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**Article**

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# Modelling the Impact of Oil Price on Food Imports: Case of Oman

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**ABSTRACT**

The purpose of this paper was to economically analyze and examine the causal relationship between food import bill and certain economic indicators in Oman during the period 1980-2019. The vector error correction model was used to assess the dynamics of food import bill. The finding indicates that food import bill in Oman is positively influenced by the population growth rate, and the GDP per capita, while oil prices showed a negative impact on food import bill. The error correction term suggesting 64% of the total disequilibrium in food import bill will be adjusted every year for any shock, justifiable for a dynamic economy like Oman.

**Keywords:** Food Import Bill, Vector Error Correction Model, Granger Causality, Oman, Oil Price, Gross Domestic Product, Population growth rate
**JEL Classifications:** C10; C51; C82; C87

## 1. INTRODUCTION

The global report on food crises (GRFC) 2020 indicate that over half of the 77 million people living in the Middle East and Asia face food insecurity. The situation has worsened due to the impact of the novel corona virus disease (COVID-19). Due to the virus, the United Nations projected that the number of people facing severe food insecurity worldwide by the end of 2020 may reach 265 million (CSIS, 2020), In addition, the economic disaster resulting from the Covid-19 pandemic could give rise to a global food crisis.

Countries all over the world have initiated strategies and policies to mitigate the negative consequences of food insecurity. Securing access to quality food has many benefits for the countries and the nations, boosting economic growth, reducing poverty, creating jobs, increasing trade opportunities, increasing global security and stability, and improving health status (Abdul and Ismail, 2019). According to the Food and Agriculture Organization (FAO) food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (Hassen and El Bilali, 2019).

Food security includes four dimensions: food availability meaning sufficient quantities of food available on a consistent basis (FAO, 2019); food access including sufficient resources to obtain appropriate and nutritious foods (Gross et al., 2000; Rivera and Qamar, 2003); food utilization, using appropriate food based on knowledge of basic nutrition and care (Weingärtner, 2004; FAO, 2008; Pieters et al., 2013; Pangaribowo et al., 2013); and stability in food availability, access and utilization (FAO, 2009).

Food security constitutes a major challenge in Arab countries due to the rising populations, and increased demand for food, degradation of natural resources, and conversion of farmland to urban use (Saab, 2015). Despite their efforts to reduce dependence on food from external sources, Arab countries continue to remain the largest importers of cereals (Sadik et al., 2014). In case of the Gulf countries, about 70% of the food in the GCC is imported from overseas with an estimated food retail market worth over US$50 billion annually (Middle East Food Sector, 2016). The total GCC food import bill increased from US$ 28.4 billion in 2011 to US$ 36.4 billion in 2015 and is expected to reach US$ 53.1 billion in 2020. The food import bill for all GCC countries, with no exception, has been showing a tremendous increase during the period 2011-2020. Saudi Arabia has the highest food import bill in 2020, amounting to US$ 35.2 billion, while Bahrain, and Qatar scored the lowest food import bills, amounting to US$ 1.6 billion, and US$ 3.3 billion for the two countries respectively. For Oman, the food import bill has shown a tremendous increase from US$ 2.1 billion in 2011 to US$ 3.3 million in 2015 and expected to reach 4.8 billion in 2020 (Economic Intelligent Unit, 2010). Given the high dependence of Oman on oil which is now showing a rock bottom price, food security in Oman has become a major concern for policy makers. Hence it is imperative for the policy makers in the country to address the issue with utmost priority. The increase in the population in Oman along with the decline in the oil prices constitute pressing factors on food security. As a result of which the country's need for food will increase and this in turn will cause a surge in the food import bill which will have implications on the food security of the country. With 2% growth of GDP in 2019 and estimated to grow by 3% in 2020, the government is cautious on the volatility of the oil prices, focusing on economic diversification and stresses on the need to manage the expenditure (PWC Middle East Report, 2020), thus ensuring deficit within sustainable levels while promoting economic growth. Further, the government is concentrating on diversifying its economy towards industrial, food processing, logistics, information technology, tourism, healthcare, fisheries, and higher education sectors setting a goal of 81% of GDP by 2020 for the non-oil sector (Qing and Ugo, 2002). Rising food prices threaten the macroeconomic stability in countries with poor resources and declining petroleum prices making the oil-rich countries more vulnerable to economic shocks. The impact of the population growth, oil price on food import bill in Oman, and its effect on the GDP need to be explored.

