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IMPACT OF THE TOTAL EXPENDITURE SHOCKS ON FOOD SECURITY: VAR MODEL

Purpose. *This study examines the causal relationship between total expenditures and food availability and identifies their shocks in food availability in Saudi Arabia.*

Methodology / approach. *The study uses a multivariate modeling technique of the Vector Autoregression (VAR) and its environment, the Granger Causality Test, Forecast Error Variance Decomposition (FEVD), and Impulse Response Function (IRF) for the observation period of 2000–2020 in Saudi Arabia.*

Results. *The results of the Granger causality show that investment expenditure has a significant impact on food availability in Saudi Arabia. However, consumption and government expenditures do affect food availability in Saudi Arabia, but have an indirect effect. The Impulse Response Functions show that the shocks of the selected variables require a long period to reach the long-run equilibrium level and the greatest response of the food availability variable is explained by its own shock and investment expenditure shocks.*

Originality / scientific novelty. *The novelty of this study is related to the investigation of a new model and focus on a new perspective. While traditional food security research has mostly concentrated on agricultural production, availability, and accessibility of food, as well as nutrition and health outcomes factors, this research conveys a new dimension by highlighting the link between total expenditure and food security. Their contribution expands the scope of food security research and highlights the impact of recognising the role of total expenditure in implementing and supporting food security at the household level.*

Practical value / implications. *It is important to design strategies and develop a budgeting plan to allocate a reasonable portion of total consumption and government expenditures on food items. Adding, regularly reviewing, and adapting the budgeting plan based on new challenges, and evolving priorities are essential to address the dynamic nature of food security.*

Key words: *food security, Saudi Arabia, sustainability, VAR, Granger causality.*

1. INTRODUCTION

According to the report of the Committee on World Food Security (CFS) sponsored by The Food and Agricultural Organization of the United Nations (FAO) [1], food security has four dimensions (availability, access, utilisation, and stability). Availability of food is the presence of enough food to feed the population, within a defined boundary, such as local, national, continental or global, and food security assessment requires evidence of food availability, also availability is related to the physical availability of food; this can involve foods obtainable / served in different locations [2; 3]. The combination of the Covid-19 pandemic, war, and economic crisis

has led to the biggest food crisis globally [4] and to solve the problem of overcoming the food crisis, many countries have developed strategies and implemented economic reforms.

In the context of Saudi Arabia, according to the National Transformation Program, which aims to reduce dependence on oil revenues and diversify sources of income to achieve fiscal balance, Saudi Arabia's Vision 2030 has contributed to enhancing public financial sustainability, the most important of which is increasing the efficiency of total expenditures [5]. In addition, the increase in total expenditure indicates an improvement in the standard of living and life in society. Saudi Arabia is currently seeking self-sufficiency and achieving food security for all food commodities [6]. The Arab region faces serious food self-sufficiency, and the gap between food production and consumption is increasing, so the imported food has increased [7]. It has also been noted recently that most major industrialised countries are striving for self-sufficiency and sustainable food security [8].

With the announcement of Saudi Arabia's Vision 2030, Saudi Arabia ranked seventh in the efficiency of government expenditure, according to the World Bank's 2017 report [9]. The percentage of government expenditure in Saudi Arabia compared to the rest of the world was estimated at 0.66 % for the year 2019 based on the FAO report [10]. It was noted that the total government consumption expenditure for Saudi Arabia during the year 2017 was estimated at Riyals 630,978 million compared to Riyals 183,804 million in the year 2000 and the percentage of expenditure increased by around 68.86 % in 2020 [11].

Statistically, the average value of food production in Saudi Arabia reached 34 % compared to the rest of the world, and the food energy supply used to estimate the prevalence of undernourishment was estimated at an average of three years (2018–2020) at 3308 calories/day. Based on the data of the Saudi General Authority Statistics [12], it was noted that the percentage of the value of food imports in the total merchandise exports is estimated at 7% with an average of three years (2017–2019). For assessing the local capability to meet food consumption, the vision confirmed the achieving actual self-sufficiency such as natural resources, land, water, food, and energy [8; 13; 14].

Most empirical approaches assess domestic production capacity by estimating the total volume of Gross Domestic Product (GDP) for human consumption and comparing it with estimates of domestic consumption [15; 16] or with domestic consumption targets in terms of the amount taken or energy requirements [17].

In the past decades, the economic and social lifestyle in Saudi Arabia has changed, which led to an increase in the proportion of total expenditure in parallel with the cost of living. Due to the importance of total expenditure and its components in macroeconomics and their relationship to output and total income and the increase in value added, this has led to increased investment opportunities for self-sufficiency in some food commodities. On the other hand, the rise in food prices as a global crisis, the steady increase in population, climate change, and declining productivity have directly affected the global economy. In this context, Saudi Arabia has accelerated the

issuance of some economic reforms denoted in Saudi Arabia's Vision 2030 and other important reforms. One of the most important strategies that Saudi Arabia seeks to achieve is to enhance food security and achieve food self-sufficiency by increasing investment expenditures in rich raw materials countries [5].

Even though there are developments in the Saudi economy, food security in the country is at risk due to increasing demand for imported food caused by an increasing population, climate change, and other food security challenges. The present study aims to analyse the causal relationship between total expenditures and food availability and to identify their shocks in food availability in Saudi Arabia. Thus, the importance of this study is focused on promoting Saudi Arabia's Vision 2030 in increasing total expenditure to achieve food security in the country and in addition to filling the research gap in studies related to total expenditure and food security in Saudi Arabia. The novelty of this study is attributed to the investigation of a new model and focus on a new perspective. While traditional food security research has mostly concentrated on agricultural production, availability, and accessibility of food, as well as nutrition and health outcomes factors, this research opens a new dimension by highlighting the link between total expenditure and food security. Their contribution expands the scope of food security research and highlights the impact of recognising the role of total expenditure in implementing and supporting food security at the household level. While these aspects are undoubtedly crucial, the connection between total expenditure and food security takes a broader perspective by recognising the multifaceted nature of household food security.

2. LITERATURE REVIEW

In recent years there has been increased considerable attention to food security worldwide and extensive different disciplines of food security research were carried out that address advanced methods of analysis. Some of them use cross-section, time series data, and panel data. Kiboi et al. [18] used the conceptual model and the meta-analysis method of the previous studies to detect the determinants of food security and found that households in urban areas experienced a decline in food security compared to households in rural areas. Food availability is the most studied component while food consumption is the most neglected component in the studies [19]. Moreover, Calloway et al. [20] performed a multivariate logistic regression model for analysing new self-administered measures of food security, the findings showed that the new measures are useful for assessing risk for poor dietary and health outcomes even after controlling for household food security status and sample characteristics.

