Error Correction, Cointegration
and
Aggregate Import Demand for Syria

Introduction

In Economic Literature, many studies focused on traditional import demand function, in static as well as dynamic forms.[1] Their goals were seeking for variables and factors that determine the level of aggregate demand import and estimating the long and short run elasticities. These studies followed two approaches. The first one was the traditional estimation by single equation, whereas the second followed the recent development of time series technique: unit root and cointegration.

The main purpose of this paper is to analyze the behavior of the aggregate import demand function for Syria using time series techniques, namely; Cointegration and Error Correction Mechanism.[2] The study covers the period 1970-1995. The annual data at 1985 constant prices are obtained from the Central Statistical Office in Syria.

Analyzing the import demand function for Syria has a special importance due to the high degree of dependence of the Syrian economy on the international trade. Econometrics wise, the estimation of import demand functions have some problems resulting from administrative obstacles, pricing behavior of imports and estimation methods of other related variables. Because of the special administrative organization of imports in Syria, it is expected that, the estimation of import demand function may face some econometrics problems. We can summarize the most important factors qualifying the imports flows as follows:

1- Importance of imports and Instability: Imports has a special importance in the Syrian economy. During the period 1970-1995, imports value of goods and services have increased from 8.3 billion Syrian Pound (SP) to 26.5 billion SP, with an annual average growth equals to 4.1 %. The average import share of GDP during the study period was about 25.4 %. The instability of this share ranged between 18.8 % in 1983 and 31.4 % in 1979.

2- Multiplicity of the exchange rates: the government uses multiple exchange rates to allocate foreign reserves to imports, depending on the type of the imported goods: raw materials, capital goods, final consumption goods, intermediate consumption goods, and luxury goods. Therefore, imports can be funded according to different exchange rates against the US dollar. Among them are the following official rates : 3.8 SP, 11.25 SP and 22 SP for one US dollar. The dollar exchange rate in the parrell markets was equal to 45 SP, whereas it was about 50 SP in the black market. Thus, any modification in the official exchange rate will lead to an artificial increase in import values.

3- Differentiation in the exchange rates according to the import sector: the public sector was given exchange rates to finance its imports differed of those given to the private sector.

4- Multiplicity of tariffs according to the importing sectors (public, private or cooperative) and according to the purpose of imports whether they were for final consumption, intermediate goods, or capital accumulation. This would lead to different extra costs which would lesd, in its turn, to price variations for the same imported product.

5- Interelationship between imports and exports revenue. This is being done through allowing exporters to use percentage of their exports revenue to finance their import needs from consumers goods and raw materials. Another use is to sell the foreign currency (US $) that comes from exports to the importers at higher exchange rate than the going rate in the parrell markets or even in black market. This regulation had lead to the differences in the exchange rates of US $ which ranged from 10% to 15% between the black market (about 45 SP) and the export price (it ranges between 55 SP to 65 SP depending on the domestic demand). This linkage increases artificially the exports values and decreases the import values, because of scarcity of foreign currency and complicated steps on obtaining it in Syria.

6- Smuggling of illegal imports. The prohibition of importing some goods and raw materials, and the restriction of imports other goods encouraged the smuggling from the neighboring countries, especially from Lebanon. This had been noticed especially during the period 1981-1984 when illegal market for the smuggled goods has spread across the country. In addition, it led to spread of black markets, smugglers, and mediators for several goods and raw materials.

Because of these factors, it is expected that imports relative prices in the Syrian economy may play a limited role in explaining the import demand function. The price concept is destorded by many deficiencies that drove it away from reality. Import prices are misrepresented and characterized by artificiality and unreality. As the US $ has many exchange rates, the same good may have many prices. The noticeable smuggling activities during some years lowered imports and decreased their share in the GDP. So, the introduction of a dummy variable is justified to take account for these activities. The statistical significance of the dummy proved the existing of this phenomenon in the Syrian economy.

This study is divided into three sections. The first one deals with the theoretical aggregate import demand functions. In the second section, the Error Correction Model is applied whereas the last section is devoted to the Johansen method for Cointegration.

