ISSN 2664-4010 (Print) & ISSN 2664-6730 (Online)
South Asian Research Journal of Agriculture and Fisheries
Abbreviated Key Title: South Asian Res J Agri Fish

| Volume-4 | Issue-2 | Mar-Apr -2022 | **DOI: 10.36346/sarjaf.2022.v04i02.001**

Original Research Article

An Import Demand Function for Long Grains (Indica) Rice for Saudi Arabia: A Vector Error Correction Model (VECM)

Bashir, Kamaleldin Ali[1*], Imad Eldin E. Abdel Karim Yousif[1]
[1]Department of Agricultural Economics, College of Food and Agricultural Sciences, King Saud University, Saudi Arabia

***Corresponding Author:** Bashir, Kamaleldin Ali
Department of Agricultural Economics, College of Food and Agricultural Sciences, King Saud University, Saudi Arabia

Article History
Received: 04.02.2022
Accepted: 10.03.2022
Published: 23.03.2022

Abstract: A vector error correction model (VECM) was utilized to estimate an import demand function for indica rice for Saudi Arabia using time series data spanning the period 1983 – 2018. Results established a long run relationship between import demand quantity, import prices, per capita income, population, and crop index. Import demand quantity was found to adjust to restore long term equilibrium level significantly fast, as full adjustment would be attained within two years. Short run demand elasticities with respect to price and income confirmed that rice is a necessary normal good. The rather low income elasticity suggests that at higher incomes consumers would probably respond by shifting to more expensive rice (*basmati)* varieties. Positive population shocks were found to have a maintained long run negative impact on imports which reflects and confirms dietary shifts away from traditional rice dishes in Saudi Arabia.

Keywords: Import demand, Indica rice, Cointegration, VECM, Saudi Arabia.

INTRODUCTION

Rice has historically been the staple food for the Saudi Arabia as well as for other Gulf countries. Various traditional meals are cooked from rice. Kabsa, a rice-based dish with spices, vegetables, and meat, has historically been considered the national dish for Saudi Arabia. Due to its cooking characteristics, usually long grain (Indica) basmati rice is used and preferred by Saudi and expatriate consumers for preparing Kabsa. However, changes in dietary habits, recent domestic policies, and changes in global prices are, in part, impacting rice consumption and imports in Saudi Arabia.

Significant changes have been documented in Saudi diet and dietary habits in recent decades, particularly among youth (Washi and Ageib, 2010; Al-Hazzaa *et al*., 2011; MOH, 2012; Alassaf *et al*., 2021; Mousa and Ahmed, 2021).Such changes are characterized by shifts from traditional rice-based diets to Western diet and could in part be attributed to globalization and economic development in Saudi Arabia during the last 30 years (Al-Qauhiz, 2011).

Since rice is not grown locally Saudi Arabia totally relies on imports from the international rice market where the country is among the top five rice importing countries. India has dominated the Saudi rice market since 1989 with an estimated 50 percent market share which kept growing ever since; this dominance is in part aided by Saudi consumer preferences (Alamri and Saghaian, 2018). In 2019 Indian exports to Saudi Arabia represented about 75% of total Saudi imports with Pakistan, USA, Thailand, and Vietnam almost equally sharing the balance. The Indian dominance has been aided by a shift in Saudi consumers' preferences from long grain white basmati rice to long grain parboiled (sella or muzza) basmati rice because of its ease to cook (USDA, 2012).

Policy shifts regarding rice alternatives may have impacted Saudi rice imports. Wheat could be considered second to rice in the Saudi diet. A number of traditional dishes are made from wheat; moreover, expatriates of non-Asian origin living in Saudi Arabia depend largely on bread (wheat) rather than rice. Saudi Arabia has recently adopted some policy measures leading to reduction in domestic wheat which might indirectly impact on rice consumption. According to the Ministry of water and electricity, the major agricultural expansion during the past three decades is believed to have contributed to the depletion of fossil water reserves in Saudi Arabia (MOWE, 2011 p. 32). Resolution 335 issued by the council of ministers in 2007 stipulated that local wheat production area should be annually reduced by 12.5% and eventually phased out by the spring of 2016. The decree reverses Saudi Arabia's longstanding policy of self-sufficiency in wheat production which has been adopted since 1980s. Concerns over the depletion of underground non-renewable aquifer water are considered as the main reason behind this policy reversal.

In a review of the theoretical and empirical literature, Vacu and Odhiambo (2020) reported that the majority of the studies used income and relative import price as the key determinants of import demand. Other explanatory variables including population of importing country, dummy variable to capture unusual occurrences, and lagged variables could also be incorporated.

