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دراسة وتحليل الطلب السعودي على فاكهة الموز المستوردة باستخدام منهجية الانحدار الذاتي لفترات الابطاء الموزعة (ARDL)

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المستخلص

في هذا البحث تم تقدير نموذج الطلب السعودي على فاكهة الموز المستوردة، وكانت أهم المتغيرات التفسيرية سعر الاستيراد ودخل الفرد بالمملكة العربية السعودية، ومن خلال اختبار جذر الوحدة باستخدام نموذج ديكي فولر الموسع، فقد تبين أن الواردات وقيمها اللوغاريتمية الطبيعية متكاملة من الدرجة صفر، في حين تبين أن أسعار الواردات ودخل الفرد وقيمها اللوغاريتمية الطبيعية متكاملة من الدرجة واحد، وبالتالي يمكن تطبيق منهجية الانحدار الذاتي والتأخر الموزع (ARDL) وأظهرت نتائج البرنامج الإحصائي Rأن النموذج بصيغته اللوغاريتمية المزدوجة هو النموذج الأفضل . كما أشارت نتائج اختبار التكامل المشترك (باستخدام اختبار الحدود) إلى وجود علاقات توازنية طويلة المدى بين واردات المملكة من الموز والمتغيرين المستقلين قيد الدراسة، وكانت معلمات النموذج معنوية وتتفق مع المنطق الاقتصادي .وكانت مرونة سعر الواردات ودخل الفرد أكبر من واحد، وبتقدير نموذج تصحيح الخطأ (UECM) كان معامل تصحيح الخطأ معنوي احصائياً وسالب الاشارة، وتعني قيمته أن نموذج واردات الموز على المدى القصير يمكن أن يصل إلى التوازن في المدى الطويل في أقل من عامين، وأظهرت الاختبارات التشخيصية (اختبارات جودة النموذج) أن النموذج قيد الدراسة لا يعاني من مشاكل اقتصادية قياسية، وأن معلمات النموذج كانت مستقرة هيكليا، وأخيراً تم استخدام النموذج للتنبؤ بواردات فاكهة الموز للفترة 2020 – 2029.

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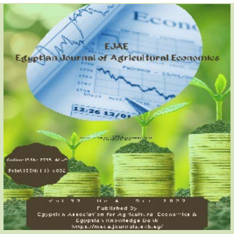

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Study and analysis of the Saudi demand for imported Bananas fruit. Using the autoregressive and distributed Lag ARDL methodology

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ABSTRACT

In this research, the Saudi demand model for imported banana fruit was estimated, and determined by two explanatory variables, included imported banana fruit prices and income per capita. Through the unit root test by ADF, imports and their natural logarithmic values are integrated from the degree of zero, while import prices, income per capita, and their natural logarithmic values integrated to a degree of one; thus, autoregressive and distributed lag ARDL methodology can be applied. The results of the R statistical program showed that the model in its double-log form with a drift is the best model. Also, cointegration test conducted by using the boundary test noted that there are long-term equilibrium relationships between Saudi imports Bananas and the two independent variables under study. The model parameters were significant at 10% and agree with the economic logic. The import price elasticity and income per capita were exceed one, so the elasticity of banana fruit import was independent variable elasticity. By estimating the unrealistic error correction (UECM), the error bound coefficient was negatively significant, and shows that Bananas imports model in the short run could reach to the long run equilibrium in less than two years. The diagnostic tests showed that the model under study does not have econometrics problems, and the model parameters were structurally stable. Finally, the model was used to predict banana fruit imports for the period 2020 – 2029.

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1- Introduction

Banana is one of the most important tropical fruit crops in the world. It occupies a large position in global trade, and in the economy of many countries, in addition to its high nutritional value and consumer demand for it more than the rest of the fruits because of its sweet taste and distinctive flavor and its availability in the markets throughout the year, in addition to the ability of its fruits to be transported, traded and stored. The increased demand for bananas is due to their high nutritional and medicinal value. And that some strains of starchy bananas used in some food products, such as some types of sweetness, flour, and banana powder.

Among the most famous banana-producing countries are Mexico, Nicaragua, Costa Rica, Venezuela, Colombia, Ecuador, Brazil, Uruguay, Chile, the West Indies, and especially the island of Jamaica. Food and Agriculture In 2000, most of North Africa's production was concentrated in Egypt and then Morocco, where there was a significant expansion in banana production under reserves, then Sudan, Comoros, and Somalia. As for the rest of the Arab countries in Asia, the largest producer is currently Lebanon, and most of the production is under reserves, then Yemen, Jordan, Oman, and then the West Bank in Palestine. More than 90 % of banana export originated from central and south America and the Philippines. The largest importers are the EU, the United States of America, China, Russia, and Japan (FAO,2022).

The Jazan region is one of the most banana producing regions in Saudi Arabia. The Kingdom imports bananas from four different countries, mainly Philippines, Ecuador, India, and Sri Lanka. The problem of the research is that despite the increasing interest by the state and the increase in the volume of investments in the field of fruit in general, the cultivated area of the banana crop has been characterized by relative stability and the cultivated area of it is not commensurate with the volume of demand for that crop. And that the increase in banana imports is due to its consumption of large quantities of water and the challenges of saline soils. The research aimed to study the development of imports, as well as study the development of prices. Shita et al., (2019) provide that, the ARDL variables should be integrated of order one or zero.

Alias and Cheong (2000), provide the fact of the inverse relationship between the import price and the demand for imported goods. Bahmani-Oskooee and Kanitpong (2017) provided the effects of exchange rate on the trade balance by examining seven Asian economies.This article estimates the demand function on the Saudi imports of Bananas fruit based on import prices and income per capita using ATSD 1985-2019. The demand function for classified imports is estimated using the ARDL linear model.