1. Theoretical Aggregate Import Demand Functions:

Aggregate import demand functions take the following general form:

$$M_t = f(Y_t, P_t, Z_t, U_t) \qquad \{1\}$$

Where:

: M_t Aggregate import demand in period (t) .

Y_t : Real gross domestic product in period (t).

: P_t Relative import prices in period (t).

Z_t : Other explanatory variables in period (t).

U_t : Random error term in period (t).

The relation shown in (1) indicates that variations in aggregate import demand are explained by variations in gross domestic product, relative import prices, and other explanatory variables. For example, population, financing level, export revenues, availability of foreign currencies, time trend, and dummy variables can be included. The random term (U_t) represents other variables not included explicitly in this relation as well as the estimation errors.

The aggregate import demand function can take the linear form:

$$M_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Y_t + u_t \qquad \{2\}$$

Where it is expected that $\alpha_1 < 0, \ \ \alpha_2 > 0$.

The linear form assumes constant response of import demand variations due to variations in relative import prices and/or gross domestic product. If the response is not constant, the exponential function, which takes the following form is preferable,

$$M_t = \gamma_0 P_t^{\gamma_1} Y_t^{\gamma_2} e_t \qquad \{3\}$$

Taking the linear logarithmic transformation to equation (3), we get:

$$\ln M_t = \ln \gamma_0 + \gamma_1 \ln P_t + \gamma_2 \ln Y_t + \varepsilon_t \qquad \{4\}$$

The choice of the logarithmic model is dictated by the objective to reduce the heteroscedasticity. To use a time series characterized by constant mean and variance over time, it is recommended to use the logarithmic form of the variables. Moreover, the logarithmic model would facilitate the estimation of elasticities .

There are theoretical reasons to expect the price elasticity of aggregate import to be negative, $\gamma_1 < 0$. Regarding the income elasticity, there is ambiguity in its sign; but it is expected mostly to be positive. However, it is possible to have a negative sign if the government followed a development policy for import substitution in which the increase in gross national product may be associated with decreasing import demand.

Applying the OLS method to estimate equation (4), it is based on the assumption of stationarity time series of imports, relative prices and gross domestic product. If this assumption does not hold, a new methodology will be used to estimate our equations. Therefore, we will discuss first the meaning of the stationarity of the time series and cointegration. Then, we will test for existing of unit root in the time series that included in the import demand function (imports, relative prices, and gross domestic product). Finally, we will apply the cointegration concept on the import demand function using Engle & Granger methodology of Error Correction Model (ECM) and Johansen cointegration method.

Based on Wold's theorem, a stationary time series with no deterministic components has an infinite moving average representation (ARMA) that can approximated by a finite process. A priori, many economic time series will be non-stationary integrated processes. Thus, if a non-stationary time series (X) needs to be differenced (d) times until reaching stationarity, then the time series is said to be integrated of order (d), denoted by $X_t \sim I(d)$.

For a pair of series, X_t and Y_t, which are both integrated of the same order (d) or $I(d)$, then any linear combination of the form $Z_t = Y_t - aX_t$, will be integrated of order (d), where α is a constant. If α fulfills the relation, $Z_t \sim I(d-b), b > 0$, then X_t and Y_t are integrated. However, the variables contained in the vector Z_t do not necessarily have the same order of integrability. Johansen demonstrated that if $X_t \sim I(0)$ and $Y_t \sim I(1)$, then Y and $\bar{X} = \sum_{j=0}^{p} X_{t-j}$ could be cointegrable. The Granger representation indicates that if X_t and Y_t are integrated, they have an error correction representation as follow:

$$a(L)\Delta Y_t = \alpha_0 - \lambda(Y_t - \alpha_1 X_t) + b(L)\Delta X_t + c(L)\varepsilon_t \qquad \{5\}$$

Where a (L), b (L) and c (L) are stable and invertible polynomials, respectively. Such models provide a more attractive way of presenting and modeling cointegrating series. The error correction models combine the long run $(Y_t - \alpha X_t)$ and the short run dynamics.

