so that cannot reject the null hypothesis (that residuals are normally distributed).

Based on these tests, it is clear that no serial correlation, no ARCH effect and the residuals are normally distributed.

Table 6. Correlogram-Q-statistic test for serial correlation.

lag	AC	PAC	Q-Stat	Prob*
1	0.194	0.194	0.8379	0.360
2	−0.079	−0.121	0.9827	0.612
3	−0.151	−0.116	1.5513	0.670
4	−0.281	−0.252	3.6579	0.454
5	−0.191	−0.133	4.7001	0.454

Source: Authors' Calculations (E-views 12).

Table 7. ARCH test for Heteroskedasticity.

0.3414	Prob. F(1, 16)	0.961545	F-statistic
0.3124	Prob. Chi-Square (1)	1.020415	Obs*R-squared

Source: Authors' Calculations (E-views 12).

Table 8. Nyblom Parameter test for Heteroskedasticity.

Variable	5% Crit.	1% Crit.	Statistic	Variable
LOG (GDP)	0.470	0.748	0.833698	Statistic
LOG (M3)	0.470	0.748	0.786624	0.833698
LOG (OPEN)	0.470	0.748	0.763753	0.786624
LOG (GOV)	0.470	0.748	0.866181	0.763753
LOG (OILP)	0.470	0.748	0.732898	0.866181
Joint	2.540	3.050	6.272346	0.998613

Source: Authors' Calculations (E-views 12).

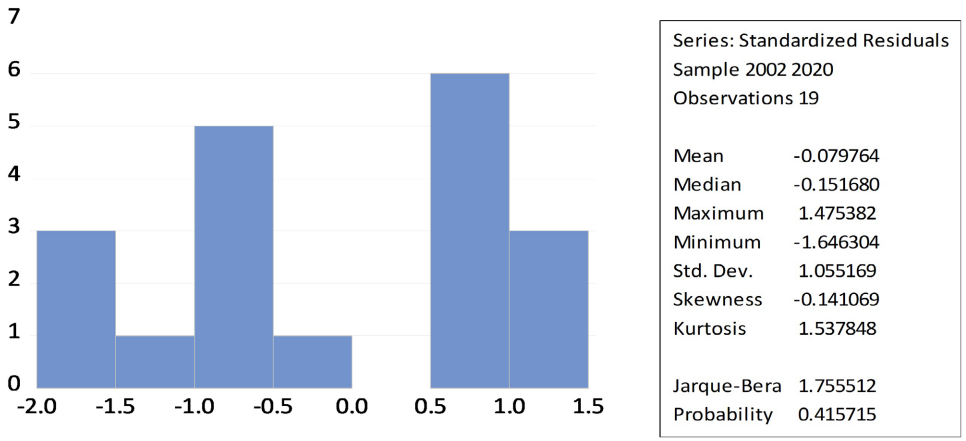

Figure 2. The Jarque-Bera normality test. Source: Authors' Calculations (E-views 12).

6. Conclusion and Recommendations

This main objective of this study is to analyze the causes of inflation in Saudi Arabia over using GARCH mode. Inflation in Saudi Arabia is measured based

on the growth rate of the Consumer Price Indexes (CPIs), released by the General Authority for Statistics. Prior to 2000 Saudi economy experienced low rates of inflation not exceeding 1%. From 2013 to 2018, Saudi Arabia's inflation rates were generally mild, dampened by government price controls and subsidies. Inflation spiked briefly in 2018 due to VAT tax implementation. The cointegration results depict the existence of a long-term equilibrium relationship between inflation and the explanatory variables. The regression results report growth domestic product, government expenditure, money supply, and oil prices are statistically significant on inflation, except openness unemployment that does not directly predict inflation rates in Saudi. The coefficient of growth domestic product (GDP) has a negative and significant effect on inflation variable as indicated by a coefficient value of (−2.157063) which means that a 1% increase in growth domestic product would likely reduce inflation by (2.2%) assuming all other factors unchanged. In the lights of all these findings, the study recommends appropriate fiscal and monetary reallocating resources towards production sectors and encouraging imports substitute policy to control inflation in the study suggests adopting a tight monetary policy, reallocating resources towards the production sector, and encouraging import substitutes to control inflation in Saudi Arabia.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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