Research problem:

The Kingdom of Saudi Arabia imports about 200 types of fruit, and most of the Kingdom’s residents work to buy three basic fruits that represent the backbone of the market on a daily basis, which are bananas, apples, and oranges, which account for about 39.3% of the Kingdom’s total fruit imports in 2019, and that the most consumed fruit is Bananas, amounting to 50 million banana cartons sold in the Kingdom annually. Despite the significant decline in the rate of self-sufficiency in bananas in the Kingdom, which does not exceed 3.8% in 2019, it is noted that the relative importance of banana imports in total fruit imports has decreased from about 13.9% in 1985 to about 7.15% in 2019, which requires studying the impact of the most important variables. The economic impact on the Kingdom’s imports of bananas, as neglecting the impact of these variables will lead to making incorrect decisions regarding determining the quantities imported to meet the Saudi market, especially during seasons in which the demand for fruit increases, such as the month of Ramadan and Hajj, where the demand for fruit increases by 35% over the rest. the year.

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The objectives of research:

Research objectives determined as

1- Study the current situation of the Kingdom of Saudi Arabia's banana imports during the period (1985-2019).

2- Standard estimation of the demand for the Kingdom's banana imports during the period (1985-2019) using the (ARDL) model.

3- Measuring the impact of the most important economic variables on the Kingdom's banana imports in the short and long term.

4- Using the estimation model to predict Saudi imports of Bananas during the period 2020-2029.

2- Materials and Methods

In many cases of application of the cointegration method, the variables under study have different degrees of integration, some variables ~*I*(0) and others ~*I*(1), therefore it is difficult to conduct cointegration tests according to the Engle and Granger (1987), Johansen and Juselius (1990), which requires that the variables be integrated at the same degree. Therefore, Pesaran, Shin, and Smith (2001) provided an appropriate model for treating this problem – the autoregressive and distributed lag model (*ARDL*) (Nkoro & Uko, 2016). Since (*ARDL*) cointegration technique does not require pretests for unit roots unlike other techniques. Consequently, *ARDL* cointegration technique is preferable when dealing with variables that are integrated of different order, *I*(0), *I*(1) or combination of the both and, robust when there is a single long run relationship between the underlying variables in a small sample size. Using ARDL methodology for the cointegration test has some advantages: First, determining the possibility of applying the model regardless of whether the variables under study are degree *I*(0), degree *I*(1), or both. They are used when the integration order is unknown or not uniform for all variables. The only condition for applying this test is that none of the variables can have an *I*(2) degree of integration. Second, it can be used if the sample size is small, which contrasts with most traditional cointegration tests that require the sample size to be large for efficient results. Third, the application of this methodology allows long- and short-run relationships to be estimated together using one equation.

Assuming that Y_t expresses the dependent variable in the period t and X_{1t}, X_{2t}, …, X_{kt} represent k explanatory variables in the period t, then the autoregressive distributed lag model; $ARDL(p, q_1, \cdots, q_k)$ can be written in general form as

$$Y_t = \beta_0 + \delta t + \sum_{l=1}^{p} \gamma_l Y_{t-l} + \sum_{j=1}^{k} \sum_{l=0}^{q_j} \beta_{jl} X_{jt-l} + \varepsilon_t,\ j = 1,2,\dots,k \qquad (1)$$

The unrestricted error correction model (*UECM*), which introduced by Pesaran et al. (2001) is the mathematical transformation of the $ARDL(p, q_1, \cdots, q_k)$ in eq.(1) above, and it takes the following form

$$\Delta Y_t = \beta_0 + \delta t + \sum_{l=1}^{p-1} \emptyset_l \Delta Y_{t-l} + \sum_{j=1}^{k} \sum_{l=0}^{q_j-1} \theta_{jl} \Delta X_{jt-l} + \lambda_0 Y_{t-1} + \sum_{j=1}^{k} \lambda_j X_{jt-1} + \varepsilon_t \qquad (2)$$

where Δ indicates the first differences of the variables, $(p, q_1, \dots, q_k)$ refer to the lengths of lag periods for variables $(Y_t, X_{1t}, X_{2t}, \dots, X_{kt})$ respectively, and do not necessarily be equal and ε_t represents the error term in the period t, which has zero mean and fixed variance from observation to other, it is also assumed that the errors $(\varepsilon_1, \varepsilon_2, \dots \varepsilon_T)$ are independent;$\{E(\varepsilon_t) = 0,\ E(\varepsilon_t^2) = \sigma^2\ and\ E(\varepsilon_t \varepsilon_{t`}) = o\ if\ t \neq t`\}$. The equation (2) above includes intercept β_0 as well as linear trend t which has coefficient δ.

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The advantage of (*UECM*) model in eq. (2), includes the long- run coefficients $(\lambda_0, \lambda_1, \dots, \lambda_k)$, as well as coefficients of short-run $(\emptyset_l`s, \theta_{jl}`s)$, where

$$\begin{aligned} \emptyset_l &= -\sum_{i=l+1}^{p} \gamma_i,\ l = 1,2,\dots,p, \\ \theta_{j0} &= \beta_{j0},\ \theta_{jl} = -\sum_{i=l+1}^{q_j} \beta_{ji}, \quad j = 1,2,\dots,k,\ l = 1,2,\dots,q_j, \\ \lambda_0 &= \sum_{i=1}^{p} \gamma_i - 1, \\ \lambda_j &= \sum_{i=0}^{q_j} \beta_{ji}\ , \quad j = 1,2,\dots,k \end{aligned} \tag{3}$$

and all these coefficients can be estimated simultaneously by using ordinary lest squares (*OLS*) method.