Following the analysis of Engle and Granger, equation (2) and (4) can be employed directly to test for cointegration. If the variables contained in the import demand function are cointegrated, then models (2) and (4) would present estimates of the long run equilibrium, and consistent estimates for elasticities can be obtained directly from these models.

According to Engle and Granger methodology, the first step is to examine whether the series contained in the import demand function has a unit root. In the cointegration literature, the more frequently used tests for a unit root are the Dickey-Fuller (1979 and 1981), Philips-Perron (1988), and Perron (1986 and 1988) test. These tests agreed in their treatment to the intercept parameter μ. Thus, the null model to test for unit root has the following form:

$$X_t = \mu + \alpha X_{t-1} + \varepsilon_t \qquad \{6\}$$

and the model under the alternative hypothesis:

$$X_t = \mu + \theta(t - T/2) + \alpha X_{t-1} + \varepsilon_t \qquad \{7\}$$

Where X_t is the logarithm of the time series, and under the null hypothesis; $\alpha = 1$ and $\theta = 0$, and T represent the number of observations. In this paper, we use the Augmented Dickey-Fuller (ADF) and the Philips-Perron (PP) to test for the stationarity of the time series.

The ADF test can be obtained by applying OLS to estimate the coefficients of the following relation:

$$\Delta X_t = \mu + \theta t + \gamma X_{t-1} + \sum_{i=1}^{n} \lambda_i \Delta X_{t-i} + u_t \qquad \{8\}$$

Where n is chosen to eliminate the autocorrelation. If a unit root exists, then $\gamma = \alpha - 1$ would not be statistically different from zero . The ADF test can be conducted by comparing the t-value on the coefficient of X_{t-1} by either the critical values presented by Fuller (1976) or by the extended tables of Dickey-Fuller that presented by Guilkey and Schmidt (1989) and denoted by τ_t.

This study try to confirm that there is a stable long-run equilibrium relationship between aggregate import demand, price and income in the Syrian economy.

II. Import demand and Error Correction Model:

The aggregate import demand (M_t), and gross domestic product (Y_t) are measured at constant prices of 1985. The price variable (P_t) is calculated by dividing import price index (P_m) on domestic price as expressed by implicit of

GDP price index (P_d), $P_t = P_{mt}/P_{dt}$. The dummy variable is included to take into account illusory decreasing in the legal import level during the period 1981 – 1984.

Table (1) shows the t values on the level obtained from ADF and PP tests. These values are clearly less than the critical values and therefore the null hypothesis of a unit root cannot be rejected for each series at the 5 per cent significant level.[3] Thus, import, price and income are non stationary time series.

Table (1)
ADF and PP Unit Roots tests

Variables	Specifications	Lags	Levels		First Differences	
			ADF	PP	ADF	PP
lm	No intercept No trend	0 ١ ٢	-1.787 -1.711 -1.425	-1.787 -١.٨٩٣ -1.893	-4.706 -2.742 -2.187	-4.706 -4.705 -4.71
	With intercept No trend	0 ١ ٢	-1.834 -1.834 -2.028	-1.834 -1.848 -1.854	-5.233 -3.193 -2.831	-5.233 -5.233 -5.229
	With intercept and trend	٠ ١ ٢	-2.274 -2.204 -2.645	-2.274 -2.262 -2.273	-5.297 -3.320 -3.208	-5.297 -5.298 -5.304
ly	No intercept No trend	0 ١ ٢	-3.587 -3.137 -2.357	-3.587 -3.913 -3.871	-3.834 -2.578 -1.121	-3.834 -3.774 -3.830
	With intercept No trend	0 ١ ٢	-2.116 -2.396 -1.436	-2.116 -2.355 -2.419	-5.612 -3.717 -1.948	-5.612 -5.623 -5.595
	With intercept and trend	٠ ١ ٢	-2.434 -2.587 -1.787	-2.435 -2.432 -2.433	-5.997 -3.698 -2.241	-5.997 -5.997 -5.992
lp	No intercept No trend	0 ١ ٢	-0.409 -0.971 -0.316	-0.409 -0.636 -0.709	-3.681 -3.469 -2.534	-3.681 -3.669 -3.631
	With intercept No trend	0 ١ ٢	-1.680 -2.169 -1.277	-1.680 -1.372 -1.797	-3.826 -3.529 -2.642	-3.826 -3.826 -3.778
	With intercept and trend	٠ ١ ٢	-1.901 -2.511 -1.778	-1.901 -2.042 -2.086	-3.731 -3.457 -2.593	-3.731 -3.734 -3.686

Also, table (1) shows the calculated t values of the first differences. These results prove that the hypothesis of unit root can be rejected or to say that the variables in their first difference are stationary time series. So the variables of the equilibrium import demand relation are cointegrated of order one, I (1).

