Complementarity and Substitutability between Agricultural Imports and Production Factors in Iraq's Agriculture

Samar R. Ajmy[1], Awf A. Alsaad[2*]

Abstract

The study aimed to study the relationship between agricultural imports (exogenous variable) with domestic variables such as labor and capital in the Iraq's agricultural sector for the production of goods for the period (1990-2018) using transcendental logarithmic cost function, which is a type of flexible functional forms. The iterative seemingly unrelated regression method (ITSUR) was adopted as a standard method for estimating the model to take advantage of the multiple properties such as imposing and testing various restrictions. After estimating the system of equations with imposing mathematical restrictions, own and cross-elasticities were calculated to investigate complementarity and substitutability between agricultural imports, capital, and labor. Share of imports was the largest with respect to the total shares within the system of cost functions as it reached 52% followed by share of the capital of 25%, and finally share of the labor of 23%. Demand for labor was highly elastic with value of Allen's partial elasticity of -1.9, and this indicates that the labor resource was affected by price changes. In addition, demand for capital and agricultural imports was less elastic as value of elasticities -1.68 and -0.87 respectively. The study recommended conducting in-depth studies on the nature of substitution among production factors in Iraqi agriculture due to the absence of such studies to know the nature of factor substitution. Especially since in recent decades there have been developments including economic and political shocks in general, and particularly in the agricultural sector.

Key Words: Transcendental Logarithmic Function, Seemingly Unrelated Regression, Allen Partial Elasticities, Factor Substitution, Agricultural Imports.

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Introduction

Foreign trade with its flows (imports and exports) may constitute the cornerstone in many countries especially developing ones. Just as there are many developing countries that are relatively distinguished in the production and export of certain commodities which represents an important source of cash, there are other countries rely heavily on imports to meet the demand for various commodities due to the inability of production as a result of a lack of comparative advantage or a lack of production resources. This makes it essential to investigate relationship between agricultural imports and domestic factors of production. The aim of this work is to know relationship between agricultural imports in particular on domestic or internal factors in the Iraqi agricultural sector such as labor and capital using estimation of a system of equations (Transcendental Logarithmic Cost Function) after taking agricultural imports into consideration by including them in the system.

Corresponding author: Awf A. Alsaad
Address: [1*,2]Department of Agricultural Economics, College of Agricultural Engineering Sciences, University of Baghdad, Iraq.
[2*]E-mail: aalsaad8017@gmail.com
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Also, this research aims at providing an indicator for policy makers in the light of calculating the economic elasticities such as Allen partial elasticities which depend in their calculation on values of coefficients of the system of equation.