According to $ARDL$ methodology, the analysis is carried out in three steps:

1. A cointegration test using the unrestricted error correction model (*UECM*) in the equation (2), where bounds testing approach developed by Pesaran et al. (2001) can be applied to test cointegration relationship, this test is based on the *F*-test (Wald test) to test the hypothesis of non- cointegration between the variables vs. the existence of cointegration, to reveal the balance relationship between variables at long-run. The null hypothesis is; $(H_0: \lambda_0 = \lambda_1 = \dots = \lambda_k = 0)$, and indicates that there is no cointegration relationship between the variables in equation (1), whereas the alternative hypothesis is $(H_1: \lambda_0 \neq \lambda_1 \neq \dots \neq \lambda_k \neq 0)$, and denotes the existence of a cointegration relationship between the variables in equation (1). Since the distribution of *F* non-standard, the calculated *F* value can be compared with the lower and upper critical bound provided by Pesaran. Then if calculated *F* value is less than the critical lower bound, the null hypothesis cannot be rejected, and it indicates that there is no cointegration. However, if calculated *F* value is higher than the critical upper bound, the null hypothesis can be rejected and co-integration exists between the variables in equation (1), it means that the model allows us to estimate the long-run relationship among the variables. However, if the calculated *F* value occurs between the lower and upper critical bound, the result is that the cointegration is not conclusive.
2. Estimating the long-run relationship between the dependent variable (Y), and the explanatory variables $(X_1, X_2, \dots, X_k)$ which is represented as

$$Y_t = \alpha_0 + \vartheta t + \sum_{j=1}^{k} \alpha_j X_{jt} \tag{4}$$

where $\alpha_0, \vartheta, \alpha_1, \dots, \alpha_k$ represent coefficients of long-run relationship, and their estimates can be computed from the (*OLS*) estimates to the long- run coefficients of (*UECM*) in eq. (2) as follows:

$$\alpha_0 = -(\beta_0/\lambda_0), \quad \vartheta = -(\delta/\lambda_0),\ \alpha_j = -(\lambda_j/\lambda_0)\ , \quad j = 1,2,\dots,k \tag{5}$$

3. The dynamic relationship in short-run of $ARDL(p, q_1, \cdots, q_k)$ model and it also includes the error correction model (*ECM*) that derived from (*UECM*) model, can be characterized as follows:

$$\Delta Y_t = \beta_0 + \delta t + \sum_{l=1}^{p} \emptyset_l \Delta Y_{t-l} + \sum_{j=1}^{k} \sum_{l=0}^{q_j} \theta_{jl} \Delta X_{jt-l} + \psi ECT_{t-1} + \varepsilon_t \tag{6}$$

where

$$ECT_{t-1} = Y_{t-1} - \left(\alpha_0 + \vartheta(t-1) + \sum_{j=1}^{k} \alpha_j X_{jt-1}\right)$$

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is the lagged error correction term, and all the coefficients of the short-run equation are those related to the kinetics of the equilibrium convergence model, and $\psi = \lambda_0$ represent the error correction factor which measures the speed of adjustment from short run towards long run equilibrium path. The value of the error correction coefficient ψ falls in the range $(-1 < \psi < 0)$, where a large coefficient in absolute value indicates a higher speed of adjustment. If the coefficient has a 0 value, it means there is no long-run relationship. On the other hand, a significant coefficient means there are adjustments between the short run and long run. So, it can be said that the factor of lagged error correction term reveals the speed (or slow) of returning the variables to the equilibrium state, and this factor must be significant and negative for the sign to reveal the existence of a co-integration between the variables.

3- Empirical model specification

In this study it is assumed that the quantity of Saudi's imports of Bananas at period t as a dependent variable (Imp_t) is determined by two independent variables, which are as follows: the price of the imported ton of Bananas in period t; $(Pric_t)$, and the income per capita in period t; (Inc_t), Then the linear regression model of Saudi's imports from Bananas it can be written as

$$Imp_t = \alpha_0 + \delta t + \alpha_1 Pric_t + \alpha_2 Inc_t + \varepsilon_t \qquad (7)$$

In order to explain the relative effect of the import price $(Pric_t)$ and income per capita (Inc_t) on the quantity of demand for banana imports (Imp_t) through the interpretation of the elasticity of banana imports (Imp_t) to this two variables respectively, the double logarithmic form was taken into account, which is expressed as follows

$$Ln(Imp_t) = \beta_0 + \delta t + \beta_1 Ln(Pric_t) + \beta_2 Ln(Inc_t) + \epsilon_t \qquad (8)$$

where $Ln(\dots)$ expresses the natural logarithm of the variable, β_1, β_2 denotes the price elasticity income respectively.

Then, $ARDL(p, q_1, q_2)$ model, which represents the equation of Saudi demand for imported bananas, can be denoted by.

$$Ln(Imp_t) = \beta_0 + \delta t + \sum_{l=1}^{p} \gamma_l Ln(Imp_{t-l}) + \sum_{l=0}^{q_1} \beta_{1l} Ln(Pric_{t-l}) + \sum_{l=0}^{q_2} \beta_{2l} Ln(Inc_{t-l}) + \epsilon_t \quad (9)$$

and the unrestricted error correction model (*UREC*) converted from equation (9) above can be written as

$$\Delta Ln(Imp_t) = \beta_0 + \sum_{l=1}^{p-1} \emptyset_l \Delta Ln(Imp_{t-l}) + \sum_{l=0}^{q_1-1} \theta_{1l} \Delta Ln(Pric_{t-l}) + \sum_{l=0}^{q_2-1} \theta_{2l} \Delta Ln(Inc_{t-l}) + \lambda_0 Ln(Imp_{t-1}) + \lambda_1 Ln(pric_{t-1}) + \lambda_2 Ln(Inc_{t-1}) + \delta t + \epsilon_t \qquad (10)$$

where;

$$\emptyset_l = -\sum_{i=l+1}^{p} \gamma_i,\ l = 1,2,\dots,p,$$
$$\theta_{j0} = \beta_{j0},\ \ \theta_{jl} = -\sum_{i=l+1}^{q_j} \beta_{ji},\quad j = 1,2,\ l = 1,2,\dots,q_j,$$
$$\lambda_0 = \sum_{i=1}^{p} \gamma_i - 1,\ \ \lambda_j = \sum_{i=0}^{q_j} \beta_{ji},\quad j = 1,2$$

Data sources and statistical description

The study relied on the *FAO* publications as a secondary source to collect data related to values and quantities of Saudi imports from Bananas, the income per capita data, were obtained from the publications of the General Authority for Statistics during the same period (1985-2019). The prices of Bananas imports were calculated by dividing the value by the quantity.