Having obtained the above result of non-stationarty of the time series, we then run the cointegrating regression for the aggregate import demand function, and obtain the following result:

$$\ln \hat{M}_t = 0.154 - 0.074 \ln P_t + 0.867 \ln Y_t - 0.229D$$

$$CRDW = 1.259 \qquad \overline{R}^2 = 0.930 \qquad \text{S.E.R} = 0.093 \qquad \{9\}$$

It is clear that the equilibrium price elasticity of import demand is very low (-0.074) where the equilibrium income elasticity of import demand is equal to (0.867). The lowest price elasticity may result of the high multicolinearity between price and income, where the correlation coefficient between these two variables is about 0.75.

The CRDW is the cointegrating Durbin-Watson Statistics, the values of t statistics are not reported or other statistics since these estimates may be biased (Engle and Granger, 1987), while the estimated parameters are not affected (Stock, 1985). Engle and Granger (1987) calculated the critical values of CRDW, and they are 1%= 0.511, 5%= 0.386, and 10%= 0.322. It is clear that the aggregate import demand function is cointegrated at the one-percent level.

Since the CRDW statistics alone is not enough to ensure the existence of cointegration, we can run ADF and PP to test for the unit root. The calculated values of ADF and PP are as follow:

Table (2)
Testing the Residuals for Unit Root

	Specifications	Lags		
		0	1	2
ADF	With intercept	-3.177	-2.141	-2.256
	No intercept	-3.251	-2.203	-2.277
P-P	With intercept	-3.177	-3.140	-3.191
	No intercept	-3.251	-3.216	-3.264

It is clear from table (2) that the obtained residuals of the aggregate import demand function regression are stationary at five percent significance level since ADF calculated values exceed the critical values.[4] In other words, the contained variables in the import demand function are cointegrated.

Given that all variables on import demand equation are cointegrated, we can proceed to the second stage of Engle-Granger cointegration approach which is to present an Error Correction Mechanism (ECM). This model can be presented in its simple form:

$$\Delta y_t = \alpha + \beta_1 (y_{t-1} - \lambda x_{t-1}) + \gamma_0 \Delta x_{t-1} + u_t \qquad \{10\}$$

After experimenting with different dynamic structures, we get to the following estimation:

$$\Delta \ln \hat{M}_t = -0.019 - 0.860 EC_{t-1} + 0.257 \Delta \ln M_{t-2} - 0.27 \Delta \ln P_{t-1} + 1.262 \Delta \ln Y_{t-1} - 0.136 \Delta D$$

(-0913) (-4.093) (1.718) (-2.993) (5.047) (-2.183) {11 }

$\overline{R}^2 = 0.641$ DW = 2.157 F = 8.858 SER = 0.078

$ARCH_{(1)} = 0.023$ $LM_{(1)} = 1.126$

(0.881) (0.304)

In this representation, the t statistics of the error term EC_{t-1} obtained from the cointegrating regression is significant at the 1 percent level. This is yet more piece of evidence, which indicates that the variables contained in the import demand function are cointegrated. Along with these results, we report the adjusted coefficient of determination ($\overline{R}^2$), the Breusch-Godfrey statistic for first order serial correlation, and autoregressive conditional heteroscedasticity (ARCH). These diagnostic statistics are significant at the one percent level. These results are indication of credibility of the estimated model as well passing the required statistical tests.