Global food security is threatened by a combination of increasing demand for food due to population growth and the inability of the food production system to meet increasing demand due to climate change, declining soil fertility and water availability issues. In this context, some scholars investigated the connection between the growing population and food security and confirmed that population dynamics negatively affect food security and food insecurity is rising because of increasing population growth and dependence on imported food [21; 22]. Another study investigated the future global

impacts of population on food security to 2050, using the modeling framework food estimation and export for diet and malnutrition evaluation, it confirmed that countries with an expected decrease in population growth had developed food security and this is vice versa for those countries with a predictable fast population growth [23]. Additionally, Elzaki [24] using three alternatives of panel data analysis, pooled ordinary square, fixed, and random effect observes that population is a significant driver of food security challenges in the Gulf Cooperation Council (GCC) countries.

Several studies investigated the impact of expenditures on food security using the household survey and concentrated on household food expenditure rather than micro expenditure [25; 26; 27]. Most studies investigate the indirect impact of the total expenditure on food security at the micro level via a share of the government expenditure on agriculture production. For instance, the study applied a panel data analysis using a fixed effect generalised least squares estimation to examine the effect of public expenditure on agricultural production and found that public expenditure on agriculture has a significant positive impact on food security [28]. Additionally, Gong [29] used a semi-parametric production function and found that public expenditure has positive effects on agricultural productivity and hence ensures food security. Soko et al. [30] examined fixed effects models supported with robust standard errors using unbalanced panel data and found that public investment increased agricultural productivity and ensured food security.

Several studies linked food security and socioeconomic factors. Ali et al. [31] using multivariable models, linear regression, and logistics regression showed that increasing maternal education and household wealth were found to have a positive significant impact on food security among children. There was an interaction effect between land size and larger families with food insecurity. However, education, crop diversity, and livestock ownership variables were not significantly related to food security [32].

Investment expenditure is vital for food security at the country level and the universal level. With rising food prices, it can be expected that investments will become more attractive to the country to secure food. Tofu et al. [33] performed qualitative methods by categorisation approach to analyse the relationship between food security and energy investment finding that biomass energy could increase food security.

Regarding food availability, most of the studies investigated food availability at the household level expenditures by field survey methods for identifying the root causes of food insecurity [34; 35]. For instance, Hernández-Solano et al. [36] used household income and expenditure surveys applying a descriptive analysis to investigate the food nutrient intake among Mexican households. Considering differences by income level, the results confirm a positive relationship between access to nutrients and income. Besides, Hasanah et al. [25] examined the impact of migration on food expenditure and household food security in eastern Indonesia. The study found that migration significantly increases food expenditure and overall household expenditure. From the literature, several studies investigated the relationship between

food security and other aspects rather than the expenditures aspect in Saudi Arabia. Amoak et al. [37] focused on the impact of climate change on food security and found that food security is directly related to climate change.

Even though food security might investigate many significant areas, other new dimensions should still be considered [38]. Therefore, we conclude that from the literature review, most studies evaluated and addressed food security using different approaches but few studies applied the Vector Autoregressive (VAR) approach to investigate food security [39]. For instance, Taghizadeh-Hesary et al. [40] using panel data for analysing food security and energy prices, found that there is a linkage between energy and food security through price volatility. Jeder et al. [41] applied the VAR model to investigate food security in Tunisia and reported a short-term causal relationship between food security and land under cereals, inflation, and food imports. Also confirmed that food security is a question of threat in the short and long-term instability. These researchers focused on analysing food security with food price and inflation and ignored the relations between food security and expenditure. Thus, this study will enrich the existing empirical literature on measuring the connection between total expenditure and food security, and investigators will be able to highlight the policy and practical implications of the results and fill the gap of food security review. Furthermore, by estimating the model with historical data, researchers can generate predictions of food availability based on different components of the total expenditure. This can assist policymakers in assessing the potential impact of different economic scenarios on food availability and making informed decisions.

3. METHODOLOGY

Saudi Arabia was selected as a case study to support Saudi Arabia's Vision 2030, which included several strategic objectives, including national strategies for investments that will drive the growth of local and foreign investments for the country. The strategic objectives, targets, and programs in Saudi Arabia's Vision 2030 appeal to reduce overall expenditure and close the food gap. One of the primary goals of Saudi Arabia's vision is to accomplish an Agricultural Transformation Program that effectively addresses the risks to food security. The main objective of this transformation is to attain a comprehensive and sustainable food security system in Saudi Arabia.

Most empirical studies of the influence of total expenditure and food security have been investigated using time series data in attempts to explain the observed differences in food security dimensions. Therefore, this study relied upon annual time series data collected from various organisations that considered food security issues such as the FAO [10], the General Authority for Statistics [42], and the Saudi Central Bank [11]. The collected annual time series consists of macro-level data for the duration of 2000–2020 (due to the availability of food security datasets during this era).

The total expenditure components data were collected and presented as explanatory variables covering the consumption expenditure (CONE) in (USD), government expenditure (GOVE) in (USD), and investments expenditure (INVE) in

(USD). The government expenditure involved the expenditures for general services, defence, education, health, different services etc. whereas the investment expenditure includes both internal and external investments. The dependent variables in the study act as food security indicator is the average value of food production represented as food availability (FAV) per capita in USD, the choice of these variables is based on research by previous literature and data availability. We selected the food availability indicator because food availability helps to assess the overall food security situation in a given region or country. In addition, according to FAO [43], food availability indicators are closely linked to the SDGs, particularly Goal 2 (Zero hunger), which aims to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture.

Table 1 presents the description of the variables, measuring units, and data sources. The study estimated descriptive statistics for each of the data series to find its key statistics of the actual values of the interested variables in Saudi Arabia. From Table 1, GOVE has the highest average value (USD 283052.85 million) with a maximum (USD 394446.61 million) and minimum value (USD 159070.62 million). The lowest means of expenditure is INVE (USD 15764.91 million) with a maximum value (USD 42953.48 million) and a minimum value (USD 549.63 million). On the other hand, food availability has an average value (USD 133.24 per capita) with a maximum (USD 137 per capita) and minimum values (USD 129 per capita). The standard deviation in comparison with the mean is low for all the variables, which indicates a small coefficient of variation.

Table 1

Statistical summary of the selected variables

Variable	Explanation and units	Mean	Std. dev.	Min	Max	Obs.	Data sources
FAV	The average value of food production (food availability) in USD per capita ^a	133.24	2.41	129.00	137.00	22	FAO
CONE	Consumption expenditure in millions of USD ^{b, c}	283052.85	89178.17	159070.62	394446.61	22	SCB and GAOs
GOVE	Government expenditure in millions of USD ^{a, c}	122513.57	59555.83	49014.40	215301.26	22	SCB and GAOs
INVE	Investment expenditure in millions of USD ^{a, c}	15764.91	11912.48	549.63	42953.48	22	SCB and GAOs

Note. a, b, and c, are the sources of data.

Source: authors' calculation based on FAO [18; 10]^a, GAOs [19]^b, SCB [20]^c.

Econometric approach. Before the empirical analysis, all variables are transformed into logarithmic form to reduce heteroscedasticity. Our study analyses the preliminary tests and econometric approaches for addressing the influences of total expenditure on food security.