The descriptive statistics and annual grows rate are presented in table 1, figure 1 also shows the general trend curves of the variables under study. We note that imports quantity from Bananas during the study period lies between a minimum value and maximum (55581, 307420 tons)

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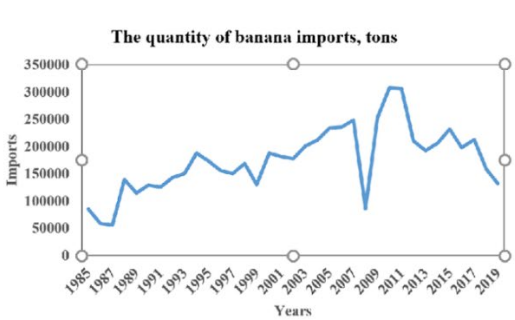
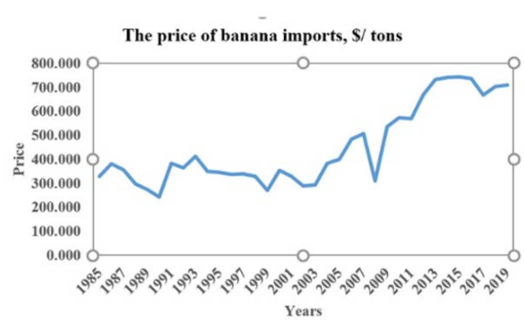
respectively, the average of imports quantity and its standard deviation about (175171, 60256) tons respectively, and grows rate shows the imports quantity will increase by 2.4% annually. As for import prices lies between a minimum value and maximum (243, 744$/ton) respectively, the average of import price and its standard deviation about ($450, $166) respectively, and it increases by 2.8% annually, finally income per capita, it lies between a minimum value and maximum at respectively (SR 23973, SR 95300), the average of income per capita and its standard deviation about (50882 SR, SR 25707) respectively, and it increases by 4.5% annually.

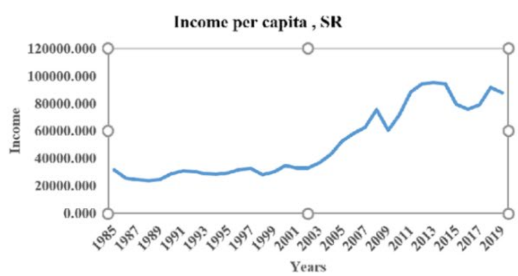
Table1: The descriptive measures and annual grows rates during period (1985-2019)

	Imports	*import price*	*Income*
Min	55581.00	242.88	23973.24
Max	307420.00	744.14	95300.02
Mean	175170.69	449.68	50881.90
St.Dev	60255.65	166.05	25707.32
Grows rate	0.024	0.028	0.045

Graph1: Trend curves of the variables under study







Degrees of integration

Program R was used to obtain the test statistics of Augmented Dickey–Fuller (*ADF*) to test the null hypothesis that the time series has a unit root or nonstationary, as well selecting the appropriate lag period automatically when applying information criteria (*BIC*). Table 2 shows the results of integration degrees for variables under study at neutral values as well neutral logarithm values. From the results in this table we note that Bananas imports (Imp_t) be integration from the degree of zero; $I(0)$, whether natural or logarithmic values, while import prices ($Pric_t$) and income per capita (Inc_t) be integration from degree one $I(1)$.

Since some variables have integration degree zero; $I(0)$, and the others with integration degree one; $I(1)$, that is mean, all variables have integration degree less than two;($< I(2)$), the *ARDL*

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methodology can be applied to study and analyze the cointegration relationships between quantity of Bananas imports (Imp_t) as a dependent variable, and two explanatory variables; which are import prices $(Pric_t)$ and income per capita (Inc_t).

Table 2: Results of integration degrees for variables under study

Type	*Critical values* (*Tau*)		
	1%	5%	10%
Trend	-4.15	-3.50	-3.18
Intercept	-3.58	-2.93	-2.60
without	-2.62	-1.95	-1.61

	Variables	ADF test statistics at the level			ADF test statistics at first difference			Integration order
		Trend	Intercept	Non-int.	Trend	Intercept	Non-int.	
Neutral values	*IMPORT*	-2.84	-2.76*	-0.42	-5.72***	-5.41***	-5.46***	$I(0)$
	PRICE	-2.18	-0.33	0.88	-5.26***	-5.13***	-4.94***	$I(1)$
	INCOME	-2.22	-0.47	1.06	-4.16***	-4.22***	-3.83***	$I(1)$
Neutral Logarithms	*IMPORT*	-3.02	-3.17**	0.45	-6.44***	-5.80***	-5.77***	$I(0)$
	PRICE	-2.59	-0.66	0.78	-5.36***	-5.29***	-5.20***	$I(1)$
	INCOME	-2.20	-0.59	1.70	-4.27***	-4.39***	-3.80***	$I(1)$

Source: computed from collected data.
*** reject the null hypotheses that the series is non-stationarity at level 1%,
** reject the null hypotheses that the series is non-stationarity at level 5%,
* reject the null hypotheses that the series is non-stationarity at level 10%,

4- Results of estimating model $ARDL(p, q_1, q_2)$.