The remaining part of the paper is structured as follows. Section 2 presents the literature review. Section 3 will explain the data and the methodology used in the econometric modeling. The empirical results are presented in section 4. Finally, section 5 summarizes the findings and draws conclusions.

## 2. LITERATURE REVIEW

### 2.1. Population Growth

The world population increased from 4.4 billion to 6.0 billion from 1980 and 2000 and it is expected to reach to 9.7 billion by 2050 and 10.9 billion in 2100 (World Bank, 2009, United Nation, 2019). The population in Oman increased from 3.04 million in 2010 to 4.63 million in 2017 with a Compounded Annual Growth Rate (CAGR) of 6.20%. Due to the increasing population of Oman, the forecast of United Nation's Food and Agriculture Organization (FAO), indicated that the food imports of Oman are expected to touch $4.8 billion by 2020, when compared to $2.1 billion in 2010, given, that 60% of its food needs are met by international markets (Takagi, 2012). In the current situation, Oman is capable of financing the imports to meet the food security of its population. In the long run, it may be difficult for the country to meet its needs. Therefore, the government needs to play a vital role in integrating the programmes for controlling the population growth to maintain a balance of demand and supply of food. To achieve the goal of food security the main aim should be to control the rapid growth of population. Population growth rate is considered to be one of the determinants of food security (Aker and Lemtouni, 1999).

This leads to the development of the first hypothesis of the study as follows:

H1: Population growth induces more demand for food, leading to increase in the food import bill.

### 2.2. Gross Domestic Product (GDP) per Capita

Gross domestic product per capita or GDP growth act as an income for the country on which it relies to secure food for its nation. The GDP per capita has a positive effect on food security (Manap and Ismail, 2019; Applanaidu and Baharudin, 2014; Timmer, 2005a), as it reflects on the country's capability to import food leading to food security. The 2008 food crises resulted in the Gulf countries providing support to increase food production locally through subsidies and financial assistance. However, the share of agriculture in gross domestic product (GDP) did not increase. It amounts to only 3.9% in Oman. GDP growth is proved to be one of the factors that helps in the reduction of food insecurity despite the reduction in the share of agriculture in GDP (Ahmad and Ali, 2016). Generally, the real GDP per capita growth is being challenged particularly in regions with food insecurity (FAO, 2019). Literature proves that GDP per capita is an influencing factor of food security (Nkouka and Ndinga, 2010). Hence, the second hypothesis for the study can be stated as follows:

$H_2$: The Growth in GDP creates more demand for food and more pressure on the food import bill.

### 2.3 Oil Prices

Studies have indicated that the oil price hikes are one of the influencing major shocks experienced by agricultural markets (Al-Maadid et al. 2017, Abbott et al., 2008; Balcombe and Rapsomanikis, 2008; Chang and Su, 2010; Rosegrant et al., 2008; Yang et al., 2008). However, some studies have shown that there is no direct relationship between oil and agricultural commodity prices (Zhang et al., 2010) and any direct relationship is due to growing demand and financial developments (Gilbert and Morgon, 2010). The government revenue in the GCC was mainly due to its oil exports that contributed 50-90% during 2012 to 2015 (Efron et al., 2018). The variations of the oil prices continue to dominate all the sectors including the food sector in the GCC economies. The 2020 Oman budget estimates total revenue of OMR 10.7 billion (USD 27.8 billion) indicating an increase of 6% in comparison to the estimated revenues of 2018. Out of which OMR 7.7 billion is oil and gas revenues and remaining OMR 3 billion is estimated from the non-oil and gas revenues. With 2% growth of GDP in 2019 and estimated to grow by 3% in 2020, the government is cautious on the volatility of the oil prices, focusing on economic diversification and stresses on the need to manage the expenditure (PWC Middle East Report, 2020). Rising food prices threaten the macroeconomic stability in countries with poor resources and declining petroleum prices making the oil-rich countries more vulnerable to economic shocks. Oman being highly dependent on oil revenues, the decline in the oil prices will affect its ability to import food resulting in food insecurity. The study conducted by Baffes et al. (2015) indicated that oil price is one of the factor influencing food security. Therefore, the third hypothesis for the study to be validated can be stated as follows:

$H_3$: The increase in oil prices leads to increase in the capacity of the government to import more food.