Unit roots. First, the study examines the unit root test including the Augmented Dickey-Fuller (ADF) test [44], and Phillips and Perron [45] tests to detect the non-

stationary problem in the data. The null hypothesis is that the variable contains a unit root, and the alternative is that a stationary process has generated the variable. Furthermore, the study tests the Kwiatkowski-Phillips-Schmidt-Shin, KPSS [46] to overcome the limitations of tests of ADF and PP. The failure to reject the null hypothesis in the KPSS test corresponds to the rejection of the null hypothesis in the ADF and PP tests. In addition, this test is more powerful in small samples [47].

Dickey-Fuller (DF) [44], and Phillips and Perron (PP) [45] unit root tests will be biased [48] and will not take into account the possibility of a structural break. Therefore, [48] stated that, before the estimation of the VAR model, unit root tests should be performed for testing the integration rank of each variable for the unknown break date, additionally, it is significant to consider the probability of a break in trend. Zivot and Andrews [49] propose an improvement of the Perron (1989) test, where they assume that the exact breakpoint is unknown and endogenise the definition of the break date. As suggested by Zivot and Andrews [49] and Perron's [50] tests for unknown break dates, the critical values were obtained by applying the break date estimated using the minimum t-statistic for unity. Hence Zivot and Andrews, [49] proposed the models of structural unit roots models.

Therefore, to test for the presence of a unit root in the one-time structural adjustment alternative, we applied the Zivot and Andrews regression equations corresponding to models A, B and C in this study and adopted the following forms of equations:

$$\text{Model (A)} \quad \Delta Y_t = K + \alpha Y_{t-j} + \beta_t + \gamma_i UD_t + \sum_{j=1}^k d_j \Delta Y_{t-j} + \varepsilon_i, \quad (1)$$

$$\text{Model (B)} \quad \Delta Y_t = K + \alpha Y_{t-j} + \beta_t + \theta UD_t + \sum_{j=1}^k d_j \Delta Y_{t-j} + \varepsilon_i, \quad (2)$$

$$\text{Model (C)} \quad \Delta Y_t = K + \alpha Y_{t-j} + \beta_t + \theta UD_t + \gamma_i DT_t + \sum_{j=1}^k d_j \Delta Y_{t-j} + \varepsilon_i, \quad (3)$$

where Δ is the first difference;

Y_t denotes variables series contains unit root referring to FAV, CONE, GOVE, and INVE;

Y_{t-j} terms on the right-hand side of the three equations allow the serial correlation and prove that the disturbance term is white noise with variance σ^2 , and $t = 1, \dots, T$ denotes the time index;

UD_t is an indicator dummy variable for a mean shift appearing at each possible time break date (TB) while DT_t is the corresponding trend variable, where:

$$UD_t = \begin{cases} 1 & \text{if } t > TB \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

and

$$TD_t = \begin{cases} 1 - TB & \text{if } t > TB \\ 0 & \text{otherwise} \end{cases} \quad (5)$$

The null hypothesis (H_0) of the three models is $\alpha = 0$, which implies that the presence of unit root in series (Y_t) with drift that excludes any structural break, whereas the alternative hypothesis $\alpha < 0$ indicates the series is trend stationary. Most of the scholars applied Model A and/or C and according to previous studies [51; 52], we use model C for unit root analysis because it allows us to break both the intercept and the trend, which is more comprehensive than models A and B.

Model specification. The simple formula of the food availability is a function on total expenditure components variables as is stated as follows in its functional form:

$$FAV = f(CONE, GOVE, INVE). \quad (6)$$

Vector autoregression model. VAR is a standard tool for forecasting macroeconomic time series, in large part because VARs produce dynamic forecasts that are reliable across formulas and forecast horizons [53]. Thus, to explore the response of food availability to selected macroeconomic variables (expenditure components) an unrestricted vector autoregressive model proposed by Sims [54] is investigated. The VAR model was chosen for several reasons including the instability of the study data and the presence of an extreme fraction in different years as seen in Figure 1. The VAR model presents a multivariate framework where changes in a specific variable (for instance consumption expenditure) are related to the changes of its lags and changes in other variables (for instance food availability) and the lags of those variables.

The general form of the VAR model to study the relationship between total expenditure on food availability indicator with k variables and p lag, (denoted VAR (p)) can be mathematically expressed as follows:

$$Y_t \sum_{i=1}^k A_i y_{t-1} + \epsilon_t = v_0 + A_1 y_{t-1} + A_2 y_{t-1} + \dots + A_p y_{t-p} + \epsilon_t = v_0 + AY_{t-1}^{t-p} + \epsilon_t, \quad (7)$$

where Y_t is a ($k \times 1$) vector of endogenous variables, presents to (LogFAV, LogCONE, LogGOVE, and LogINVE);

k is the lag order of the model;

A_i is the coefficient matrix to be estimated = $A_1, A_2 \dots \dots$, A_p are ($K \times K$) matrices of lag coefficients, v_0 is a ($K \times 1$) vector of constant;

y_{t-1} is the i -order lag variable of Y_i vector;

ϵ_t is a ($K \times 1$) white noise innovation process, with $E(\epsilon_t) = 0$, $E(\epsilon_t, \epsilon'_t) = \sum_{\epsilon}$ and $E(\epsilon_t, \epsilon_s) = 0$, (for $t \neq s$). Since the VAR method could better suit the small sample [55].

The lag length selection criteria. After we performed the VAR analysis the selection of the length lag is very essential for determining the lag length for the VAR(p) model by using the optimum model selection criteria. Determining the optimal lag order of the VAR model can eliminate the autocorrelation existing in the residual error and improve the effectiveness of the model parameter estimation [56]. According to [57] we used the lag length selection criteria which involve the Akaike Information Criterion (AIC), Schwartz-Bayesian (SBIC) criterion, Hannan-Quinn (HQIC) criteria, Likelihood Ratio, Sequential modified (LR) criteria, and Final Prediction Error (FPE).

Granger causality test. The causal relationship between food availability and total expenditures in Saudi Arabia was found using a Granger causality [58] and Hsiao [59],

who developed a version of the Granger causality test that can be specified as follows to revive the VAR model:

$$\log TE_t = \alpha_1 + \sum_{i=1}^n \beta_i \log FAV_{t-1} + \sum_{j=1}^m \delta_j \log TE_{t-j} + \mu_t, \quad (8)$$

$$\log FAV_t = \theta + \sum_{i=1}^n \phi_i \log TE_{t-1} + \sum_{j=1}^m \varphi_j \log FAV_{t-j} + \omega_t, \quad (9)$$

where TE is total expenditures components, CONE, GOVE, and INVE;

α and θ are intercepts of the two equations, respectively;

β_i and ϕ_i , represent the coefficients of the equations;

μ_t and ω_t are error terms for the two equations, respectively;

symbols m and n represent the maximum number of lags for each of the variables.

Impulse response functions and forecast-error variance decomposition tests (FEVDs). The VAR analysis often leads to the estimation of impulse response functions (IRFs) and FEVDs, which are the fundamental parts of the VAR method. In this study, the analysis of the orthogonalised impulse response function up to the VAR order is applied. The IRF indicates whether the impacts of innovations are positive or negative or whether they have a short-run or long-run effect [54; 60]. Even though the impulse response function traces the impact of a one standard deviation shock on the present and future values of all the endogenous variables through the dynamic structure of VAR, it does not provide the magnitude of such impact [61]. Consequently, the variance decomposition method is used to examine this magnitude. Variance decomposition measures the percentage contribution of each innovation to h-step ahead of the forecast error variance of the dependent variable.