According to what was reached regarding the determination of the degrees of integration for variables under study, the *ARDL* methodology which uses error correction model (*UECM*) in eq. (10) which converted from model $ARDL(p, q_1, q_2)$ in eq. (9) is the most appropriate approaches to conduct a test of cointegration between model variables using the limits tests proposed by Pesaran et. al (2001). The R statistical program was used to obtain the results of estimating the $ARDL(p, q_1, q_2)$ coefficients as well (*UECM*), where the program automatically determines the appropriate lag periods for each variable in the model according to (*BIC*) criteria. From the outputs of program, the form $ARDL(2,3,3)$ with intercept is the appropriate form in the analysis. Then the distribution of lag periods in model is as follows: The dependent variable $Ln(Imp_t)$ has 2 lag periods $(p = 2)$, and both of two independent variables $Ln(Pric_t)$, $Ln(Inc_t)$ it has 3 lag period $(q_1 = q_2 = 3)$. The estimation results of $ARDL(2,3,3)$ as well (*UECM*) summarized in Table 3.

Table 3: Estimation results of selected {*ARDL*(2,3,3) } and *UECM* corresponding to this model

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based on Schwarz Bayesian Criterion.

ARDL(2,3,3): Dependent variable is $Ln(Imp_t)$					*UECM* : Dependent variable is $\Delta Ln(Imp_t)$				
Regressors	Estimate	Std.Error	t value	Pr(>|t|)	Regressors	Estimate	Std.Error	t value	Pr(>|t|)
Intercept	5.9830	1.6639	3.5960	0.002	Intercept	5.9830	1.6639	3.5960	0.002
$Ln(Imp_{t-1})$	0.2613	0.1754	1.4900	0.151	$Ln(Imp_{t-1})$	-0.5608	0.1828	-3.0680	0.006
$Ln(Imp_{t-2})$	0.1779	0.1549	1.1490	0.264	$Ln(Pri_{t-1})$	-0.8600	0.4096	-2.1000	0.048
$Ln(Pri_t)$	0.8354	0.2727	3.0630	0.006	$Ln(Inc_{t-1})$	0.5667	0.2881	1.9670	0.063
$Ln(Pri_{t-1})$	-0.4217	0.2935	-1.4370	0.1656	$\Delta Ln(Imp_{t-1}$	-0.1779	0.1549	-1.1490	0.264
$Ln(Pri_{t-2})$	-0.9180	0.3281	-2.7980	0.011	$\Delta Ln(Pri_t)$	0.8354	0.2727	3.0630	0.006
$Ln(Pri_{t-3})$	-0.3558	0.2207	-1.6120	0.122	$\Delta Ln(Pri_{t-1})$	1.2737	0.3318	3.8380	0.001
$Ln(Inc_t)$	-0.7397	0.4657	-1.5880	0.127	$\Delta Ln(Pri_{t-2})$	0.3558	0.2207	1.6120	0.122
$Ln(Inc_{t-1})$	0.1532	0.7192	0.2130	0.833	$\Delta Ln(Inc_t)$	-0.7397	0.4657	-1.5880	0.127
$Ln(Inc_{t-2})$	-0.2979	0.6322	-0.4710	0.642	$\Delta Ln(Inc_{t-1})$	-1.1533	0.4693	-2.4570	0.023
$Ln(Inc_{t-3})$	1.4511	0.4752	3.0540	0.006	$\Delta Ln(Inc_{t-2})$	-1.4511	0.4752	-3.0540	0.006
R-Squared = 0.696 *BIC* = 13.27					*R*-Squared = 0.7994 *BIC* = 13.27				
F-Stat = 4.797 on 10 and 21 *df* *Pr*(>*F*-Stat) = 0.0012					*F*-Stat = 8.369 on 10 and 21 *df* *Pr*(>*F*-Stat) = 0.000025				
D W-Statistics = 1.786 *P-value* = 0.354					*D W*-Statistics = 1.786 *P-value* = 0.354				

From the results in table 3 above, we note that the independent variables in *ARDL* (2,3,3) model, explain about 69.6% of total variations in the dependent variable; $Ln(Imp_t)$ which represents the logarithm value of Saudi's imports of Bananas. While the independent variables in the (*UECM*) model, explain about 79.9% of total variations in the dependent variable, which represent the first difference of Saudi's imports of Bananas; $\Delta Ln(Imp_t)$. The value of *F* test statistics in *ARDL* (2,3,3) model; $F - stat = 4.797$, and its $p - value = 0.0012$, so the *ARDL* (2,3,3) model is appropriate at significant level 1%. While in the (*UECM*) model, $F - stat = 8.369$, and its $p - value = 0.000025$, so the (*UECM*) model is appropriate at significant level 1%. Both models do not suffer from the problem of autocorrelation between errors, where the value of the Durbin Watson statistic $D.W - stat = 1.786$ and the corresponding $p - value = 0.354$ greater than 0.05 significant level.

Test the existence of cointegration

The results of testing the cointegration for variables in model *ARDL* (2.3.3) is summarized in Table 4. The value of *F* test statistic about 7.8531 which above upper bound (4.85) at 95% confidence level, so the null hypothesis; $(H_0: \lambda_0 = \lambda_1 = \lambda_2 = 0)$ in empirical (*UECM*) showed in eq. (10) can be rejected and indicates that the existing of a cointegration relationship between the variables under study.

Table 4: Results of a cointegration test for variables of *ARDL* (2,3,3) model.