## 3. DATA AND METHODOLOGY

To examine the determinants of food security, the annual time-series data for the model has been generated from the World Development Indicators (World Bank group, 2020). The variables are derived from a myriad of literature related to food security presented in Table 1. The data were converted to their natural logarithms to reduce variability and ensure normality of the data.

This study adopts a vector error correction (VEC) model and Granger causality approach to investigate the relationship between food import bill and gross domestic product per capita, oil price and population over the time spanning from 1980 to 2019.

The variables have been subjected to pre-test of stationarity before actual estimation process. However, the justification for adopting vector auto regressive (VAR)/vector error correction (VEC) model is subject to co-integration test result as well as given that VEC treats all the variables in both dynamic and static models as a priori endogenous and thus control for interactions between endogenous and exogenous variables (Luetkepohl, 2011).

If a set of variables are found to be co-integrated, that is there exists a linear, stable and long-run relationship among variables, such that the disequilibrium errors would tend to fluctuate around zero mean and then a suitable estimation technique is a VECM which adjusts to both short run changes in variables and deviations from equilibrium. In literature, co-integration tests, e.g., Engle and Granger (1987), Johansen (1988), Johansen and Juselius (1990), Pesaran et al. (2001) are used to confirm the presence of potential long run equilibrium relationships between two variables. Johansen's technique is used in order to establish how many co-integration equations exist between variables.

In case of co-integration and VECM in time series analysis, a spurious relationship arises when a vector auto-regressive (VAR) model is applied to the series that are integrated (Brooks, 2008). The solutions recommended are either using a VAR model on first difference or using a vector error correction model (VECM). The differentiating of non-stationary variable removes long-run relationships among variables which could otherwise result in meaningful interpretations (Nkoro and Uko, 2016). The second solution is preferred as it provides the long relationship and produces efficient coefficient estimates (Hoffman, 1996). The VECM equation is given as follows:

$$\Delta z_t = \pi z_{t-1} + \sum_{t=1}^{k-1} T \Delta z_{t-1} + m + \varepsilon_i \tag{1}$$

Where $z_t$ is (n×1) vector of the n variables, with m is (n×1) vector of constants. $T$ represents (n×(k-1)) matrix of short-run coefficients, $\varepsilon_i$ denotes a (n×1) vector white noise residuals and π is a (n×n) coefficient matrix. If the π matrix has reduced rank (0<r<n), it can be split into (n×r) matrix of loading coefficients α and a (n×r) matrix of co-integrating vectors β.

The estimated econometric model is a four variable model which hypothesize the food import bill as a function of gross domestic product per capita (current), oil price and population.

Food import Bill = *f (*GDP per capita, Oil Price, Population).

All the variables were converted to natural logarithms(ln) in order to reduce the variability in the variables and provides robust empirical results compared with the simple linear specification (Shahbaz et al., 2015).

Although most economic series are non-stationary, it is possible to have a stationary linear combination of integrated variables. Such variables are said to be co-integrated. The appropriate way to treat the co-integrated variables is to apply the VEC model because it allows better understanding of non-stationary variables and also improves longer term forecasting (Žiković and Vlahinic-Dizdarevic, 2011).

The empirical analysis consisted of several steps. First, the unit root tests were used to examine the presence of non-stationarity in variables. Secondly, the existence of co-integration between food import bill and macroeconomic variables was investigated. Finally, the achieved results were used to estimate the VECM relationship. The precondition that has to be fulfilled in order to perform a co-integration analysis is that each of the variables must be integrated of the same order. To determine the existence of co-integration, one must first test whether each variable contains a unit root and if variables are integrated of the same order.

When the trace test and max-eigenvalue test indicate the same results of co-integration vector, it can be concluded that variables are bound together by a long-term equilibrium relationship. Once the co-integration vector had been detected, the VEC model was estimated.