Several studies applied different methods of import demand specification for the KSA including Doroodian, Koshal, and Al-Muhanna (1994); Alseleem (1998); Aldakhil and Al-Yousif (2002); Kang, Kennedy, and Hilbun (2009). Both Doroodian, *et al*. (1994) and Aldakhil and Al-Yousif (2002) estimated aggregate demand functions for Saudi Arabia and while the former used traditional specification the latter used an error correction model (ECM). Kang *et al*. (2009) estimated import demand functions for the top four rice importing countries: Indonesia, Philippines, Nigeria, and Saudi Arabia. They used a simultaneous equations model and concluded that imports are generally inelastic with respect to price and income. Alseleem (1998) also found modest changes in Saudi rice imports from different regions due to variations in income (per capita GDP).

Purpose of study

The importance of rice in Saudi diet combined with some noticeable changes in the local and global arena regarding dietary habits, relevant domestic policy shifts, and changes in global prices, call for a fresh investigation of Saudi Arabia’s import demand characteristics. In particular, possible long term relationships and causality were not adequately addressed in previous literature and are worthy of exploration: this study aims to achieve that purpose.

METHODOLOGY

Data

The data used in this analysis is a time series data collected from various sources: Food and Agriculture Organization (FAO), and various Saudi governmental sources. The data spans the period 1983- 2018 and comprises import quantities, import values, and crop production index (FAO); consumer price index (CPI), and gross domestic product (GDP) and population data (General Authority for Statistics, KSA). Unit prices were calculated as a proxy for import price using import quantities and values.

Table (1) presents the descriptive statistics of variables used in in the study. Means, standard deviations and extreme values are shown. The relatively high range for real import price (IMPP) is due to a sharp rise in 2007- 08 international rice trading prices as part of price spikes for major agricultural commodities such as wheat, corn, and soybeans. According to Childs and Kiawu (2009), the primary cause of the rise in prices for these commodities was rising global incomes, dietary changes, increased use of biofuels, tight grain supplies, and increased participation in futures markets by nontraditional investors. Similar price surges were observed in 1981 but markets swiftly adjusted in 1982 and in 1972-1974 and markets adjusted in 1976.

A structural break test (Chow test) suggested two break points in the data, namely in 1992 and 2004 and hence the two dummy variables DUM1992 and DUM2004 were included as exogenous variables in the specification of the VECM. The crop production index (CRPINX) is used as a proxy for substitutes in the local Saudi market.

Table-1: Variables definitions and descriptive statistics (N=36).

Label	Description	Mean	Std. Dev.	Min	Max
GDP	Per capita gross domestic product in 000 US$ adjusted for inflation (2012=100)	11.0848	3.6756	6.6981	18.4112
IMPQ	Quantity imported: Annual Saudi imports of indica rice (milled equivalent) in 000 tons.	804.4655	362.2139	250.2210	1524.0110
IMPP	Real import price: Unit value of imports in constant US$ per ton (2012=100).	614.5806	121.2227	488.0768	1071.4270
POP	Annual population of Saudi Arabia in millions	21.8473	6.3036	11.8368	33.4137
CRPINDX	Crop production index: agricultural production for each year relative to the base period (2006).	85.7111	17.4118	36.1000	118.2000

Dum2004	A dummy variable indicating a structural break at the year 2004 (=1 for years 2004 - 2018, = 0 otherwise)	0.4167	0.5000	0	1
Dum1992	A dummy variable indicating a structural break at the year 1992 (=1 for years 1992 - 2018, = 0 otherwise)	0.7500	0.4392	0	1
Dum2007	A dummy variable indicating a shift in wheat farming policy in the year 2007 (=1 for years 2007 - 2018, = 0 otherwise)	0.3333	0.4781	0	1

Methods

The main analytical framework of this study is the Vector Error Correction Model, VECM, estimated using EViews 12. Prior to estimating the model, the time series data characteristics were examined. The data were tested for unit roots (stationarity) as well as for cointegration.

Testing for unit roots (stationarity)

Testing for non-stationarity is performed to avoid spurious regression (Granger and Newbold, 1974 - later formalized by Phillips (1986). Among the most popular tests is the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981) which tests the null hypothesis that the series has a unit root against the alternative that the series is stationery. In this study, the ADF test was run using the three forms: with an intercept, with an intercept and a linear trend, and without either, both for levels and first differences.

Testing for cointegraion

This step follows after first establishing that all variables exhibit the same order of integration. Tests of cointegration aim to determine the number of cointegrating relationships (the cointegrating rank). Johansen's (1988, 1991, 1995) more general multivariate maximum likelihood method, used in this study, is probably the most popular form for estimating cointegrating vectors.