Test statistics	Value	95% Lower Bound	95% Upper Bound	p.value
F-statistics.	7.8531	3.79	4.85	0.0017
W-statistics.	23.559	11.37	14.55	0.0017

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Analyze and discuss the results of the long-term relationship

The statistical test demonstrated the existence of cointegration among the variables of the model *ARDL*(2,3,3) which represents the function of Saudi's imports of Bananas; thus, there is a long-run relationship among these variables, the estimation of its parameters has been obtained by using R statistical program and summarized in table 5

Table 5: Estimation results of coefficients long-run relationship

term	Coefficient α	estimate	St. Error	t.statistic	P.value (2-tais)
(Intercept)	α_0	10.669	1.958	5.450	0.000021
$Ln(Pri_{t-1})$	α_1	-1.534	0.889	-1.726	0.0991
$Ln(Inc_{t-1})$	α_2	1.011	0.545	1.855	0.0777

The results in table 5 above show that the import price (Pri) of bananas exerts a negative effect and significantly on Saudi imports of bananas in long run, where the alternative hypothesis; $\{H_1: \alpha_1 < 0\}$ can be accept at the significant level 5%, and this agrees with the economic logic. It is also noted that the estimation of demand elasticity on bananas imports to the import price is negative, where $(\hat{\alpha}_1 = -1.53)$ and indicates that under given income per capita (Inc), an increase in import prices by 10% results in an expected decrease in imports by 15.3%, Thus, the demand elasticity to price is elastic.

While it is noted that, in the long run, the income per capita (Inc) exerts a positive effect and significantly on Saudi imports of bananas, where the alternative hypothesis; $\{H_1: \alpha_2 > 0\}$ can be accept at the significant level 5%, and this agrees with the economic logic. It is also noted that the estimation of demand elasticity on banana imports to the income per capita is positive, where $(\hat{\alpha}_2 = 1.011)$ and indicates that under given import price (Pri), an increase in income per capita by 10% results in an expected increase in imports by 10.1%, Thus, the demand elasticity to income (Inc) is equal elasticity.

Also, it notes the estimation of intercept α_0 in long run equation is $(\hat{\alpha}_0 = 10.7)$, it indicates that, the intercept is positive and significant at the significant level 5%, under removing the effect of both the import price and the income per capita, the mean of Saudi imports of bananas expected to be 10.7 Ton.

From the above analysis of the long-run relationship that represents the Saudi demand for banana imports as a function of two explanatory variables, which are import prices (Pri) and income per capita (Inc), these results can be discussed as follows:

- It is logical that, when the countries from which Saudi Arabia imports bananas fruits decide to raise the import price, Saudi importers decide to reduce its import of bananas and replace one or other types of alternative fruits.
- Due to the high nutritional value of the banana fruit, and the Saudi consumer's keenness and awareness of the importance of this type of fruit and its nutritional value, it is logical that any increase in family income is accompanied by an increase in demand for this type of fruit, and then Saudi importers decide to increase its imports to meet this demand.

Estimating the error correction Model (ECM)

The *ECM* describes the dynamic relationship between the dependent variable and the independent variables in the short run. The parameter estimates of the error correction model can be deduced from the parameter estimates of the (*UECM*) related to $ARDL(2,3,3)$ that shown in table 3. The obtained results summarized in table 6.

Table 6: The estimates of the error correction model parameters related to for the selected *ARDL* (2,3,3). Dependent variable is $\Delta Ln(Imp_t)$.

Regressor	Coefficient	Standard Error	t Stat.	p-value
$\Delta Ln(Imp_{t-1})$	-0.1779	0.1549	-1.1490	0.264
$\Delta Ln(Pri_t)$	0.8354	0.2727	3.0630	0.006
$\Delta Ln(Pri_{t-1})$	1.2737	0.3318	3.8380	0.001
$\Delta Ln(Pri_{t-2})$	0.3558	0.2207	1.6120	0.122
$\Delta Ln(Inc_t)$	-0.7397	0.4657	-1.5880	0.127
$\Delta Ln(Inc_{t-1})$	-1.1533	0.4693	-2.4570	0.023
$\Delta Ln(Inc_{t-2})$	-1.4511	0.4752	-3.0540	0.006
$(Ecm_{t-1})^*$	-0.5608	0.1828	-3.0680	0.006

$R - squareed = 0.7994.$ $BIC = 13.27$

$F.Stat. = 8.369, \quad p - value = 0.000035$ $D.W.Stat. = 1.786, \quad p - value = 0.354$

$^*Ecm_{t-1} = Ln(Imp_{t-1}) - 10.669 + 1.534\ Ln(pri_{t-1}) - 1.011\ Ln(Inc_{t-1})$

The results of the short run relationship in table 6 above, show the following

- The relative change in demand on banana imports at lagged one periods $\Delta Ln(Imp_{t-1})$, has not a significant effect on demand on banana imports at the current period $\Delta Ln(Imp_t)$ at the significant level 5%.
- The relative change in the prices of Saudi banana imports at the current period $\Delta Ln(Pri_t)$, as well as at lagged one period $\Delta Ln(Pri_{t-1})$, has a positive and significant effect on the relative change in demand on banana imports $\Delta Ln(PImp_t)$, at significant level 5%, whereas, the relative change in the prices of banana imports at lagged two periods $\Delta Ln(Pri_{t-2})$, did not prove a significant effect at the level 5%.
- The relative change in the income at the lagged one period $\Delta Ln(Inc_{t-1})$, as well as at lagged two period $\Delta Ln(Inc_{t-2})$, has a positive and significant effect on the relative change in demand on banana imports $\Delta Ln(Imp_t)$, at level 5%, whereas, the relative change in the at the current periods $\Delta Ln(Inc_t)$, did not prove a significant effect at the level 5%.
- Also the results show that the coefficient of lagged error correction term Ecm_{t-1} is estimated by $(\hat{\psi} = -0.56)$ which is negative and significant at level 1%, meaning that imports of Bananas, import prices and income per capita have cointegration when imports of Bananas is a dependent variable and it does not includes linear trend, and this supports the effect of import prices and income per capita in the short- and long-run dynamic models. Whereas, the factor of the error correction term was -0.56, it means that about 56% of the long-term shocks can be corrected every year, that is, the Bananas imports model in the short run could reach to the long run equilibrium in less than two years. In other words, when the Bananas imports index deviates during the short-run in the previous period (t-1) from their equilibrium values in the long run, the equivalent of 56% of these deviations is corrected in period *t* until it reaches equilibrium in the long run in less than two years.