To capture the short-term deviations of series from their long-term equilibrium path, Granger causality requires inclusion of an error term in the stationary model (Granger, 1986). Therefore, to identify the causality of the variables, Granger causality test is used and the equation is as below

$$\Delta y_t = \alpha_1 + \alpha_y \left( y_{t-1} - \beta_{z_{t-1}} \right) + \sum_{i-1}^{p} a_{11}^{(i)} \Delta y_{t-i} + \sum_{i-1}^{q} a_{12}^{(i)} \Delta z_{t-i} + \varepsilon_{yp} \tag{2}$$

The terms in parentheses are the error correction terms (ECTs). $z_t$ is said not to Granger-cause $y_t$ if $z_t$ cannot help predict future y.

## 4. EMPIRICAL RESULTS

The Table 2 presents the descriptive statistics of the data.

It is observed that the mean and median are close to equal. The Jarque-Bera test indicates the probabilities of the variables are >0.5 justifying the acceptance of the null hypothesis of a normal distribution. Thus, indicating the distribution of all the variables are normal.

The commonly accepted ADF (Augmented Dickey-Fuller) unit root test is adopted to the stationary test of Food import bill (proxy for food security), GDP per capita, oil price, Population. This test is better, compared to the other unit root testing techniques (Nkoro and Uko, 2016). The test results in Table 3 show that level value of the four sequences is non-stationary, and further test indicates Food import bill, GDP per capita, Oil Price, Population are first-order difference stationary. First-order difference is calculated in order to reduce the fluctuations of the data. The four new series Food import bill, GDP per capita, Oil Price, Population are obtained, and their unit root test results are also shown in Table 3.

The first step in the VAR model is to determine Lag intervals for endogenous variables. The larger the lag intervals for endogenous variables, the more it can entirely reflect the dynamic nature of the model. There are different methods that can determine optimal lag period for the VAR model. In comprehensive consideration of selecting Lag Intervals for Endogenous variables, the researcher adopted lag length criteria to determine lag intervals for endogenous, as shown in Table 4.

According to Table 4, after the comparison of lag length criteria, it can be found that the optimal lag order for the VAR model is 4. The VAR (lag period is 4th order) model is established with an econometric software, as shown in Table 4.

The key of co-integration test lies in selecting proper form of co-integration test and lag order. Co-integration relationship between variables in the VAR model is generally tested with the Johansen (1988) and Johansen and Juselius (1990) method. Johansen co-integration test on food import bill, GDP per capita, oil price, population is applied. Table 5 shows that, in both trace and maximum eigen value test, test results are to accept the null hypothesis, under the 5% level. This means there are stable and long-term equilibrium relationships among the variables. On the premise of the existence of co-integration relationships, Vector Error Correction modeling can be further conducted.

Co-integration analysis demonstrates that GDP per capita, Oil prices, Population and Food Import Bill do have long-run equilibrium relationships, but, in the short term, the three are in disequilibrium. The short-term imbalance and dynamic structure can be expressed as VEC model. Since the lag order of VAR is 4, VEC model's lag order should be 4-1=3. Accordingly, VEC model is established with an EViews, an econometric software.

Therefore, co-integrating equation of VEC model is with reference to Table 6. $ECT_{(t-1)} = -2.4241 Ln(GDPPRC_{t-1}) + 0.8671 Ln(OILPRICE_{t-1}) - 0.2803 Ln(POP_{t-1}) + 2.4435$

**Table 1: Variables, symbols and previous studies**

| Variables | Symbols | Sources | Studies |
|---|---|---|---|
| Food import bill | FIB | National Centre for Statistics and Information Centre (NCSI) Oman/World Data Bank | • Konandreas and Valdés (1980) |
| Gross domestic product per capita | GDPPRC | National Centre for Statistics and Information Centre (NCSI) Oman/World Data Bank | • Manap and Ismail, (2019)<br>• Applanaidu and Baharudin (2014)<br>• Timmer, 2004 |
| Oil price | OILPRICE | US energy information Administration (EIA) | • Al-Maadid et al. (2017)<br>• Abbott et al.(2008)<br>• Balcombe and Rapsomanikis (2008)<br>• Chang and Su (2010) |
| Population | POP | National Centre for Statistics and Information Centre (NCSI) Oman/World Data Bank | • Applanaidu and Baharudin (2014)<br>• David et al. (2010)<br>• Hanif et al. (2019) |