The impulse response at horizon h of the variables to an exogenous shock to variable y can be easily displayed as proposed by [54] as follows:

$$y_t = \sum_{i=0}^{\infty} \vartheta_i v_{t-i} [\vartheta_0 = I_k \text{ is the } (K \times K) \text{ IM}], \quad (10)$$

$$\vartheta_i = \sum_{j=1}^i \vartheta_{i-j} A_j [i = 1, 2, 3, \dots], \quad (11)$$

where ϑ_i are explained as impulse responses of the model;

$A_j = 0$ for $j > p$ (for a k dimensional VAR (p) process);

v_t represents the orthogonal residuals and IM represents identity matrix [62].

Follows [63], the h-step ahead vector error equation used in this study is written as:

$$Y_{it+h} = E[Y_{it+h}] = \sum_{k=0}^{h-1} A_j [e_{i(t+h-i)} \vartheta_i], \quad (12)$$

where Y_{it+h} is observed vector at time $t + h$;

$E[Y_{it+h}]$ is the h-step ahead forecast vector error made at time t ; or the orthogonalised shocks $E[Y_{it+h}]$ is the h-step ahead predictor is the g-step ahead predictor vector made at time t ;

the orthogonalised shocks $e_{it} K^{-1}$ (with K matrix) have a covariance matrix I_k .

4. RESULTS

In this section, we present and analyse our empirical findings. Therefore, this part is divided mainly into the preliminary results and the main results involved the results

of the VAR model, VAR diagnosis tests; Granger casualty; IRFs, and FEVDs. Before we illustrate the main outcomes of the study, we plotted the selected variables. Visualising the data through a plot can help to identify the distribution, variability, and potential dependencies between variables. Based on the FAO [64], GAOs [42], and SCB [65], Figure 1 shows the most straightforward comparison of annual food availability (FAV) and the total expenditure components involving government expenditure (GOVE), consumption expenditure (CONE), and investment expenditure (INVE). During 2000–2020, it was observed that the consumption expenditure was more than the government expenditure and investment expenditure. Food availability fluctuates throughout the years, while government expenditure has increased during the last years, consumption and investment expenditures and food availability have declined. This means that Saudi Arabia’s food security, as well as consumer and investment spending, have been positively linked.

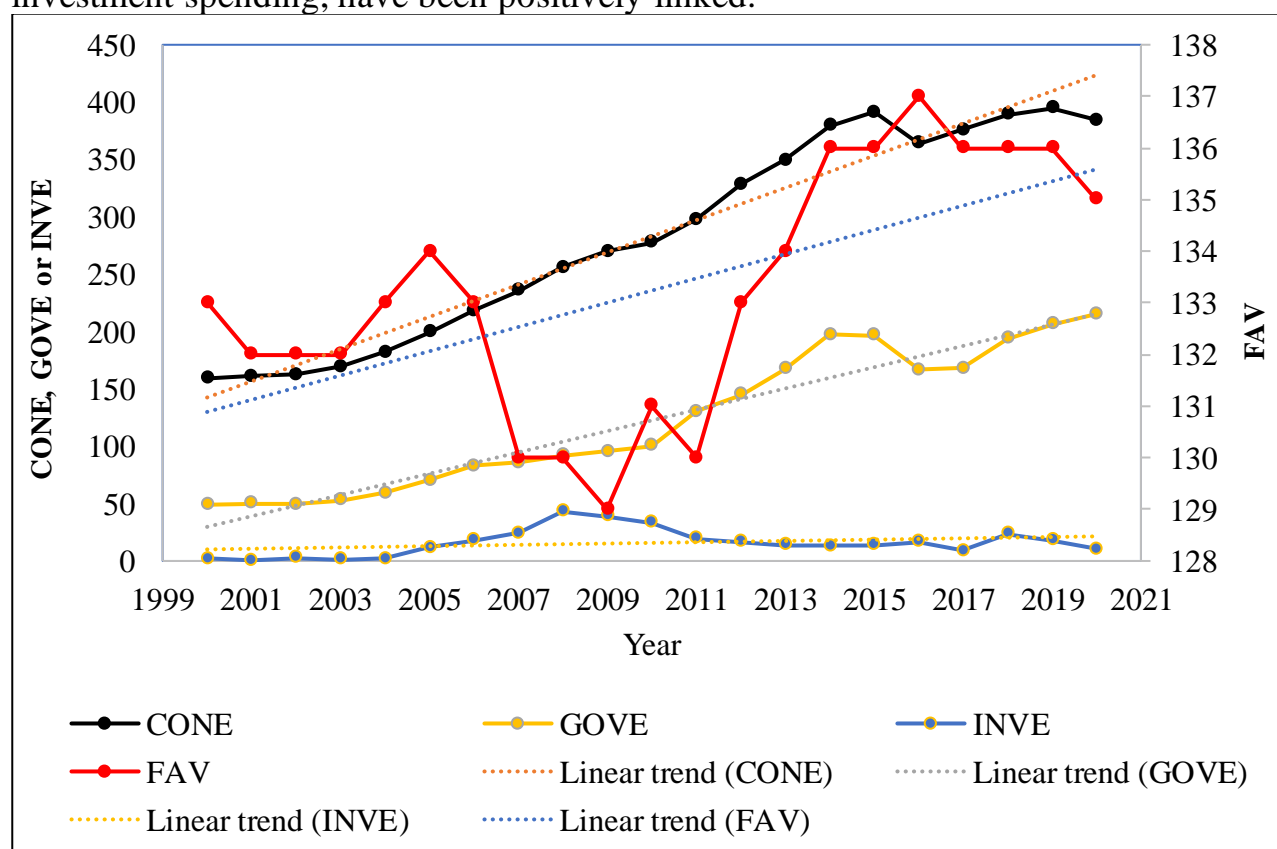


Figure 1. Trends of total expenditures (in million USD) and food availability (in million tons) in Saudi Arabia during the period 2000–2020

Notes. 1. The right axis represents FAV.

2. The left axis represents CONE, GOVE, and INVE values.

3. Trend equations are: $CONE = 14.055t - 27967$ ($R^2 = 0.9563$); $GOVE = 9.2787t - 18528$ ($R^2 = 0.9345$); $INVE = 0.568x - 1126$ ($R^2 = 0.0875$); $FAV = 0.2351t - 339.24$ ($R^2 = 0.3674$).

Source: authors’ design based on FAO [64], GAOs [42], and SCB [65].

Preliminary results. Based on the Augmented Dickey-Fuller (ADF) test and Phillips-Perron test suggest that for the levels of all interested variables, we cannot reject the unit root null hypothesis. This implies that the variables are non-stationary on their levels $1(0)$. In contrast, the KPSS test has shown that the only INVE series is

stationary while the remainder of the series is non-stationary. Furthermore, the first differences 1(1) suggest that all variables are stationary (Table 2).