Many studies covered factor substitution in the agricultural sector and agricultural imports. Singh (2020) examined the flexibility of input substitution and technical competence in the Canadian food processing sector. It is the second industrial sector in terms of returns and in addition to absorbing a lot of employment at the state level. The researcher found that labor and capital were substitutes for each other, and therefore the rise in the minimum wage may encourage the industry to adopt the production of capital-intensive goods. Also, the complementary relationship between the capital and energy component may mean a rise in energy prices that may discourage the industry from adopting the trend towards producing capital-intensive commodities. Kitenge (2016) studied the effects of food and agricultural imports on the factors of production in the agricultural sector in the United States of America for the period (1978-1978). Labor, capital, and imports were included in the same translog cost function model and estimated using SUR method. The researcher expanded the research methodology compared to previous similar research by studying elements within the agricultural production system such as labor, capital, fertilizers, pesticides, and agricultural services, as well as elements outside the agricultural production sector such as food and agricultural imports. The results of the study showed that the transcendental logarithmic costs function revealed a dynamic relationship between agricultural production factors inside and outside the system. On average, labor and capital were weak substitutes, while agricultural labor and agricultural imports were strong complements. Lastly, agricultural capital and agricultural imports were strong complements as well. Akinlo (2008) studied the demand for imports in Nigeria using the logarithmic transcendental cost function model. The results of the study proved the hypothesis that local capital is a substitute with labor and imports. As a conclusion, this means that the liberalization of the imposed trade restrictions will somehow have a positive impact on the demand for local work. The researcher also found that the price of imports has a significant impact on the prices of investment goods that are produced locally in the years of study. Yanikkaya (2004) studied the role of imports in general in the US economy and specifically with regard to their impact on the internal factors of production (labor and capital). The study was for the period (1993-1970). The study was carried out by adopting the cumulative transcendental logarithmic cost function to obtain measures of the various economic elasticities between the factors of production and imports. The demand for labor was the mostly elastic, followed by the demand for imports and then the demand for capital. The results of the substitution elasticities showed that, in general, the productive factors were substitutes to each other. Finally, the partial elasticities of substitution between imports and capital were higher compared to the partial flexibilities of substitution between imports and labor. Truett and others (1994) completed a search for an estimation of the total transcendental logarithmic cost function in Mexico. Imports were included as an independent production factor in the function. Mexico is linked to several trade agreements, so it is important to study such variables to know the implications for the external situation and the movement of trade flows for the country especially since Mexico has an important trade agreement NAFTA with both the United States of America and Canada. The results of the research showed that both imports, labor and capital were substitutes for each other and this agreed with the research hypothesis, and the author concluded that reducing the price of imports will reduce the demand for both local labor and local capital. In 1993, Craigwell and Boamah completed an economic study on the possibility of substituting imports with traditional production factors such as labor and capital in the country of Barbados. Research period was (1987-1959). The approach of the transcendental logarithmic costs function was adopted, where the dependent factors were shares of labor, capital, and imports versus prices of factors of production and production value. Estimation method was the Iterative Zellner procedure, which is widely used in the literature similar to this study. In general, the results of the study showed the possibility of substituting imports with traditional production factors such as labor and capital, as indicated by values of the various economic elasticities. Capital and imports were substitutes, as well as imports and labor, as reciprocal relationship appeared between them. Finally, the relationship was complementary between labor and capital in the study, specifically during the last years of research.

Materials and Methods

The Transcendental Logarithmic Cost Function (Translog)

The logarithmic cost function can be depicted as a second-order approximation of Taylor's Series Approximation with the logarithm of any cost function. Usually, the non-homothetic cost functions formulas are very general as they allow the ratios of demand on the factors of production from cost minimization depending on the level of output. On the other hand, in homothetic cost functions, the relative demand for factors of production is independent of the level of output. The heterogeneous cost function can be described as follows (Greene, 2012):

$$\ln C = \ln \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln P_i + \frac{1}{2} \cdot \sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} \ln P_i P_j + \alpha_y \ln Y + \frac{1}{2}\gamma_{yy} (\ln Y)^2 + \sum_{i=1}^{n} \gamma_{iY} \ln P_i \ln Y$$

Where: C = cost, P = output or factor price, and Y = output

Because the cost function must be homogeneous of degree 0 with respect to the prices of the factors of production, this requires imposing the following restrictions:

$$\sum_{i=1}^{n} \alpha_i = 1 \quad , \quad \sum_{i=1}^{n} \gamma_{ij} = \sum_{j=1}^{n} \gamma_{ji} = \sum_{i=1}^{n} \gamma_{iY} = 0$$

Using the Shephard Lemma (1970) derivation method, the cost shares equation can be obtained according to the following formula:

$$\frac{\partial \ln C}{\partial \ln P_i} = \frac{P_i}{C} \cdot \frac{\partial C}{\partial P_i} = \frac{P_i X_i}{C} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln P_j + \gamma_{iY} \ln Y$$

Where: $\sum_{i=1}^{n} P_i X_i = C$

Considering that the definition of cost shares can be expressed as follows:

$$S_i = {}^{P_i X_i}/_{C}$$

So, it means that: $\sum_{i=1}^{n} S_i = 1$.

Cost Shares System of Equation

As long as the factors included in the model are three independent factors (labor, capital, and agricultural imports), we assume that agricultural production is a function of three variables: labor, capital, and agricultural imports, which were treated as a production element as discussed previously in the reference review:

$$Q = Q(K, L, M)$$

Where: Q = production, K = capital, L = labor, M = agricultural imports.