**Table 2: Descriptive statistics**

| Variables | Mean | Median | Maximum | Minimum | Standard deviation | Jarque-Bera | Probability |
|---|---|---|---|---|---|---|---|
| Ln (FIB) | 20.789 | 20.736 | 22.101 | 19.389 | 0.833 | 2.644 | 0.266 |
| Ln (GDPPRC) | 9.1468 | 8.952 | 10.004 | 8.453 | 0.524 | 4.436 | 0.109 |
| Ln (OILPRICE) | 3.547 | 3.377 | 4.718 | 2.543 | 0.653 | 2.850 | 0.240 |
| Ln (POP) | 14.669 | 14.631 | 15.435 | 13.959 | 0.390 | 0.963 | 0.618 |

**Table 3: Unit root test results of sequence level values**

| Variables | Level critical values | | | | | First difference critical values | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1% | 5% | 10% | T-Statistic | P-value | 1% | 5% | 10% | T-Statistic | P-value |
| Ln (FIB) | −3.62 | −2.95 | −2.61 | −0.6692 | 0.8432 | −3.62 | -2.94 | −2.61 | −9.853 | 0.0000 |
| Ln (GDPPRC) | −3.61 | −2.94 | −2.61 | −0.7217 | 0.8294 | −3.62 | -2.94 | −2.61 | −6.4997 | 0.0000 |
| Ln (OILPRICE) | −3.61 | −2.94 | −2.61 | −1.0127 | 0.7393 | −3.62 | -2.94 | −2.61 | −5.8382 | 0.0000 |
| Ln (POP) | −3.64 | −2.95 | 2.61 | −0.4246 | 0.8937 | −3.65 | 2.96 | −2.62 | −3.2252 | 0.0276 |

**Table 4: Lag intervals for endogenous variables with lag length criteria**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 11.87798 | NA | 7.59e-06 | −0.437666 | −0.261719 | −0.376255 |
| 1 | 178.5680 | 287.0772 | 1.77e-09 | −8.809332 | −7.929600 | −8.502282 |
| 2 | 229.3318 | 76.14569 | 2.66e-10 | −10.74065 | −9.157135 | −10.18796 |
| 3 | 259.1379 | 38.08555 | 1.35e-10 | −11.50766 | −9.220354 | −10.70933 |
| 4 | 303.9021 | 47.25116* | 3.31e-11* | −13.10567* | −10.11458* | −12.06170* |

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

**Table 5: Results of cointegration test**

| Unrestricted cointegration rank test (trace) | | | | | Unrestricted cointegration rank test (maximum eigenvalue) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Hypothesized No. of Cointegrating equation (CEs) | Eigenvalue | Trace statistic | 0.05 critical value | Prob.** | Hypothesized No. of Cointegrating equation (CEs) | Eigenvalue | Max-Eigen | 0.05 critical value | Prob.** |
| None* | 0.728 | 90.450 | 47.856 | 0.0000 | None* | 0.728 | 45.610 | 27.584 | 0.0001 |
| At most 1* | 0.522 | 44.839 | 29.797 | 0.0005 | At most 1* | 0.522 | 25.853 | 21.131 | 0.0100 |
| At most 2* | 0.416 | 18.986 | 15.494 | 0.0143 | At most 2* | 0.416 | 18.841 | 14.264 | 0.0088 |

Trace test indicates 3 cointegrating eqn (s) at the 0.05 level. *denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) P-values

**Table 6: Results of cointegration equation**

| Cointegrating equation | CointEq1 |
|---|---|
| Ln (FIB (−1)) | 1.0000 |
| Ln (GDPPRC (−1)) | −2.4241 |
| | [-4.0810] |
| Ln (OILPRICE (−1)) | +0.8671 |
| | [2.4672] |
| Ln (POP (−1)) | −0.2803 |
| | [−0.7589] |
| C | 2.4435 |

The signs will be reversed in the interpretation. From this equation it can be seen that, each percentage-point increase in GDP per capita will cause the increase of 2.4241 percentage points in food import bill, each percentage-point decrease in oil prices will cause the increase of 0.8671 percentage points in food import bill and each percentage-point increase in population will cause the increase of 0.2803 percentage point in food import bill. However, there is no significant relationship between oil prices and food import bill, which is inconsistent with the general economic situation.