Both the maximum eigenvalue and the trace statistics (TR) used in the Johansen method test the null hypothesis H_0: $r = r_0$ against the alternatives H_1: $r > r_0$ and H_1: $r = r_0+1$ for the trace and maximum eigenvalue statistics respectively where r is the number of hypothesized cointegration relationships. The two statistics may yield conflicting results. The common practice in empirical work is to either use both simultaneously or the trace statistics exclusively. Lüutkepohl *et al.*, (2001), reported that in some situations the trace tests tend to have superior power over the maximum eigenvalue tests albeit at the expense of more distorted sizes. However, Banerjee *et al*. (1993) argued that the maximum eigenvalue result is preferred. This study adopts the trace statistic to determine the number of cointegrating relationships (the cointegrating rank) among the variables.

Vector Error correction model (VECM)

Vector error correction models (VECM) [1] and their single equation counterpart (ECM) are quite popular in applied econometrics. They have been widely used for analyzing possible cointegrating relationships among economic variables. According to Engle and Granger (1987), VECM can be defined as a particular representation of a vector autoregressive model (VAR) designed for use with nonstationary series that are known to be cointegrated [2]--the Granger representation theorem. The connection between cointegration and error correction models has been investigated by a number of authors; see Davidson (1986), Stock (1987), and Johansen (1988, 1991, 1995) among others.

Given a k-variable VAR(p) model of order p (i.e., with p lags) of I(1) variables which can be represented as follows:

$$\boldsymbol{y}_t = v + \sum_{\boldsymbol{j=1}}^{\boldsymbol{p}} \boldsymbol{A_j} \quad \boldsymbol{y}_{t-j} + \epsilon_t \qquad (1)$$

Where $\boldsymbol{y}_t$ is a (kx1) vector of variables expressed as a function of p lags of those variables and $\boldsymbol{A}_j$ is a (kxk) matrix of fixed coefficients; it is assumed that $E(\epsilon_t) = 0$, $E(\epsilon_t \epsilon_t') = \Sigma$, and $E(\epsilon_t \epsilon_s) = 0 \ \forall t \neq s$. Note that exogenous or dummy variables can also be added to the right hand side.

---

[1] See Alogoskoufis and Smith (1991) for a comprehensive survey on issues related to specification, interpretation, and estimation.

[2] This is the most recent, earlier definitions were presented by Hendry and von Ungern- Sternberg (1981); Hendry, Pagan, and Sargan (1984); and Nickel (1985).

With $\Delta y_t = y_t - y_{t-1}$, one could reparametrize the VAR as a VECM representation (Granger, 1981; Engle and Granger, 1987; Johansen, 1991) as follows:

$$\Delta \boldsymbol{y}_t = v + \Pi \boldsymbol{y}_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta \boldsymbol{y}_{t-i} + \epsilon_t \quad (2)$$

Where $\Pi = \sum_{j=1}^{j=p} \boldsymbol{A}_j - \boldsymbol{I}_k$ and $\Gamma_i = -\sum_{j=i+1}^{j=p} \boldsymbol{A}_j, i = 1, \dots, p-1$

The terms Πy_{t-1} in equation (2) are called the error-correction terms; they measure the long run adjustment to equilibrium. The $\Gamma_i \Delta y_{t-1}$ terms on the other hand capture the short run impacts. It is the combination of these term that give VECM one of their major advantages over classical regression models, namely accounting for both long term equilibrium effects implied by cointegration as well as for the short run dynamic adjustment.

The rank of Π, in equation (2), indicates the number of cointegrating vectors where three different cases, with different modeling implications, could be distinguished:

i. If rank (Π) = zero: Π is the null matrix, there is no cointegration and the VECM in equation (2) reduces to a VAR (p-1) in differences.
ii. If rank (Π) = m, m = k: Π is full rank in which case y_t is stationery; hence there is no error-correction representation and the relationship should be modeled in levels, not differences.
iii. If rank (Π) = m, 0 < m < k: there exists (m x r) matrices α and β such that Π = α β' where the columns of β are the linearly independent cointegrating vectors, and the columns of α are the adjustment coefficients which indicate the speed of adjustment to last period's deviations from the cointegrating relationships.

Case (iii) is the one that calls for VECM as the adequate model.

Lag selection for VECM

The number of lags that should be included in the VECM needs to be determined beforehand. It is customary to consult a number of lag selection criteria for choosing the appropriate number of lags. Among the most widely used are the Akaike information criteria, AIC, and Schwarz information criteria, SIC.

RESULTS AND DISCUSSION

Dickey-Fuller test of non-stationarity

Table (2) presents results of the ADF unit roots tests both at levels and first differences for the variables used in the study. From these results it can be concluded that each series has unit root at levels and it is stationary when first difference is taken. It can be said that all variables are I (1), i.e., integrated of order 1. The next step before using VECM as the appropriate model is to verify the existence of cointegration among nonstationary variables using Johansson test.