Table 2

Results of unit root test for interested variables in level

Variable	ADF test	Stationary	Phillips-Perron	Stationary	KPSS Test	Stationary
FAV 1(0)	-2.47 (0.39)	Non-stationary	-6.96 (0.68)	Non-stationary	0.41*** (0.01)	Non-stationary
FAV 1(1)	-4.27 (0.00)	Stationary	-4.31(0.00)	Stationary	0.12 (0.74)	Stationary
CONE 1(0)	-0.59 (0.97)	Non-stationary	-5.58 (0.77)	Non-stationary	0.77*** (0.01)	Non-stationary
CONE 1(1)	-4.17 (0.00)	Stationary	-5.11 (0.00)	Stationary	0.29 (0.73)	Stationary
GOVE 1(0)	-2.17 (0.51)	Non-stationary	-9.34 (0.52)	Non-stationary	0.77 (0.01)***	Non-stationary
GOVE 1(1)	-2.122 (0.03)	Stationary	-2.08 (0.03)	Stationary	0.10 (0.73)	Stationary
INVE 1(0)	-1.92 (0.60)	Non-stationary	-5.05 (0.81)	Non-stationary	0.20 (0.10)	Stationary
INVE 1(1)	-5.44 (0.00)	Stationary	-5.34 (0.00)	Stationary	0.17 (0.73)	Stationary

Notes. 1. The values in parentheses represent the p-value. ***significant at 1 %.

2. The H_0 is non-stationary for ADF and PP tests, while the H_0 is stationary for the KPSS test.

Source: authors' calculations.

Thus, the unit root is tested by allowing a structural break (ZA method) and we still fail to reject the unit root. The results of the ZA method show a single unknown break date for variables of interest. However, the ZA test indicates a structural break date of 2004, 2014, 2015, and 2009 for FAV, CONE, GOVE, and INVE, respectively (Table 3).

Table 3

ZA unit root results

Variable	Test Swald	Estimated break date
FAV	15.12 (0.06)*	2004
CONE	30.14 (0.00)***	2014
GOVE	9.46 (0.12)	2015
INVE	16.59 (0.00)***	2009

Notes. 1. The values in parentheses represent the p-value.

2.***, and * refer to levels of significance at 1 % and 5 %, respectively.

Source: authors' calculations.

The unit-roots results prove that working with non-stationary variables leads to spurious regression results. Therefore, we take awareness of the results of unit root test, and we approve a VAR model, a disaggregated formulation in measuring the effect of total expenditures on food availability.

Before we estimated the VAR diagnosis tests, we checked the VAR model optimal lag lengths, VAR stability and Wald statistics, and Lagrange multiplier tests. Table 4 shows the reliability of the model with the lag length set to two based on the

lag order chosen using the LR test statistic and the information criterion for FPE, AIC, HQIC and SBIC.

Table 4

Criteria for optimal lag selection

Post-estimation lag order statistics								
Sample: 2002 thru 2020					Number of obs = 19			
Lag	LogL	LR	FPE	AIC	HQIC	SBIC	df	P-value
0	123.392	-	4.1e-11	-12.5676	-12.5339	-12.3688		
1	186.284	125.780	3.1e-13	-17.5036	-17.3354	-16.5095*	16	0.000
2	208.469	44.369*	2.1e-13*	-18.1546*	-17.8518*	-16.3651	16	0.000

Notes. *Indicates lag order selected by the criterion (optimal lag), endogenous, exogenous, constant.

LR: Likelihood Ratio, sequential modified LR test statistic (each test at 5 % level).

FPE: Final prediction error.

AIC: Akaike information criterion.

HQIC: Hannan-Quinn information criterion

SBIC: Schwarz information criterion.

Source: authors' calculations.

VAR model results. The results from Table 5 indicate that the investment expenditure has a significant negative impact on food availability. Furthermore, all equations appear to have low RMSE values and relatively high R-squared values, indicating a good model fit. Moreover, the p-values for the F-statistic tests are all extremely small (0.00), suggesting a significant association among the variables in each equation.

Table 5

Regression results for the VAR model for Saudi Arabia

Independent variables	Dependent variables (Equations)			
	LogFAV	LogCONE	LogGOVE	LogINVE
1	2	3	4	5
LogFAV (-1)	0.0539159 [0.20] (0.268)	1.237537 [0.83] (1.490)	4.935929 [1.16] (3.073)	4.803016 [0.29] (16.37)
LogFAV (-2)	-0.0240078 [-0.13] (0.185)	-0.6760796 [-0.66] (1.025)	-2.454403 [-1.61] (2.114)	26.99673 [2.40]*** (11.265)
LogCONE (-1)	0.0864764 [0.78] (0.110)	1.070257 [1.75]* (0.612)	1.192634 [0.95] (1.261)	21.18149 [3.15]*** (6.722)
LogCONE (-2)	0.0043679 [0.06] (0.076)	0.1078804 [0.25] (0.424)	0.7117273 [0.81] (0.874)	-12.54104 [-2.69]*** (4.658)
LogGOVE (-1)	0.0125987 [0.29] (0.043)	0.082634 [0.35] (0.239)	0.6143537 [1.25] (0.492)	-5.835523 [-2.23]** (2.623)
LogGOVE (-2)	-0.0202075 [-0.54] (0.038)	-0.2826688 [-1.35] (0.209)	-0.9759469 [-2.26]** (0.4312)	-0.384645 [-0.17] (2.298)
LogINVE (-1)	-0.0079721 [-2.96]*** (0.0027)	0.0104241 [0.70] (0.015)	0.0035523 [0.12] (0.0308)	0.4230257 [2.58]*** (0.164)
LogINVE (-2)	-0.009128 [-2.33]** (0.003)	0.0088538 [0.41] (0.022)	0.0118325 [0.26] (0.045)	0.2943958 [1.23] (0.238)
Constant	-1.673975 [2.95]*** (0.568)	-1.218 [-0.39] (3.154)	-8.808844 [-1.35] (6.501)	-82.21204 [-2.37]** (34.649)

Continuation of Table 5

1	2	3	4	5
RMSFE	0.003087	0.017139	0.035327	0.188285
R-squared	0.9216	0.9909	0.9849	0.8872
F-statistic	14.701***	136.147***	81.393***	9.827***
P > F	(0.00)	(0.00)	(0.00)	(0.00)
Log-likelihood	208.4688			
FPE	2.13e-13			
Determinant of the covariance matrix	3.47e-15			
AIC	-18.155			
HQIC	-17.852			
SBIC	-16.365			

Notes. 1. The test statistic (Std. err.) is in parentheses, [t] in square brackets.

2. RMSFE: it means the forecast errors (the difference between the predicted and actual values) are relatively small compared to the scale of the data.

3.***, **, * refer to levels of significance at 1 %, 5 % and 10 %, respectively.

Source: authors' calculations.

VAR diagnosis analysis. VAR is used widely in econometric analysis because they are easy to specify and estimate [66], but it is usually difficult to interpret the VAR coefficients directly [67]. Thus, the VAR diagnosis analysis was performed, the study used the Granger causality test, impulse response analysis, and forecast error variance decomposition as the alternative approaches proposed, which help in understanding the relation among variables of the VAR system.