The total cost function accordingly will take the following form:

$$C = C(P_K, P_L, P_M, Q)$$

Whereas: C = total costs, P_K = the price of the capital, P_L = the price of the labor, P_M = the price of agricultural imports.

By following the methodology of minimizing costs and the theoretical description of the logarithmic transcendental costs function that was explained above, the form of the transcendental costs function will be the following:

$$S_i = \beta_i + \sum_{j} \theta_{ij} P_j + \theta_{iy} y + \theta_{it} t + u_i$$

Where: β_i = intercept, S_i = the share of the input factor, P_j = the price of the input factor, y = the value of the output, t = time (1990-2018) and u_i = the random variable. Constraints of adding-up, linear homogeneity in prices, and symmetry assume the presence of the following restrictions:

$$\sum_{i} \beta_i = 1, \quad \sum_{j} \theta_{ij} = 0\,, \quad \sum_{i} ij = 0, \quad \sum_{i} \theta_{it} = 0, \quad \sum_{i} \theta_{iy} = 0$$

Where i represents the factors of production in the model (such as labor L, capital C, and agricultural imports M). As for Si, it is the share of the production in the total cost.

Data

Data were collected for the period (1990-2018) for the variables (production value and prices of production factors) from various secondary sources, such as annual statistical abstracts issued by the central statistical organization. As well as the datasets of the Food and Agriculture Organization FAO of the United Nations, and also datasets of the World Bank. The variables were calculated as follows:

Labor share is equal to: SL = (PL*QL) / C

Share of the capital is equal to: SC = (PC * QC) / C

Share of the agricultural imports is equal to: SM = (PM * QM) / C

So: {(PC*QC) + (PL*QL) + (PM*QM) }/ C S = SL + SC + SM

Where the share of the labor represented the number of workers multiplied by the total wages in

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the agricultural sector. As for the price of agricultural imports, it was calculated according to Kitenge (2016), by multiplying the percentage of agricultural imports from the total merchandise imports by the value of the total commodity imports. The value of agricultural imports thus is the value of agricultural imports divided by the annual index of the producer. As for the share of the capital, what is meant by the capital here is the capital stock, which is calculated based on the annual capital accumulation and the annual discount rate. While the method of Sharma (1991) was adopted in calculating the price and quantity of the capital. Finally, the independent variable Y represents the value of annual agricultural production. The time component was introduced for the purpose of taking technical progress into account.

Since we have more than one share of the factors of production (labor, capital, and agricultural imports) in which the share equations will be estimated, those equations within the system take the following form:

$$S_M = \frac{\partial lnC}{\partial lnP_M} = \beta_M + \theta_{MM} lnP_M + \theta_{MC} lnP_C + \theta_{ML} lnP_L + \theta_{MY} Y + \theta_{MT} T$$

$$S_C = \frac{\partial lnC}{\partial lnP_C} = \beta_C + \theta_{CM} lnP_M + \theta_{CC} lnP_C + \theta_{CL} lnP_L + \theta_{CY} Y + \theta_{CT} T$$

$$S_L = \frac{\partial lnC}{\partial lnP_L} = \beta_L + \theta_{LM} lnP_L + \theta_{LC} lnP_C + \theta_{LL} lnP_L + \theta_{LY} Y + \theta_{LT} T$$

After dividing the above system equations by the production factor price for the equation to be eliminated (the labor factor share equation in this case), the system will take the form below:

$$S_M = \frac{\partial lnC}{\partial lnP_M} = \beta_M + \theta_{MM} ln {}^{P_M}/_{P_L} + \theta_{MC} ln {}^{P_C}/_{P_L} + \theta_{MY} Y + \theta_{MT} T$$

$$S_C = \frac{\partial lnC}{\partial lnP_C} = \beta_C + \theta_{CM} ln {}^{P_M}/_{P_L} + \theta_{CC} ln {}^{P_C}/_{P_L} + \theta_{CY} Y + \theta_{CT} T$$

The application of the above constraints requires deleting an equation during the estimation process so that the covariance matrix is not to be singular. So, the parameters of the omitted equation can be easily retrieved by the same constraints. Suppose that the return omitted during the estimation is the equation of the share of imports from the costs, so the parameters can be obtained as in the following:

$S_M = 1 - (S_K + S_L)$, $\beta_M = 1 - (\beta_K + \beta_L)$, $\theta_{MM} = -(\theta_{KK} + \theta_{LL})$, $\theta_{MK} = -(\theta_{KL} + \theta_{LK})$, $\theta_{ML} = -(\theta_{KM} + \theta_{LM})$, $\theta_{MY} = -(\theta_{KY} + \theta_{LY})$, $\theta_{MT} = -(\theta_{KT} + \theta_{LT})$.