Table-2: Augmented Dickey-Fuller (ADF) unit root tests for levels and first differences

Variable	Level			First difference		
	Constant	Constant +Trend	None	Constant	Constant +Trend	None
	statistic					
IMPQ	-0.9574	-3.4981*	1.9283	-6.9534***	-6.8888***	-6.6249***
IMPP	-3.7349***	-3.6970**	-0.9993	-6.2089***	-5.8415***	-6.2750***
GDP	-2.4002	-2.5821	-0.1343	-6.1247***	-6.0829***	-6.1093***
POP	2.4642*	-1.2377	-1.2377	-3.6010***	-4.6714***	-0.2113
CRPINDX	1.2234	-0.4078	3.5082	-9.7720***	-8.4242***	-6.2089***

Notes: (a) lag length is based on Schwarz information criteria (SIC) as reported in EViews; (b) p-values, reported by EViews, are from MacKinnon (1996).

Johannsen's cointegration test

It appears from table (3) that both for the maximum eigenvalue and the trace statistic, the result of the cointegration rank is 1 based on the p-values as the first null hypothesis cannot be rejected at rank 1. Thus, it can be concluded that the variables are I(1) with the existence of one cointegrating relationship. Existence of cointegration can be viewed as an indirect test of long-run causality. This is the scenario described in case (iii) above which calls for the VECM as the adequate model.

Table-3: Johansen's cointegration test results

Maximum Eigenvalue				
Hypothesized No. of CE(s)	eigenvalue	Max-eigen statistic statistic statistic	5% critical value	Prob.**
None * (H_0: r=0, H_1: r=1)	0.6318	47.9580	40.0776	0.0053
At most 1 (H_0: r=1, H_1: r=2)	0.3511	20.7604	33.8769	0.7020
At most 2 (H_0: r=2, H_1: r=3)	0.2670	14.9095	27.5843	0.7553

At most 3 (H_0: r=3, H_1: r=4)	0.2249	12.2269	21.1316	0.5254
At most 4 (H_0: r=4, H_1: r=5)	0.1237	6.3390	14.2646	0.5701
At most 5 (H_0: r=5, H_1: r=6)	0.0455	2.2353	3.8415	0.1349
Trace				
Hypothesized No. of CE(s)	eigenvalue	trace statistic ststaisticstatistic	5% critical value	Prob.**
None * (H_0: r=0, H_1: r=1)	0.6318	104.4290	95.7537	0.0111
At most 1 (H_0: r=1, H_1: r=2)	0.3511	56.4710	69.8189	0.3593
At most 2 (H_0: r=2, H_1: r=3)	0.2670	35.7106	47.8561	0.4111
At most 3 (H_0: r=3, H_1: r=4)	0.2249	20.8011	29.7971	0.3702
At most 4 (H_0: r=4, H_1: r=5)	0.1237	8.5742	15.4947	0.4062
At most 5 (H_0: r=5, H_1: r=6)	0.0455	2.2353	3.84147	0.1349

* denotes rejection of the hypothesis at the 5 % level.

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

Lag selection results

Table (4) show the outcome of the lag selection criteria which indicates that five out of the six criteria suggest 2 lags for the VAR model. As the VECM representation of a VAR uses one less lag, the estimated model will have one lag. This is reasonable for the annual data used in this study.

Table-4: lag selection criteria for the VAR model:

		Lag selection criteria				
lag	LogL	LR	FPE	AIC	SIC	HQ
0	12.5376	NA	4.88e-07	-0.3426	-0.1399	-0.2674
1	261.9764	430.8487	1.83e-11	-10.5444	-9.3279	-10.0934
2	310.9900	73.5234*	6.42e-12*	-11.6359*	-9.4057*	-10.8088*
3	329.3446	23.3604	9.80e-12	-11.3338	-8.0899	-10.1308

* indicates lag order selected by the criterion.

LR= modified likelihood ratio; FPE= final prediction error; AIC= Akaike information criteria; SIC= Schwarz information criteria; and HQ= Hannan-Quinn information criteria.

VECM estimation results

Table 5 presents the relevant estimation results for the VECM. The long run relationship, the cointegrating equation, appears on the top portion while the combined short/long run results appear underneath. From table 5 the long run relationship between rice imports, import price, GDP, population, and CRPINDX for one cointegrating vector in the period 1983-2018 can be explicitly displayed in equation (3) below:

$$IMPQ(-1) = -3.0845 - 0.5069IMPP(-1) - 0.0214CRPINDX(-1) + 0.0307GDP(-1) + 1.2651POP(-1) \quad (3)$$

The empirical form of the combined short run long run relationship is presented in equation (5) whose results appear in the bottom portion of table 5. This is one out of a system of 5 other equations in the estimated VECM represented by equation (2) above. The coefficients of the lagged variables, C(3) through C(7), represent short term effects.