In addition, the study revealed that the inverse roots of the VAR characteristics polynomials (which describe the behaviour of the VAR system over time) that lie within the unit circle indicated that there was no problem in terms of stability of two-lag VAR model for the VAR model and stability of food availability and total expenditure models. It is clear from the Table 6 and Figure 2 that no root lies outside the unit circle, as each modulus values are lower than 1, this assessment implies that the VAR model fits the stability condition.

Table 6

The eigenvalue stability condition of the VAR model

Eigenvalue	Modulus
0.7999326 + 0.218611i	0.829267
0.7999326 - 0.218611i	0.829267
0.3926963 + 0.6752859i	0.781167
0.3926963 - 0.6752859i	0.781167
0.6279784	0.627978
-0.5305243 + 0.3265375i	0.622963
-0.5305243 - 0.3265375i	0.622963
0.2093644	0.209364

Note. All the eigenvalues lie inside the unit circle, which proves that VAR satisfies stability conditions.

Source: authors' calculations.

For more reliability of the VAR model, the Wald lag exclusion test has been

adopted to examine the possibility of lag elimination of any variable in the VAR system. The Wald test is a safety test for the number of lags chosen from the selection criteria [68]. Based on the results of the Wald test (Table 7), we find that the selected variables used in the VAR are significant (p-value < 0.05). Thus, the VAR model will be estimated by using the lag in order number two, which is determined by selection criteria in Table 4.

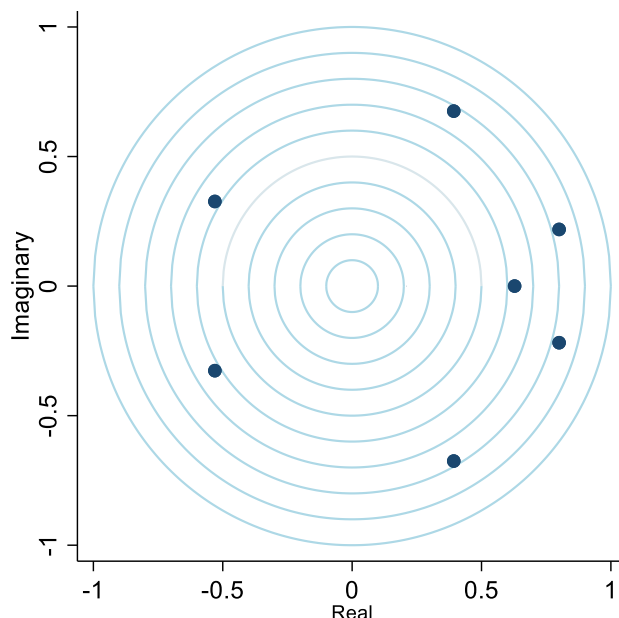


Figure 2. Companion matrix eigenvalues

Source: developed by the authors.

Also, the study has applied the Lagrange multiplier (LM) test, which is a multivariate test statistic for autocorrelation in residuals up to the specified lag order. The null hypothesis of the LM test is the non-existence of serial correlation versus the alternative of autocorrelated residuals. Our result from Table 7 shows that lag lengths (Lag 2) accept the null hypothesis of no serial correlation indicating that the error terms of the equations are not correlated, this suggests that the fitted VAR system is reasonable.

Table 7

Wald statistics and Lagrange multiplier test

Lag	VAR Lag exclusion Wald tests for equations				
	LogFAV	LogCONE	LogGOVE	LogINVE	All
1	23.522*** (0.00)	50.103*** (0.00)	55.726*** (0.00)	52.966*** (0.00)	148.742*** (0.00)
2	12.343*** (0.01)	7.958* (0.09)	18.999*** (0.00)	34.372*** (0.00)	72.431*** (0.00)
Lagrange Multiplier test					
Lag	Chi ²	Prob > Chi ²	df	Decision	
1	27.198**	0.039	16	Reject	
2	13.797	0.614	16	Accept	
Ho: No autocorrelation at lag order					

Notes. 1. The test statistic X². The values in parentheses represent the p-value.

2.***, **, * refer to levels of significance at 1 %, 5 % and 10 %, respectively.

Source: authors' calculations.

The results of the Granger causality test are presented in Table 8. We find strong evidence of the unidirectional causality from consumption expenditure to government expenditure and bidirectional causality runs from food availability to investment expenditure and vice versa, and also from consumption expenditure and government expenditure to investment expenditure, which indicates that investment expenditure supports the food availability of the country, where consumption expenditure and government expenditure do not influence the food availability directly for the case of Saudi Arabia.

Table 8

Granger causality Wald tests

Equation ^a	Excluded ^b	X ²	Prob > X ²	The results of causality run
LogFAV	LogCONE	2.4359	0.29	No causality
	LogGOVE	0.62362	0.73	No causality
	LogINVE	38.467***	0.00	INVE → FAV
	All	49.632***	0.00	ALL → FAV
LogCONE	LogFAV	1.493	0.47	No causality
	LogGOVE	3.491	0.17	No causality
	LogINVE	1.724	0.42	No causality
	ALL	7.540	0.27	No causality
LogGOVE	LogFAVE	5.325*	0.07	No causality
	LogCONE	9.350***	0.00	CONE → GOVE
	LogINVE	0.213	0.89	No causality
	ALL	18.563***	0.00	INVE → GOVE
LogINVE	LogFAV	15.665***	0.00	FAV → INVE
	LogCONE	19.891***	0.00	CONE → INVE
	LogGOVE	10.032***	0.00	GOVE → INVE
	All	33.824***	0.00	All → INVE

Notes. 1.^aDependent variables; ^bindependent variables.

2.*** and * refer to levels of significance at 1 % and 10 %, respectively.

3. X² = Chi-square.

Source: authors' calculations.

Forecasting error variance decompositions and impulse response functions. The study performs the variance decomposition test to explain the magnitude of the forecast error variance determined by the shocks to each of the selected variables over a given time. The variance decompositions (up to 10 years) are presented in Table 9. Variance decomposition implies the degree to which a shock or innovation may be caused by the dependent variable in the long run and short run [69]. In this study, we take, for example, 3 years represents the short-run and 10 years for the long run.

In the model (1), the results indicate that most of the variations in forecast error variance for FAV in the short run are explained by its innovations (45.88 %), whereas, in the long run, nearly 35.64 % of the variation in FAV is attributed to its innovations. Then, the balance 64.36 % of the variation in FAV is attributed to shock in CONE, GOVE, and INVE, i.e., an impulse on CONE, GOVE, and INVE causes 24.16 %, 20.66, and 24.16 % of variance fluctuation in FAV, respectively. On the other hand, in

the long run in model (2), about 20.89 % of the variation in CONE is explained by shocks in FAV, while 53.86 %, 18.68, and 6.54 % of the variation can be explained by shocks in CONE, GOVE, and INVE. Table 9 also manifests that for model (3) around 21.95 % of the variation in GOVE is explained by its own shocks, while 20.43 %, 51.14, and 6.47 % of the variation can be explained by shocks in FAV, CONE, and INVE, respectively in long run. The obtained results in the last model (4), indicate that in the long run certainly, 22.10 % of the variation in INVE is explained by shocks in INVE, while 23.60 %, 26.08, and 28.20 % of the variation can be explained by shocks in FAV, CONE, and GOVE, respectively.