Regarding the estimation method, the seemingly unrelated regression (SUR) was adopted for the purpose of estimating the above system of equations as it is one of the efficient methods and according to previous studies and research. Specifically, the Iterative method or ITSUR was followed. SUR is a formula A generalization of the multiple linear regression model, which includes several regression equations together. Each of these equations has an independent dependent variable and a set of explanatory or independent factors. The model was derived and used for the first time by the economist Professor Arnold Zellner (1962). It is possible to estimate each of these combined models separately, but this standard estimation method was resorted to due to the hypothesis which states that these combined equations are implicitly related through random error, so this type of regression is called seemingly unrelated regression.

There are many practical applications for the use of systems of equations in economic models, as well as SUR method as a standard estimation method, but one of the most famous and most important of these uses in this field is the demand equation system, as well as systems of equations for transcendental logarithmic costs functions Baltaji (2011) and Deaton (1986).

Results

The system of equations was estimated using the Eviews 10.0 software, and the results of the estimation were as in the table. 1 below, as the labor share function was omitted to satisfy the condition of completion, and then the coefficients of the work share function are retrieved through the restrictions imposed previously which were adding-up, price homogeneity and symmetry:

Table 1. Coefficient estimates of translog cost function system

Variable	Coefficients	R^2	DW
β_M	-33.521560	0.65	1.72
$\theta l_{MM} lnP_M$	0.013368		
$\theta_{MC} lnP_C$	-0.010725		
$\theta_{ML} lnP_L$	-0.002643		
$\theta_{MY} Y$	-0.023421		
$\theta_{MT} T$	0.0000476		
β_C	8.560067	0.81	1.21
$\theta_{CM} lnP_M$	-0.010725		
$\theta_{CC} lnP_C$	0.082447		
$\theta_{CL} lnP_L$	-0.071722		
$\theta_{CY} Y$	0.030787		
$\theta_{CT} T$	-0.0000125		
β_L	25.961493		
$\theta_{LM} lnP_M$	0.002643		
$\theta_{LC} lnP_C$	-0.071722		
$\theta_{LL} lnP_L$	0.069079		
$\theta_{LY} Y$	-0.007366		
$\theta_{LT} T$	-0.0000351		

Source: obtained using coefficients from Eviews output.

Based on the estimations of the regression coefficients in the system of equations above, the missing price coefficients in the first and second equations (the price of the labor) as well as the coefficients of the third equation (the prices of the import, capital and labor) were retrieved through the restrictions imposed in advance during the estimation:

$$S_m = -33.521560 + 0.013368pm - 0.010725pc - 0.002643pl - 0.023421y + 0.0000476t$$

$$S_c = 8.560067 - 0.010725pm + 0.082447pc - 0.071722pl + 0.030787y - 0.0000125t$$

$$S_l = 25.961493 + 0.002643pm - 0.071722pc + 0.069076pl - 0.007366y - 0.0000351t$$

Calculation of Allen Partial Elasticities (AES_{ii} and AES_{ij})

1. Allen own elasticity (AES_{ii})

It is calculated according to the formula below and it shows whether the demand is elastic or inelastic on the factor:

$$AES_{ii} = (\beta_{ii} + S_i^2 - S_i)/S_i^2$$

2. 2- Allen cross elasticity (AES_{ij})