$$\begin{aligned} D(IMPQ) &= C(1) + C(2) \\ &* (IMPQ(-1) + 0.5069 * IMPP(-1) + 0.0214 * CRPINDX(-1) - 0.0307 * GDP(-1) - 1.2651 * POP(-1) \\ &+ 3.0845) + C(3) * D\big(IMPQ(-1)\big) + C(4) * D\big(IMPP(-1)\big) + C(5) * D\big(CRPINDX(-1)\big) + C(6) \\ &* D\big(GDP(-1)\big) + C(7) * D\big(POP(-1)\big) + C(8) * DUM1992 + C(9) * DUM2004 \end{aligned} \quad (4)$$

Equation (3) has generally performed satisfactorily well. All variables exhibited the expected signs: positive for POP and GDP; negative for IMPP and CRPINDX. As indicated by the t-ratios all coefficients are significant at the 5% level except for GDP. The long run coefficients in equation (3) are likely to be a mixture of adjustment and expectational as well as long run structural parameters (Alogoskoufis, 1991).

Since the equation was estimated in the double logarithmic functional form, the coefficients of equation 3 can be interpreted as long run elasticities. The estimated long run price elasticity of (-0.5069) indicates that, as expected, rice is considered a necessary commodity while the income elasticity of (0.0307) confirms that rice is considered as a normal good. Given the rather low income elasticity, it could also be deduced that at higher incomes consumers would probably respond by shifting to more expensive brands such as some top-end *basmati* varieties. These results are in conformity with demand theory and common sense as well with previous empirical findings (Kang *et al*., 2009).

Table-5: VECM results: estimates of the rice import demand function

		estimate	std. error	t-ratios	p-values
Cointegrating equation:					
Dependent variable: (LIMPQ(-1))					
	LIMPP(-1)	-0.5069	0.1377	3.6806	
	CRPINDX(-1)	-0.0214	0.0022	-9.6838	
	LGDP(-1)	0.0307	0.1238	0.2481	
	LPOP(-1)	1.2651	0.2189	5.7784	
	c	-3.0845			
VECM: import demand equation:					
Dependent variable: D(LIMPQ)					
	CointEq1	-0.8339***	0.1184	-7.0402	0.0000
	D(LIMPQ(-1))	0.1849*	0.0983	1.8808	0.0622
	D(LGDP (-1))	0.5700***	0.1278	4.4592	0.0000
	D(CRPINDX(-1))	0.0006	0.0038	0.1497	0.8812
	D(LIMPP (-1))	-0.3370**	0.1688	-1.9959	0.0480
	D(LPOP(-1))	-2.9175	2.6374	-1.1062	0.2706
	DUM1992	0.5146***	0.0787	6.5430	0.0001
	DUM2004	0.4150***	0.0801	5.1830	0.0000
	C	-0.4457***	0.1074	-4.1495	0.0000
		R^2	0.79	F-stat.	12.7150
		Adj. R2	0.73	Prob(F-stat.) ***	0.0000
		DW stat.	2.1098		

*, **, and ***: significant at 10, 5, and 1 percent significance levels respectively.

Empirically equation (4) performed well. The overall model is statistically significant at the 1% level and most coefficients were significant at the 1% level with the only exception POP and CRPINDX which were not significant at conventional levels. The value of R^2 of 0.79 indicates that the model specification was able to capture most of the relevant explanatory variables. The value of D-W statistics of (2.1098) signals absence of serial correlation which is further discussed among other diagnostics in the model diagnostics section. A Wald test indicated that the short run coefficients are jointly significant as the null hypothesis: $H_0: C(3) = C(4) = C(5) = C(6) = C(7) = 0$ was rejected in favor of the alternative with a Chi-square of (25.1009) and a p-vale of (0.0001).

The estimated cointegration coefficient (-0.8339) is negative and significant at the 1% level. Thus, it can be concluded that the variables in the rice import demand function cannot drift too far apart: import demand quantity will adjust to restore long term equilibrium level. The adjustment of import demand was found to be significantly fast. Specifically, a deviation in the long run equilibrium level in one year would be corrected in the next year by the value of the coefficient or 83%. Thus, according to the model full adjustment would be attained within two years. However, given the thin nature of the international rice market fluctuations are not uncommon which would obscure visually observing the adjustment process.

The short run price elasticity of (-0.3370) was significant at the 5 percent level and was sensibly less than, albeit slightly, its long run counterpart of (-0.5069). The negative sign of the population coefficient, albeit insignificant, could indicate the dietary shifts away from rice. The fact that children and youth (under 34 years) represent 67% of Saudi Arabia's population lends credence to such indication.