Based on the co-integration equation, the relevant adjustment parameter of the underlying vector (coefficient of the error correction term) was defined and included in the VEC model. Negative and a statistically significant value of coefficient of error correction term, reports and validates the presence of long -run equilibrium association between variables (Brooks, 2008). Table 4 shows that the adjustment coefficient has the appropriate negative sign and is statistically significant. This implies that the null hypothesis of no co-integration can be rejected. The adjustment coefficient measures the speed with which Food import Bill converges to its long-run equilibrium, meaning that 64% of deviations are eliminated from the long-run equilibrium in each year. Hence indicating the adjustment towards the equilibrium takes place at 64% per annum.

Co-integration tests indicates a long-term equilibrium relationship between the two variables, but, in terms of causal relationship, further testing is needed. The Granger Causality Test was applied to find the causality between the variable and the results of the granger causality test shown in Table 8.

The Granger causality results indicate that oil prices, population and food import bill are non-granger causes of each other, while there is a unidirectional causality at 10% significance level running from Gross Domestic Product per capita to food import Bill.

## 5. CONCLUSIONS

The analysis reports that the food import bill, is positively related to population and GDP per capita, which means that Food import bill increases as GDP per capita and population increases indicating the acceptance of the $H_1$ and $H_2$. The results are inconsistent with the literature (Nkunzimana et al., 2016; Porkka et al., 2017). It is observed that out of the two determinants, GDP per capita has the maximum influence on food import bill which has implications on food security. However, the analysis leads to the rejection of the hypothesis $H_3$ indicating, oil price has a negative impact on food import bill.

With production of <1 million b/d of oil, the Sultanate of Oman has less oil and gas reserves compared to its GCC neighbors, except Bahrain (World Bank, 2016). In the long run, according to a number of estimates, Oman's oil resources is expected to be depleted by the year 2022 (Ibrahim and Abdel-Gadir, 2015) resulting that Oman is expected to be a net oil importer. Therefore, if the oil prices are high, the food import capacity will be less. The 64% adjustment in the Error Correction term of the food import bill of the co-integration equation indicates that if any disequilibrium occurs, the system adjusts in 1 year which is justifiable for a dynamic economy like Oman (Pourreza et al., 2018). The government is actively pursuing a development plan to tackle the threat of diversifying Oman's oil-dependent economy by aiming to reduce the oil sector's GDP contribution to nine per cent by 2020 (Lehane, 2015). It is very imperative for Oman to develop a vibrant food security strategy to cater for