It is calculated in light of the formula below, and is determined whether the two productive workers are alternatives or complements to each other. Here it should be noted that despite the similarity of this type of elasticities with other elasticities formulas such as the Morishima elasticities of substitution, there are differences in the methodology for calculating each of them Russell (2020). Whereas Morishima's elasticity allows for adjustment in each of the production factors, Allen's elasticity allows for adjustment to occur only in one production factor. Therefore, Allen Partial Elasticities are called:

$$AES_{ij} = (\beta_{ij} + S_i S_j)/S_i S_j \quad , \quad i \neq j$$

After considering formulas above of elasticities, the following values were obtained:

$$AESMC = \frac{(-0.010725) + (0.52 * 0.25)}{0.52} = 0.22937$$

$$AESML = \frac{(-0.002643) + (0.52 * 0.23)}{0.52} = 0.22491$$

$$AESCM = \frac{(-0.010725) + (0.25 * 0.52)}{0.25} = 0.4771$$

$$AESCL = \frac{(-0.071722) + (0.25 * 0.23)}{0.25} = -0.05688$$

$$AESLM = \frac{(-0.002643) + (0.23 * 0.52)}{0.23} = 0.50850$$

$$AESLC = \frac{(-0.071722) + (0.23 * 0.25)}{0.23} = -0.06183$$

$$AESMM = \frac{0.013368 + (0.52)^2 - (0.52)}{(0.52)^2} = -0.87363$$

$$AESCC = \frac{0.082447 + (0.25)^2 - (0.25)}{(0.25)^2} = -1.68084$$

$$AESLL = \frac{0.074365 + (0.23)^2 - (0.23)}{(0.23)^2} = -1.94206$$

Table 2. Allen partial elasticities

No.	AES_{ij} or AES_{ii}	Value
1	AES_{MM}	-0.8736
2	AES_{CC}	-1.6804
3	AES_{LL}	-1.9420
4	AES_{MC}	0.2293
5	AES_{ML}	0.2249
6	AES_{CM}	0.4771
7	AES_{CL}	-0.0568
8	AES_{LM}	0.5085
9	AES_{LC}	-0.0618

Source: obtained using formulas of elasticities above.

Discussion

Since the purpose of estimating the above system of equations is to calculate the different economic elasticities to infer the nature of the relationship between the factors of production, it is therefore not necessary to discuss and explain the signs and coefficients of the sizes of the variables related to estimating the above models. Table. 1 shows coefficients of system estimates. The main goal here is to obtain the coefficients for the purpose of extracting the various elasticities and knowing the relationship between the factors of production.

Table 2 shows the values of the intrinsic partial Nin elasticities, as well as the Nin substitution elasticities among the production factors. The values of the elasticities AESii show the own elasticities, while the other values AESij show the elasticities that reflect the substitution or complementary relationship between the factors of production. From the above table, the eigenvalues are negative, and this is consistent with the logic of economic theory and studies and research on this subject, and the values were (-0.87, -1.68, -1.94), respectively, for (imports - imports) and (capital - capital) and (labor - labor). It also notes the large volume of own-elasticities related to work and capital compared to agricultural imports.

Conclusion

The demand for labor was highly elastic, according to what was shown by the partial own-elasticity values (-1.9), and this indicates that the labor resource was affected by price changes, and this was one of the most important joint results with several researches on the impact of imports on the demand for labor. Many previous studies have proven that trade policies associated with the rise in the price of imports often lead to a decrease in the demand for labor. The demand for the capital was also elastic (own partial elasticity of -1.68), and finally the demand for imports was also elastic with the value of the partial own-elasticity equal to -0.87. Also, it was found that share of imports was the largest with respect to the total shares within the cost function, reaching 52%, followed by the share of the capital by 25%, and finally the share of the labor by 23%. The large proportion of the share of the agricultural imports component is an indication of its importance in the share system as the total quotas must be 100% according to the theoretical definition of the economic model used.

The study recommended conducting in-depth studies on the nature of substitution among production factors in Iraqi agriculture due to the almost absence of such studies to know the nature of the relationship between these factors. Especially since, during the last decades, there were many developments including economic and political shocks in general, and the agricultural sector in particular, which led to the different composition of production factors in the structure of the agricultural sector, and this reflected on the production of goods and services and the final demand. It is also necessary to work effectively to protect the local product from the impact of commodity dumping, because many farmers and producers in the agricultural sector were affected by commodity dumping, which made them lose competition and the imported produced commodities are sold at a lower price than the local product.

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