Impulse response

Impulse responses allow for tracing the time paths of shocks in the relevant variables. Panels (a) through (e) in figure (1) present the impulse response function diagram of rice imports changes caused by shocks (innovations) in IMPQ, IMPP, GDP, POP, and CRPINDX respectively. Panel (a) indicates that a positive shock in imports in the first period causes a short run decline in imports which reaches a minimum at the third period. Thereafter, imports slightly rise to peak at period 5 after which imports stabilize. This means own shocks have a relatively more pronounced impact on imports in the short term, and this effect is maintained at a slightly higher level in the long term.

In panel (b) it appears that a positive shock in IMPP causes an immediate albeit short lived sharp rise in imports in the second period but imports decline thereafter to initial levels through the tenth period except for slight rise in period 6 through 8. This indicates a positive initial impact in the short run and a maintained negative impact in the long run.

The impact of GDP shocks on imports (panel c) reveals a short run positive effect which soon reverses after the second period, becomes positive at period four and maintains a stable condition thereafter. Population shocks have a fluctuating effect on imports as shown by panel (d); a positive shock in the first period causes a sharp decline reaching a minimum in period 2 and then rises to reach a peak at period four and eventually stabilizes at period 7 with a maintained long run negative impact. This nature of impact is interesting in that it may reflect and confirm the dietary shifts away from traditional rice dishes referred to in research. Finally, panel (e) presents the impact of innovations in CRPINDX which resembles the impact of POP in panel (d) with a relatively more pronounced impact.

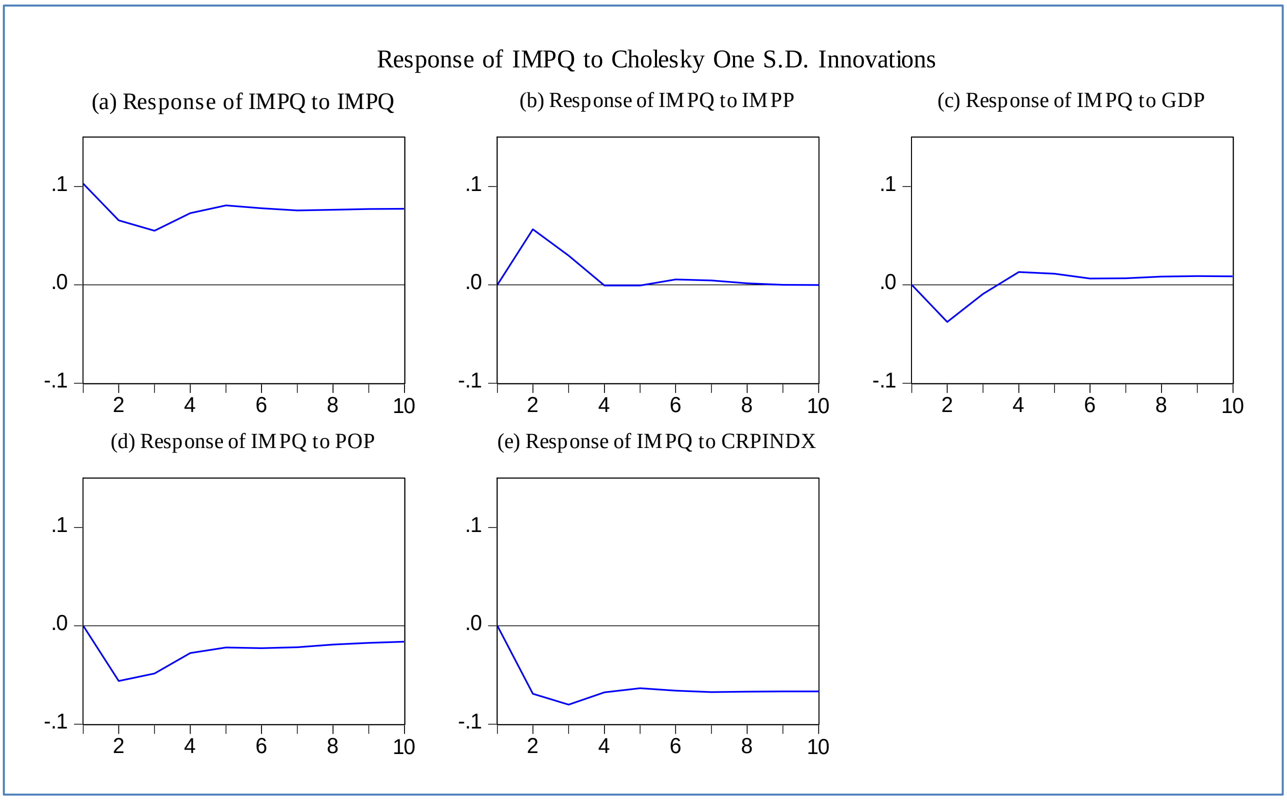

Fig-1: Impulse Response Functions

Model diagnostics

A number of diagnostic residual tests were performed to check the estimated model adequacy. All performed tests show that the model exhibits desirable properties. In particular the Jarque-Bera test for joint normality, the VEC test for serial correlation, and the test for heteroscedasticity were conducted. Results of these tests appear in table (6) and all three tests indicate that the relevant OLS assumptions are not violated. Table (6) also presents results of the cumulative sum, CUSUM, test of coefficients systematic stability with the conclusion that coefficients are stable (see Figure 2).