Results of Diagnostic Tests of the $ARDL(2,3,3)$ Model

To verify the quality of the $ARDL(2,3,3)$ model used in the analysis and free from econometrics

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problems, diagnostic tests were performed according to the Lagrange Multiplier (*LM*) statistic. R statistical program was used to obtain the results of diagnostic tests by running the available data, and the results are summarized in Table 7

Table 7: Diagnostic tests for $ARDL(2,3,3)$ model

Test Statistics	*Test Statistics*	p-value
A: Serial Correlation	CHSQ (1) = 0.296	0.587
B: Functional Form	F (1,20) = 0.641	0.433
C: Normality	CHSQ (2) = 2.369	0.306
D: Heteroscedasticity	CHSQ (1) = 0.895	0.344

A: Lagrange multiplier test of residual serial correlation
B: Ramsey's RESET test using the square of the fitted values
C: Jarque- Bera test of normality for residuals
D: Breusch-Pagan Test, based on the regression of squared residuals on squared fitted values

The results of the diagnostic tests in table 7 above shows the following:

- According to Breusch-Godfrey serial correlation test. C*hi-square* test statistics $\{\chi^2 = 0.296,\ pr(\chi^2_{(1)} > 0.296) = 0.587\}$ indicates that the null hypothesis that there is no serial correlation between the error terms can be accepted at level 5%, so the model does not suffer from the problem of existing serial correlation between error terms.
- According to Ramsey's RESET test. F test statistics $\{F = 0.641,\ pr(F_{(1,20)} > 0.641) = 0.433\}$ indicates that the null hypothesis that the functional form for $ARDL(2,3,3)$ model does not suffer from indeterminacy can be accepted at level 5%. So, the functional form specified to the model is appropriate and correct.
- According to Jarque- Bera test, the *chi-square* test statistics $(\chi^2 = 2.368)$ and its *p.value* $\{pr(\chi^2_{(2)} > 2.368) = 0.306\}$ indicates that the null hypothesis that the residuals has normal distribution can be accepted at level 5%.
- According to Autoregressive Conditional Heteroscedasticity (*ARCH*) test, The *chi-square* test statistics $(\chi^2 = 0.895)$ and its *p.value* $\{pr(\chi^2_{(1)} > 0.895) = 0.344\}$ indicates that the null hypothesis that the variances of the random error terms are constant in the estimated $ARDL(2,3,3)$ model can be accepted at level 5%. So, the model does not suffer from the problem of heteroscedasticity.

Results of the structural stability test for the estimated ARDL model

According to Pesaran and Pesaran (1997), the next step in estimating the *UECM* formula for the *ARDL* model is to test the structural stability of the short and long run parameters, that is, the data under study must be free from presence of any structural changes in them over time. To achieve this, two tests are used: (1) Cumulative Sum of Recursive Residual (CUSUM) and (2) Cumulative Sum of Square Recursive Residual (CUSUMSQ). The structural stability of the estimated

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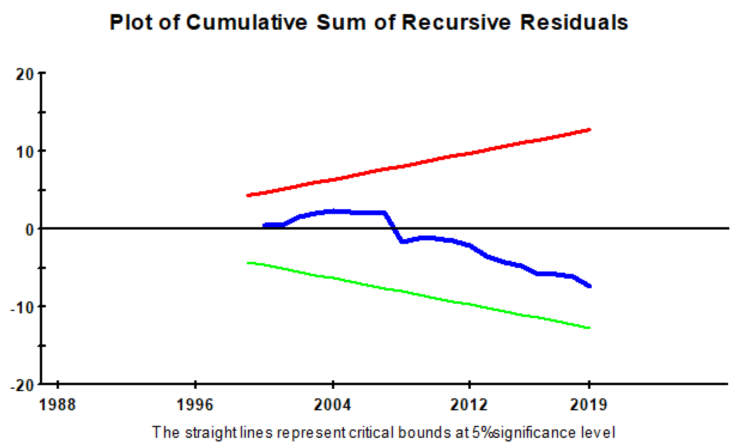
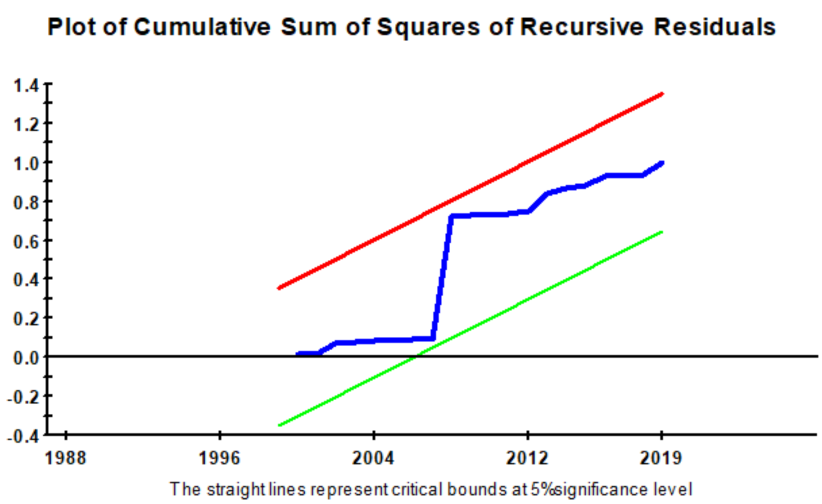
coefficients in the *UECM* formula related to the *ARDL* (2,3,3) model is achieved if the CUSUM and CUSUMSQ statistic form fall within the critical limits at the 5% significance level, and then these coefficients will be unstable if the graph of the statistic for both the aforementioned tests moves outside the critical limits at this level.