Since the estimated error term has a significant negative sign, it can be interpreted as that it measured the disequilibrium percentage in the dependent variable that can be corrected from period to another.[5] Therefore, the error correction parameter indicates that about 86% of the disequilibrium in the import demand in Syria would be adjusted from period to another. For the other two equations, the speeds of adjustment in the short run are estimated to be 0.546 and.-0.644, which are related to VAR specification.

III. The Import Demand and Johansen Method for Cointegration

It is widely recognizable that Engle and Granger test for cointegration would be enough if we want to examine the effect of error correction mechanism on import demand for two sequences periods such as t and t-1.

However, since our concern is concentrated on the whole structure of the import demand function, it is more useful to apply Johansen multivariate cointegration analysis.

The Maximum Likelihood procedure (Johansen's test), suggested by Johansen (1988 and 1991) and Johansen and Juselius (1990), is preferable when the number of variables in the study exceeds two variables due to the possibility of existence of multiple cointegtating vectors. The advantage of Johansen's test is not only limited to multivariate case, but it is preferable than Engle-Granger approach even with a two-variable-model (Gonzalo,1990).

To determine the number of cointegrating vectors, Johansen (1988 and 1991) and Johansen and Juselius (1990) suggested two statistic tests. The first one is the trace test (λ_{trace}). It tests the null hypothesis that the number of distinct cointegrating vectors is less than or equal to q against a general unrestricted alternative q = r. This test is calculated as follow:

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{p}\ln(1-\hat{\lambda}_i) \qquad \{12\}$$

where $\lambda_{r+1},......,\lambda_n$ are the smallest value eigenvectos p-r. The null hypothesis stated that the number of cointegrating vectors is equal to at most to r. In other words, the number of cointegrating vectors is equal to or less than r (where r=0,1,2,3 in our study). The second statistical test is the maximal eigenvalue test $(\lambda_{\max})$ that is calculated according the following formula:

$$\lambda_{\max}(r, r+1) = -T\ln(1-\hat{\lambda}_{r+1}) \qquad \{13\}$$

This test concerns a test of the null hypothesis that there is r of cointegrating vectors against the alternative that r+1 cointegrating vectors.

The results of trace and maximal value tests summerized in table 3 indicate the possibility of rejecting the null hypothesis that says of no cointegrating vectors at the 5 percent significant level.[6] This means that the whole structure of the import demand is cointegrated with import relative prices and gross domestic product. In addition, it means that there is stationary linear combination between the import demand, relative prices of imports and gross domestic product despite that each variable is nonstationary. Finally, this result confirmed the existing of long run equilibrium relationship between these variables, which means that they do not diverge away from each other where it shows similar behavior. The number of lags is selected by using the Akiake Information Criterion (AIC).[7]

Table (3)
Cointegrating Test

$Eigenvalue\ \hat{\lambda}_i$	Maximal Value $\lambda_{max} = -T\ln(1-\hat{\lambda}_i)$	Trace $\lambda_{trace} = -T\sum \ln(1-\hat{\lambda}_i)$	Critical Value 5% for Maximal Value test	Critical Value 5% for Trace test	Null Hypothesis
0.720623	30.60464	77.34364	31.46	62.99	$r \le 0$
0581947	20.931529	46.73900	25.54	42.44	$r \le 1$
0.482622	15.81556	25.80747	18.96	25.32	$r \le 2$
0.340537	9.99191	9.99191	12.25	12.25	$r \le 3$

Critical values are taken from Osterwald-Lenum (1992).

Since the calculated value of trace test (77.34) exceeds the critical value (62.99) at the 5 percent level of significance, it is possible to reject the null hypothesis that there is not any cointegrating vector. The reported results of the Johansen procedure shown in Table 3 reject the hypothesis that there are at most more than three cointegrating vectors.[8] The first one seems to be reasonable in terms of the magnitude of the coefficients that they do compare with the cointegrating regression. The normalized cointegrating regressions that resulted from these vectors are (values in parenthesis are standard errors):

Table (4)
Normalized Cointegrating Vectors

lnM	lnP	lnY	Dummy	trend	constant	Log likelihood
1	0.249 (0.050)	-1.692 (0.091)	0.348 (0.022)	0.036 (0.004)	8.510	142.42
1	-0.759	-0.406	0.107	-0.0004		
1	0.660	-0.870	0.542	0.005		