Table-6: Results of diagnostic tests of the estimated demand function.

Test for	Test name/statistic	H_0	Decision rule	Decision
Normality	Jarque-Bera	Residuals are multivariate normal	P-value = (0.3749)	Do not reject H_0
Serial correlation	VEC serial correlation LM tests	No serial correlation at lag order h	P-value = (0.5293, 0.2862, 0.1460, 0.5960, 0.9812) for lags 1 – 5 respectively	Do not reject H_0 for up to 5 lags
Heteroscedasticity	VEC residual heteroscedasticity tests	Residuals are homoscedastic	P-value = (0.5948)	Do not reject H_0
Coefficients stability	CUSUM test	Coefficients are stable	CUSUM within 95% interval	Do not reject H_0

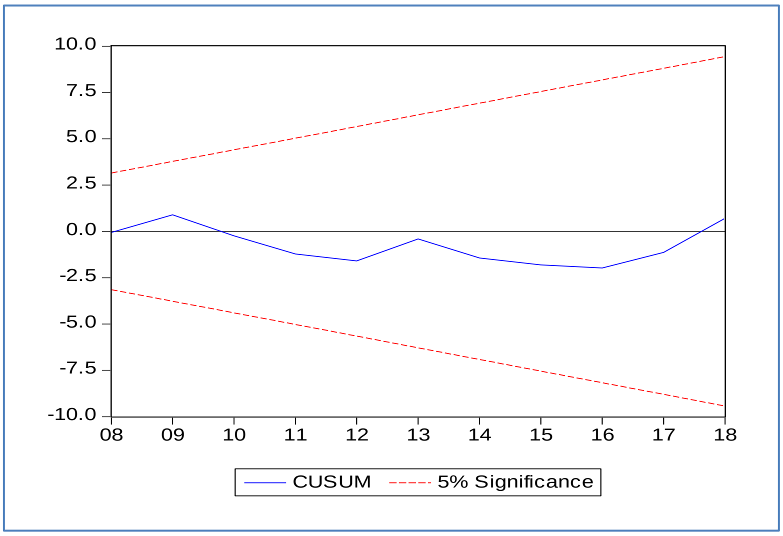

Fig-2: CUSUM test of coefficients stability

CONCLUSIONS

The rice import demand function for KSA was specified using VECM. Rice is considered necessary commodity for Saudi consumers as indicated by low demand price elasticity. The lower income elasticity suggests that at higher incomes consumers would probably respond by shifting to more expensive rice (*basmati)* varieties**.** The estimated cointegration coefficient suggests that import demand quantity will adjust to restore long term equilibrium level significantly fast, as full adjustment would be attained within two years. The impulse responses of included variables showed that positive shock of import prices causes an immediate sharp rise in imports in the second period but imports decline thereafter to initial levels. The impact of GDP shocks on imports causes a short run positive effect which soon reverses after the second period. Population shocks have a fluctuating effect on imports as a positive shock in the first period causes a sharp decline and then rises with a maintained long run negative impact. This result may reflect and confirm the dietary shifts away from traditional rice dishes.

REFERENCES

- Alamri, Y., & Saghaian, S. (2018). Measuring the intensity of competition among rice exporters to Saudi Arabia. *International Journal of Scientific and Research Publications*, *8*(1).
- Alassaf, A., Almutairi, A., Alzaydi, M., Aljumah, A., & AlDosari, M. N. (2021). Dietary Habits of Saudi Medical Students at King Saud bin Abdulaziz University for Health Sciences in Riyadh, Saudi Arabia. *Majmaah Journal of Health Sciences*, *9*(1), 28-38.
- Aldakhil, K., & Al-Yousef, N. (2002). Aggregate import demand function for Saudi Arabia: An error correction approach. *Journal of Economic & Administrative Sciences*, *18*(1), 83-100.
- Al-Hazzaa, H. M., Abahussain, N. A., Al-Sobayel, H. I., Qahwaji, D. M., & Musaiger, A. O. (2011). Physical activity, sedentary behaviors and dietary habits among Saudi adolescents relative to age, gender and region. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), 1-14.
- Alogoskoufis, G., & Smith, R. (1991). On error correction models: specification, interpretation, estimation. *Journal of Economic Surveys*, *5*(1), 97-128.
- Al Qauhiz, N. M. (2010). Obesity among Saudi Female University Students: Dietary Habits and Health Behaviors. *The Journal of the Egyptian Public Health Association*, *85*(1-2), 45-59.
- Alseleem, Yousef, A. (1998). “The Effect of Saudi Per Capita Gross Domestic Product Variations on the Saudi Rice Imports.” Agric. Res. Center, King Saud Univ. Res. Bult., No (77), PP. (5-33).
- Banerjee, A., Dolado, J. J., Galbraith, J. W., & Hendry, D. (1993). *Co-integration, error correction, and the econometric analysis of non-stationary data*. Oxford university press.
- Childs, N. W., & Kiawu, J. (2009). *Factors behind the rise in global rice prices in 2008*. US Department of Agriculture, Economic Research Service.
- Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica: journal of the Econometric Society*, 1057-1072.
- Doroodian, K., Koshal, R. K., & Al-Muhanna, S. (1994). An examination of the traditional aggregate import demand function for Saudi Arabia. *Applied Economics*, *26*(9), 909-915.
- Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: journal of the Econometric Society*, 251-276.