Table 9

Forecast error variance decomposition results under VAR environment

Period	Model (1): FEVD for logFAV				Model (2): FEVD for logCONE			
	Log FAV	Log CONE	Log GOVE	Log INVE	Log FAV	Log CONE	Log GOVE	Log INVE
1	1	0	0	0	0.094458	0.905542	0	0
2	0.661837	0.175503	0.020482	0.142178	0.164411	0.827906	0.003225	0.004459
3	0.458805	0.120913	0.101132	0.319150	0.190061	0.785114	0.017641	0.007184
4	0.413171	0.109707	0.165032	0.312091	0.188474	0.733826	0.069115	0.008584
5	0.412173	0.094440	0.185455	0.307931	0.179972	0.689284	0.114997	0.015748
6	0.410788	0.090430	0.209861	0.288921	0.175471	0.653677	0.141369	0.029483
7	0.405681	0.098847	0.212347	0.283124	0.180578	0.619284	0.153715	0.046423
8	0.393462	0.127025	0.204093	0.275420	0.191893	0.586659	0.163057	0.058391
9	0.374533	0.165263	0.200528	0.259677	0.202709	0.558963	0.174713	0.063615
10	0.356362	0.195451	0.206556	0.241631	0.208955	0.538671	0.18688	0.065494
Period	Model (3): FEVD for logGOVE				Model (4): FEVD for logINV			
	Log FAV	Log CONE	Log GOVE	Log INVE	Log FAV	Log CONE	Log GOVE	Log INVE
1	0.009745	0.552622	0.437634	0	0.042312	0.008843	0.028230	0.920615
2	0.175919	0.596162	0.227793	0.000125	0.139050	0.338935	0.197562	0.324453
3	0.193812	0.650115	0.155230	0.000844	0.226282	0.270131	0.219415	0.284173
4	0.172735	0.636450	0.188712	0.002102	0.224483	0.276285	0.260195	0.239037
5	0.159506	0.623572	0.211856	0.005066	0.234735	0.263514	0.276828	0.224924
6	0.151695	0.614466	0.211807	0.022033	0.236090	0.258243	0.282588	0.223078
7	0.161681	0.591915	0.198747	0.047657	0.237267	0.256763	0.283994	0.221977
8	0.183406	0.561834	0.193521	0.061240	0.237296	0.257438	0.283610	0.221657
9	0.198881	0.532668	0.204423	0.064028	0.236783	0.258528	0.283036	0.221653
10	0.204273	0.511436	0.219573	0.064719	0.236029	0.260840	0.282035	0.221096

Source: authors' calculations.

In summary, the results of variance decomposition analysis reveal that investment expenditure is relatively more important than consumption expenditure and government expenditure in explaining the variation of food availability in Saudi Arabia, particularly in the long run. Therefore, our empirical results confirm that a shock to food availability from investment expenditure can cause variance fluctuation more significant than consumption expenditure and government expenditure; this means that investment expenditure is a long-term catalyst for Saudi food security. In comparing our results with [70], we note that the long-run relationship between food security and government

expenditure has been checked by applying the Johansen Co-integration test.

Impulse response function analyses. The results of IRF are shown in Figure 3 (A, B, C, and D), the solid blue line symbolises the impulse response of one variable (for instance food availability) to a one standard deviation shock to a different variable (for instance consumption expenditure), whereas the dashed lines symbolise the upper and lower bounds of the 95 % confidence intervals on horizons given 10-year periods.

Figure 3a shows the behaviour of food availability against its own shock, where it can be observed that food availability response is positive for at least 6 or 8 years, and after that, it becomes stable for 9 and 10 years. In Figure 3B, the behaviour of consumption expenditure in reaction to the food availability is positive in the first years and 6–9 years and becomes stable in the last 8–10 years. Figure 3C exposes the information about shocks between food availability and government expenditure. A positive response for up to 5 years followed by a negative trend for at least 6–8 years will occur in the food availability. The government expenditure response was negative against the shock, whereas the investment expenditure had a positive impact of food availability shocks (Figure 3D).

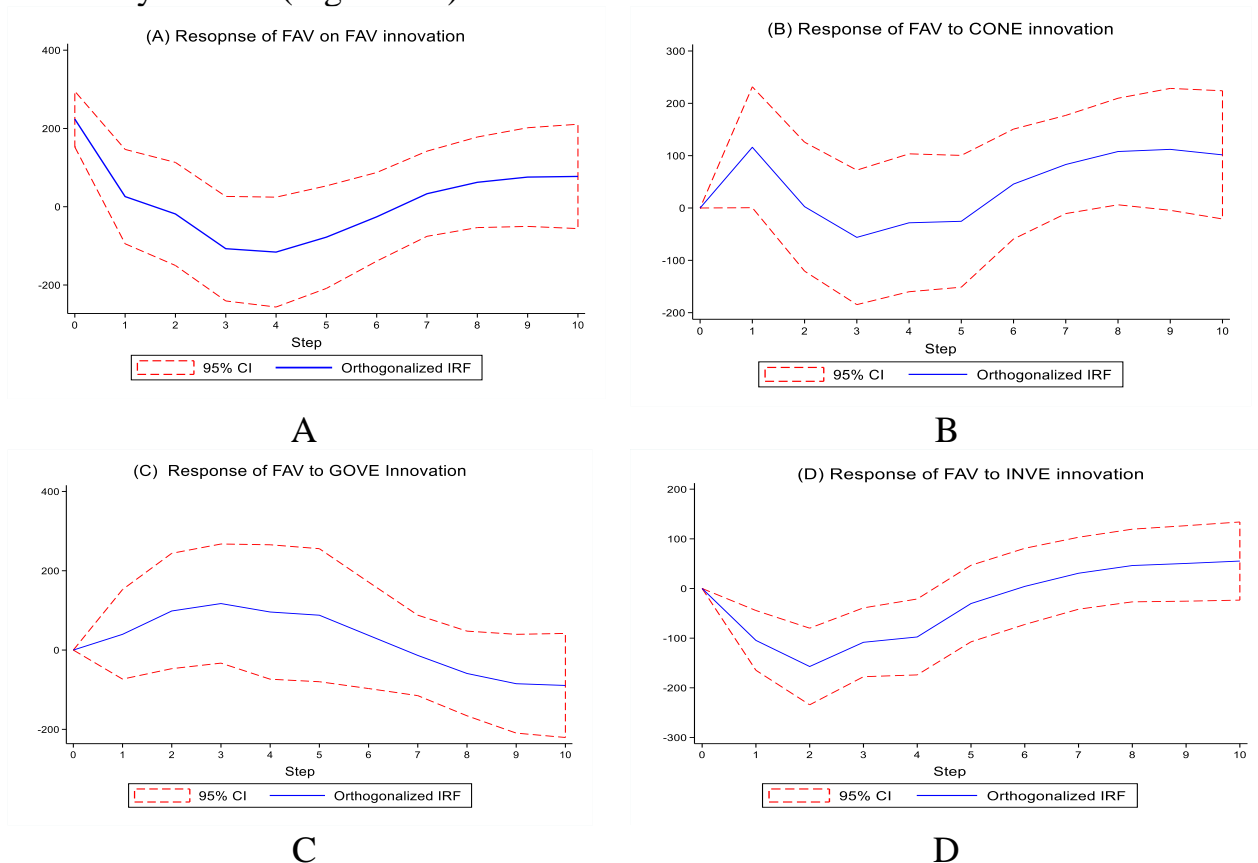


Figure 3. IRF of food availability to total expenditure in the VAR environment model

Source: developed by the authors.