It is evident through the figure 2 blow that the estimated coefficients of the *ARDL* (2,3,3) model used are structurally stable over the time interval under study, which confirms the existence of stability between the variables of the study and consistency in the model between the results of error correction in the short and long run, where the CUSUM and CUSUMSQ statistic both fall within the critical limits at the 5% significance level.





5- Forecasting Saudi imports of Bananas from 2020-2029

One of the main objectives of this study is to predict the Saudi's imports from Bananas during

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future period 2020 – 2025. This objective was achieved in two steps:

- In the first step, best *ARIMA* (p, d, q) models were used to obtain the predicted values to the independent variables $\{Ln(pri_t)\}$ and $Ln(Inc_t)$ during the period 2020– 2029. R program was used to choose the appropriate *ARIMA*(p,d,q) model automatically according to criteria information *AICC* and get prediction values.
- Using the fitted *ARDL* (2,3,3) model to predict Saudi's imports from Bananas given prediction values of independent variables in step 1. R program was used for obtaining the prediction values $\widehat{Ln}(Imp_t)$. Table 8 presents the predictions values for each of the explanatory variables and dependent variable.

Table 7: The predictions values for each of the explanatory variables and dependent variable

Years	Independent variables		Dependent variable $(\widehat{\imath mp_t})$	
	$Ln(pri_t)$ *ARIMA* (0,1,0)	$Ln(Inc_t)$ *ARIMA* (0,1,1) *with drift*	$Ln(\widehat{\imath mp_t})$ *ARDL* (1,0,1,0)	$(\widehat{\imath mp_t}) =$ exp $(Ln(\widehat{\imath mp_t}))$
2020	6.5591	11.4160	11.836	138151
2021	6.5591	11.4461	12.043	169976
2022	6.5591	11.4763	11.962	156678
2023	6.5591	11.5064	12.020	166122
2024	6.5591	11.5365	12.027	167154
2025	6.5591	11.5666	12.060	172845
2026	6.5591	11.5968	12.085	177157
2027	6.5591	11.6269	12.115	182590
2028	6.5591	11.6570	12.144	187940
2029	6.5591	11.6871	12.174	193685

From the results above it noted that under the assumption of the predicted values of the independent variables in their logarithmic form, Saudi imports of Bananas are expected to increase from 138151 tons in 2020 to 193685 tons in 2029 with growth rate 2.87% annually. The average of the period was 171230 tons, with a standard deviation of 15988 tons.

6- Conclusion

- The quantity of Saudi's imports of Bananas impor as a dependent variable explained by two independent variables (the price of the imported banana fruit, and income per capita).
- This study explained the relationship between the Saudi demand for Bananas and the two explanatory variables (import price and income per capita) in the long run.
- The study relied on time series data (1985-2019) for the quantity of imports, import prices, and income per capita that increased by annually grows rates 2.4%, 2.8%, 4.5% ,respectively.
- From results of unit root test by using (*ADF*) approach, imports and its natural logarithmic values be integration from the degree of zero; $[(Imp_t\ ,Ln(Imp_t))\sim I(0)]$, while import prices $(Pric_t)$, income per capita (Inc_t) and its natural logarithmic values be integration from degree one; $\left[\left(Pric_t\ ,Inc_t,\ \ Ln(Pric_t)\ and\ Ln(Inc_t)\right)\sim I(1)\right]$.

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- Since all variables have integration less than two ;(< I(2)), the $ARDL$ methodology was applied to study and analyze the cointegration relationships between imports quantity, and two of the explanatory variables (import prices, income per capita.
- In order to obtain the relative effects of the explanatory variables and elasticities directly, the double logarithmic form (Cobb and Douglas equation) was suggested to represent the demand equation under study.
- A time series data (TSD 1985-2019) was obtained, R statistical program was used for obtaining the results of $ARDL$ approach. From the outputs, the appropriate form of $ARDL(p, q_1, q_2)$ was $ARDL(2,3,3)$ with drift.
- The results of application bound testing approach, showed that the existing of a cointegration relationship between the variables in $ARDL(2,3,3)$ model.
- The results that related to the estimation of the long-run demand model showed that import price has a negative significant effect on Saudi's imports of Bananas in the long run at significant levels 10%, but income per capita has a positive significant effect at significant levels 10%. The effect value of each independent variable indicates that the elasticity of demand on Bananas imports to these variables elasticity and agrees with economic logic.
- In the *ECM,* the estimated value for the coefficient of lagged error correction term was -0.56, which was negative and significant at level 1%, it means that about 56% of the long-term shocks can be corrected every year, that is, the Bananas imports model in the short run could reach to the long run equilibrium in less than two years.
- Diagnostic tests show that the $ARDL(2,3,3)$ model is free of econometrics problems.
- It was also found from the structural stability test for the short and long run model parameters that the coefficients of $ARDL(2,3,3)$ are structurally stable during the study period.
- The fitted $ARDL(2,3,3)$ model was used to predict Saudi's imports from Bananas given prediction values of independent variables during period 2020-2029, it was shown that the imports of Bananas gradually increased over the forecast period (2020-2029).

Recommendations

The results showed that the value for the coefficient of lagged error correction term was (-0.56), and it was statistically significant at the 1% level. It indicates that 56% of all deviations and imbalances in the balance of independent variables are corrected in less than two years. Therefore, attention must be paid to agricultural development, which leads to an increase in local production by horizontal expansion by increasing the cultivated area and vertically using modern technology and technology in agriculture and irrigation (Recommending the expansion of banana cultivation in Saudi Arabia despite water scarcity. Bananas are grown in areas with a comparative advantage in Jazan in terms of fertile soil, the presence of Wadi Beish and Sabya, rainfall above average, and modern irrigation methods are used to reduce water consumption).

Conflict of interest: none

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