(One lag is used in the VAR; values in parenthesis are standard errors)

The second vector was rejected because of the price coefficient sign. The first vector was prefered over the third one due to the limited price role in explaining imports level. This means that the long run import demand elasticity with respect to price is equal to –0.249 while the income elasticity is about 1.69. In the relation $\pi = \alpha\beta'$, the first term in α (0.074) represents the speed at which $\Delta \ln M_t$, the dependent variable in the first equation of VECM, adjusts towards the single long-run cointegration relationship, while $\alpha_2 = 1.033$, and $\alpha_3 = 1.282$ represent respectively, the speeds at which $\Delta \ln y$ and $\Delta \ln p$ respond to the desequilibrium changes represented by the cointegration vector.

We can conclude that, the cointegration analysis confirms the existence of a long run relationship between import demand, price and income in Syria. The low value of the price elasticity is an indication of the pricing deformation and administrative rigidity. The income seems to be the more important variable in the import demand function. The coefficient of the error term in the ECM reveals a high speed of adjustment in the short run.

Summary

This paper has estimated import demand functions for Syria based on annual data for the period 1970-1995. The gross domestic product has a significant effect on explaining the change in the import demand where the equilibrium estimated import demand elasticity with respect to income and price are 0.867 and –0.074; respectively. The price elasticity is low, perhaps because of the deformation of the import structure pricing and the multicolinearity effect.

This study shows using two stages Engel-Granger approach for cointegration that the variables of import, income and prices are non-stationary time series. The result of error term with negatively significant sign in the second stage is an indication of the fact that the variables in the import demand function are cointegrated. The disequilibrium of the demand imports is corrected from period to another by 0.86 percent.

The Johansen's test rejects the null hypothesis that there are no cointegrating vectors and accepting the hypothesis of at least three cointegrating vectors is existed. This means that the whole structure of demand is cointegrated during the studying period. The long run income elasticity is about 1.692 where the price elasticity is - 0.249.

The estimated results confirm the significance and limited role of the relative prices in explaining the changes in import demand. This is because of the differentiation in the exchange rates, tariff variations, interrelated import availability with export revenues in artificial way, and increasing smuggling activities. This would justify the necessary recommendation of unifying exchange rates and removing the organizational and administrative obstacles from legal imports to limit illegal imports as represented by smuggling activities.

Regarding the income, the estimated results showed the positive relationship with import demand. This means that the economic development that occurred in Syria during the last twenty-five years did not success in substituting domestic output for imports that kept raising as the income increases. It is notable from the increasing in income elasticity that the economic development in Syria would be joint by increasing in the import levels. This is true especially if it is accompanied by the IMF recommendation of unifying the exchange rates and removing the structure disturbances in the Syrian economy that resulted from the organizational, administrative and pricing obstacles.

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ENDNOTES

[1]These studies were applied to developed and developing countries that are different in its economic structure and varied in the degree of economic growth.

[2]The Engle-Granger method for cointegration and Error Correction Mechanism (two step method) and Johansen method for cointegration (Maximum Likelihood).

[3]Two lagged periods is sufficient because the series are annual time series. Moreover, increasing the number of lag periods would not affect the results. Critical values at 5 % are

Specifications		ADF	PP
Levels	No intercept No trend	-1.956	-1.956
	With intercept No trend	-2.990	-2.995
	With intercept and trend	-3.611	-3.602
First Difference	No intercept No trend	-1.956	-1.956
	With intercept No trend	-2.996	-2.990
	With intercept and trend	-3.621	-3.611

[4] Critical values:T=25, with intercept: 1%=-3.72, 5%=-2.985, 10%=-2.632, No intercept:1%=- -2.66, 5%=-1.956, 10%=-1.623 .

[5]Davidson and Mackinnon (1993).

[6]Johansen and Juselius (1990) suggest that the maximal eigenvalue test have greater power than the trace test so we use both tests to check for consistency.

[7] Number of lags, trend and intercept are introduced to minimize the AIC.

[8]The same conclusion would be reached for the maximal test.