**Table 7: VECM estimation results and test**

| Error correction: | D (LNFIB) | D (LNGDPPRC) | D (LNOILPRICE) | D (LNPOP) |
|---|---|---|---|---|
| CointEq1 | −0.642111 | −0.141223 | −0.354703 | −0.005104 |
| | (0.33358) | (0.15896) | (0.31646) | (0.00122) |
| | [−1.92488] | [−0.88843] | [−1.12084] | [−4.16687] |
| D (LN FIB(−1)) | −0.283137 | 0.119464 | 0.253974 | 0.004037 |
| | (0.33957) | (0.16181) | (0.32214) | (0.00125) |
| | [−0.83381] | [0.73829] | [0.78839] | [3.23761] |
| D (LN FIB(−2)) | −0.224137 | 0.011696 | 0.023852 | 0.001960 |
| | (0.30451) | (0.14510) | (0.28888) | (0.00112) |
| | [−0.73607] | [0.08060] | [0.08257] | [1.75341] |
| D (LN FIB(−3)) | −0.020157 | −0.029199 | −0.015189 | 0.000970 |
| | (0.22234) | (0.10595) | (0.21093) | (0.00082) |
| | [−0.09066] | [−0.27559] | [−0.07201] | [1.18847] |
| D (LNGDPPRC(−1)) | −0.993809 | −1.165156 | −1.956053 | −0.005793 |
| | (1.18157) | (0.56304) | (1.12092) | (0.00434) |
| | [−0.84109] | [−2.06941] | [−1.74504] | [−1.33542] |
| D (LNGDPPRC(−2)) | −0.237138 | −0.024497 | −0.216881 | −0.006596 |
| | (1.17469) | (0.55976) | (1.11439) | (0.00431) |
| | [−0.20187] | [−0.04376] | [−0.19462] | [−1.52932] |
| D (LNGDPPRC(−3)) | 0.555885 | −0.304595 | −0.727069 | −0.000440 |
| | (0.92495) | (0.44075) | (0.87747) | (0.00340) |
| | [0.60099] | [−0.69108] | [−0.82859] | [−0.12957] |
| D (LNOILPRICE(−1)) | 0.515523 | 0.479028 | 0.569874 | 0.001047 |
| | (0.50515) | (0.24071) | (0.47922) | (0.00185) |
| | [1.02054] | [1.99005] | [1.18917] | [0.56467] |
| D (LNOILPRICE (−2)) | 0.460784 | −0.065182 | −0.240039 | 0.001678 |
| | (0.52935) | (0.25224) | (0.50218) | (0.00194) |
| | [0.87048] | [−0.25841] | [−0.47800] | [0.86350] |
| D (LNOILPRICE (−3)) | −0.259566 | 0.136991 | 0.188710 | −0.000199 |
| | (0.45492) | (0.21678) | (0.43158) | (0.00167) |
| | [−0.57057] | [0.63193] | [0.43726] | [−0.11910] |
| D (LN POP(−1)) | 11.40527 | 1.611422 | 9.105399 | 2.545659 |
| | (24.3865) | (11.6206) | (23.1348) | (0.08954) |
| | [0.46769] | [0.13867] | [0.39358] | [28.4310] |
| D (LNPOP(−2)) | −34.90256 | −5.219337 | −15.87693 | −2.434302 |
| | (45.8774) | (21.8614) | (43.5227) | (0.16844) |
| | [−0.76078] | [−0.23875] | [−0.36480] | [−14.4516] |
| D (LNPOP(−3)) | 28.54665 | 1.027507 | 0.046173 | 0.865374 |
| | (25.5838) | (12.1911) | (24.2707) | (0.09393) |
| | [1.11581] | [0.08428] | [0.00190] | [9.21255] |
| C | −0.083205 | 0.155385 | 0.333110 | 0.000672 |
| | (0.15668) | (0.07466) | (0.14864) | (0.00058) |
| | [−0.53104] | [2.08119] | [2.24106] | [1.16764] |
| R-squared | 0.524591 | 0.391619 | 0.414610 | 0.998172 |
| Log likelihood | 4.907386 | 31.59242 | 6.804242 | 206.7637 |
| Akaike AIC | 0.505145 | −0.977356 | 0.399764 | −10.70910 |
| Schwarz SC | 1.120958 | −0.361543 | 1.015577 | −10.09328 |

The data in Table 7 shows the fitting degree of VEC model , $R^2$>0.5

**Table 8: Granger causality test results**

| Null hypothesis: | Observations | F-Statistic | Prob. | Decision | Causality |
|---|---|---|---|---|---|
| LNFIB does not Granger Cause LNGDPPRC | 37 | 0.18904 | 0.9030 | Accept | No |
| LNGDPPRC does not Granger Cause LNFIB | | 2.32025 | 0.0953 | Reject | Yes |
| LNFIB does not Granger Cause LNOILPRICE | 37 | 0.67933 | 0.5716 | Accept | No |
| LNOILPRICE does not Granger Cause LNFIB | | 2.22640 | 0.1056 | Accept | No |
| LNFIB does not Granger Cause LNPOP | 37 | 0.20176 | 0.8944 | Accept | No |
| LNPOP does not Granger Cause LNFIB | | 2.19268 | 0.1095 | Accept | No |

its increasing population and increasing demand for food., which may otherwise result in health repercussions and impact attaining sustainable development goals in the long term. Thus, a proper food security strategy is highly recommended to the policy makers in Oman to take into consideration, population dynamics, growth of the GDP, and changes in government income sources of oil. Promoting the diversification of the economy, and increasing the share of agriculture in the GDP, and controlling population growth could be some options to address the challenges of food security in Oman.

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