Based on the obtained results, the study makes several significant recommendations. It is recommended that strategies and a budgeting plan be developed to allocate a reasonable portion of consumption and government expenditures toward food. This can be achieved by adapting strategies to the context, considering

agricultural investments, setting specific goals and targets for enhancing food security (such as increasing food production) and analysing current consumption patterns and expenditure data to determine households' and individuals' spending on food. It is essential to create a budget allowance for consumption and government expenditure that aligns with the food security goals and meets the needs of the population. Involving stakeholders in the budgeting process is crucial. Furthermore, regularly reviewing and adapting the budgeting plan in response to changing circumstances, emerging challenges, and evolving priorities is essential to address effectively the dynamic nature of food security issues.

5. DISCUSSION

In the VAR model, the combination suggests MSE values, high R-squared values, and significant F-statistic tests suggest that the model performs well in explaining the relationships between total expenditure and food security. This indicates that the total expenditure influences food security and this result is consistent with [70; 71; 72]. However, the negative impact of investment expenditure on food availability implies that resources are taken away from food production. This outcome raises questions about the allocation of resources and the priorities in the economy. It may indicate that other sectors are receiving more investment compared to food production. It suggests a need for policymakers to consider carefully the impact of investment decisions on food availability. It may be necessary to establish strategies that balance investment in other sectors with ensuring appropriate resources and support for food production, storage, and distribution. Our results agreed with [73] who proved that investment in food production has declined.

Although consumption and government expenditures may not directly affect food availability, the result suggests that they have indirect effects on food availability. This implies that while consumption and government expenditures may not be immediate determinants of food availability, they may influence other factors or variables that, in turn, affect food availability. Babatunde [74] stated that poor government expenditure allocation in agriculture production indirectly affects food security.

Furthermore, the finding that shocks in selected variables require a long period to reach the long-run equilibrium level indicates a slow adjustment process. This suggests that any changes or shocks in the selected variables, including consumption, government expenditures, and investment expenditure, may take some time to have a substantial impact on food availability. The IRFs provide insights into the dynamics of the system and the relative importance of different shocks on food availability. The result highlighting the greatest response of food availability to its own shock and investment expenditure shocks suggests that these factors play a significant role in driving changes in food availability. Several studies reported that food security is not only a response to the shocks of expenditures but also other factors [75; 76; 77; 78]. These studies have explored various factors influencing food security, including government expenditure allocation, weather, climate changes, economic growth, and food prices. By referencing these studies, the discussion builds upon the existing

knowledge and demonstrates the relevance and implications of the findings.

The novelty of our study appears in providing information that lies in the gratitude for the indirect effects of consumption and government expenditures on food availability, the understanding of the slow adjustment process, the contextual relevance to Saudi Arabia, and the integration with existing literature. These outcomes contribute to the understanding of the dynamics and determinants of food availability in the specific context and call for further research and policy considerations. Thus, these findings have implications for policy and call for further research to deepen our understanding of the dynamics and determinants of food availability in Saudi Arabia.

6. CONCLUSIONS

Regarding the National Transformation Program in Saudi Arabia, which aims to reduce dependence on oil revenues and diversify sources of income to achieve fiscal balance, Saudi Arabia's Vision 2030 has contributed to enhancing public financial sustainability, the most important of which is raising the efficiency of total expenditures. The present study aims to analyse the shocks of the expenditure components on food security and to identify the causal relationship between total expenditure and food availability in Saudi Arabia. The study mainly relies on the times series data consisting of macro-level data for the duration of 2000–2020. The dependent variables in the study act as food availability is represented by the average value of food production whereas the total expenditure components data act as explanatory variables. The study applies the VAR model and its environment, FEVDs, and IRFs. The study examined the VAR model's optimal lag lengths, VAR stability, Wald statistics, and Lagrange multiplier tests for detecting the model's robustness. The results of this study indicate the reliability of the model with a lag length of two and that the VAR model meets the condition of stability.

From the results of the Granger causality, we observed that investment expenditure supports the food availability of Saudi Arabia whereas consumption expenditure and government expenditure do not influence the food availability directly.

The results indicate that most of the variations in forecast error variance for food availability in the short run are explained by its innovations (45.88 %), whereas, in the long run, nearly 35.64 % of the variation in food availability is attributed to its innovations. Furthermore, in the long run, about 20.89 % of the variation in consumption expenditure is explained by shocks in food availability, while 53.86 %, 18.68, and 6.54 % of the variation can be explained by shocks in consumption expenditure, government expenditure, and investment expenditure. Around 21.95 % of the variation in government expenditure is explained by its shocks, while 20.43 %, 51.14, and 6.47 % of the variation can be explained by food availability, consumption expenditure, and investment expenditure, respectively in the long run. In the long run, 22.10 % of the variation in investment expenditure is explained by shocks in investment expenditure, while 23.60 %, 26.08, and 28.20 % of the variation can be explained by shocks in food availability, consumption expenditure, and government expenditure, respectively. Concluding that investment expenditure is relatively more

important than consumption expenditure and government expenditure in explaining the variation of food availability in Saudi Arabia, particularly in the long run. The government expenditure responses were negative to the shock, while the investment expenditure had a positive impact on food availability shocks.

7. LIMITATIONS AND FUTURE RESEARCH

The limitations of this study are that it does not use a multidimensional approach to studying food security. It only considers food availability and total expenditure as factors, overlooking other important aspects such as food access, use, stability, and resilience. By failing to integrate qualitative and quantitative research methods, the study may not provide a comprehensive understanding of the complex nature of food security and expenditure.

Further research can be done to address the limitations mentioned in this study. For example, a study that assumes a multidimensional approach to food security, considering all food security pillars and total expenditure is important. Proposing a mix of qualitative and quantitative approaches can provide a more robust and evidence-based understanding of the topic, researchers can benefit from the powers of each technique and gain a more comprehensive understanding of food security and expenditure dynamics. It is recommended to conduct longitudinal and comparative studies that track changes in food security and expenditure over time and across different countries. This can shed light on the contextual factors that influence global food security consequences and identify best practices or interventions that have proven effective in specific settings.

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Conflicts of interest: the authors declare no conflict of interest.

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