- FAO, FAOSTAT: URL: https://www.fao.org/faostat/en/#home.
- General Authority for Statistics, Kingdom of Saudi Arabia. URL:https://www.stats.gov.sa/.
- General Authority for Statistics. (2020). Kingdom of Saudi Arabia. Saudi Youth in Numbers: A Report for International Youth Day URL: https://www.stats.gov.sa/sites/default/files/saudi_youth_in_numbers_report_2020en.pdf.
- Granger, C., & P. Newbold. (1974). "Spurious Regression in Econometrics." *Journal of Econometrics.* 2:11–120.
- Granger, C. W. (1981). Some properties of time series data and their use in econometric model specification. *Journal of econometrics*, *16*(1), 121-130.
- Hendry, D. F., & Ungern-Sternberg, T. (2011). Liquidity and Inflation Effects on Consumers' Expenditure.
- Hendry, D. F., Pagan, A. R., & Sargan, J. D. (1984). Dynamic specification. *Handbook of econometrics*, *2*, 1023-1100.
- Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of economic dynamics and control*, *12*(2-3), 231-254.
- Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica: journal of the Econometric Society*, 1551-1580.
- Johansen, S. (1995). *Likelihood-based inference in cointegrated vector autoregressive models*. OUP Oxford.
- Kang, H., Kennedy, P. L., & Hilbun, B. M. (2009). *An empirical estimation of the import demand model and welfare effects: the case of rice importing countries* (No. 1369-2016-108628).
- Lüutkepohl, H., Saikkonen, P., & Trenkler, C. (2001). Maximum eigenvalue versus trace tests for the cointegrating rank of a VAR process. *The Econometrics Journal*, *4*(2), 287-310.
- MacKinnon, J. G. (1996). Numerical distribution functions for unit root and cointegration tests. *Journal of applied econometrics*, *11*(6), 601-618.
- MacKinnon, J. G., Haug, A. A., & Michelis, L. (1999). Numerical distribution functions of likelihood ratio tests for cointegration. *Journal of applied Econometrics*, *14*(5), 563-577.
- Ministry of Water and Electricity MOWE, Riyadh, KSA, annual report, 2011.
- Al-Dkheel, M. (2012). Dietary guidelines for Saudis: The healthy food palm.
- Mousa, S., & Ahmed, M. (2021). Healthy food trends among saudi consumers. *Palarch's journal of archaeology of egypt/egyptology*, *18*(16), 212-223.
- Nichell, S. (1985). Error correction, partial adjustment and all that: an expository note. *Oxford bulletin of economics and statistics*, *47*(2), 119-129.
- Vacu, N., & Odhiambo, N. M. (2020). The Determinants of Import Demand: a Review of International Literature. *Acta Universitatis Danubius. Œconomica*, *16*(5).
- Philips, P. C. (1986). Understanding spurious regression in econometrics. *Journal of econometrics*, *33*(3), 311-340.
- Sargan, J. (1964). "Wages and prices in the United Kingdom: A study in Econometric methodology" *Econometrics and Quantitative Economics.* D. F. Hendry and K. F. Wallis, eds. Blackwell: Oxford.
- Stock, J. (1987). "Asymptotic Properties of Least Squares Estimators of Cointegrating Vectors." *Econometrica*, 55:1035-1056.
- U. S. Department of Agriculture (USDA), Foreign Agricultural Service (FAS). (2012). URL:http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Grain%20and%20Feed%20Annual_Riyadh_Saudi%20Arabia_3-26-2012.pdf,.
- Washi, S. A., & Ageib, M. B. (2010). Poor diet quality and food habits are related to impaired nutritional status in 13-to 18-year-old adolescents in Jeddah. *Nutrition Research*, *30*(8), 527-534.