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Demand for inputs in tomato and cucumber: The case of Uzundere

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The aim of this study was to determine the gross margins of cucumbers and tomatos in greenhouses, price and cross elasticities and Morishima Technical Substitution Elasticity of the inputs such as labor, seedling, fertilizers and drugs, which play a key role in the production of these products in Uzundere District of Erzurum Province in Turkey. Model solutions, which were created by using Translog Cost Function were carried out by Seemingly Unrelated Regression (SUR). Price elasticity and cross elasticity of the inputs were calculated by using these model solutions. Similarly, Morishima Technical Substitution Elasticities of the inputs were obtained by the numerator equalities models. According to the study results, gross margins of cucumbers and tomatos per m^2 were 5.000 TL and 3.303 TL, respectively. In addition, it was found that labor has the highest cost percentage within total cost.

Key word: Translog, cost, demand, tomato, cucumber, Turkey.

INTRODUCTION

Agricultural production is seasonal, while its consumption is continuous. In order to adapt the seasonal production to this continuous consumption, greenhouses, which use intensive way of production, are of great importance. Greenhouses are structures which enable farmers to grow culture plants economically in periods, in which climatic conditions are not appropriate to cultivate plants outdoors. They can provide developmental factors needed for crop production, and enable people to move around in them. Greenhouse cultivation area in Turkey is 47.774 ha, and greenhouse area is 30.575 ha. Distribution of greenhouse area in Turkey is approximately 65% in Antalya, 21% in Mersin, 7% in Mugla, and 7% in other provinces (Anonymous, 2005). Since greenhouse cultivation reduces the costs, usually it is used in a widespread manner in warm climate regions. Particularly in northern districts of Erzurum, in which the altitude decreases within short distances from the Centrum of Erzurum towards the Black Sea, vegetable cultivation in greenhouses becomes more and more widespread. In other words, climatic conditions in northern districts of Erzurum are much milder and this makes economical production in greenhouses possible.

Greenhouse cultiva-tion in Uzundere district of Erzurum province increased in recent years, due to the suitability of the climatic conditions and public incentives for greenhouse cultivation. The fact that the land is rough and scarce in Uzundere district, greenhouse cultivation becomes advantageous in the region and makes it an important income source for the farmers. Most of the products produced in Uzundere are sold in local markets of Erzurum Centrum. But they are sold in Bayburt and Artvin provinces too. This provides and advantage for the customer who can buy fresh products in their local markets. Furthermore, greenhouse cultivation enables farmers to obtain more products from a unit area, increases the operational profit and makes it possible to reduce the hidden unemployment in the agricultural sector (Pezikoglu, 1999). In this context, it becomes important to calculate the production cost of the products cultivated in the greenhouse and to determine the economical results of the operational activities (Rad and Yarsi, 2005).

The aim of the study is to calculate the gross margins of cucumbers and tomatoes cultivated in greenhouses in Uzundere district of Erzurum province, price and cross elasticities and also Morishima technical substitution

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elasticity of the inputs for cost items such as labor, seedling, fertilizers and drugs, which play a key role in the production of these products. The main purpose of determining the cost and usage levels of physical production inputs is to be able to perform income and cost analyses of individual production activities which take place in agricultural enterprises (Ozkan at al., 2005). During the recent years, an increase is being observed in the trend of obtaining the economic criteria which are essential and mandatory for efficient use of the resources in agriculture from production functions. It is observed during the last 20 years that one of these functions, translog production function is being used in a widespread manner for the functional analyze of the agricultural production activity, especially in developed countries (Akcay and Esengun, 1999). Translog function was suggested by Christensen et al., and was used frequently to analyze the technological structure, which consists the base of the input demand and production. Binswanger, Kako, Ball, Chambers and Ray used Trans-log studies in time series and with agricultural cumulative data (Grisley and Gitu, 1985).

MATERIAL AND METHOD

Material

The data used in the study were obtained from the surveys performed in the enterprises in Uzundere district of Erzurum province, in which vegetables are cultivated in greenhouses. The data belong to the year 2008.

Method

There are 221 greenhouses registered in the Agriculture Directorate of Uzundere district of Erzurum province (Anonymous, 2008). Greenhouses which were between the range 240 and 1.500 m^2 were taken into consideration. Greenhouses smaller than 240 m^2 were considered as not having commercial value and the ones that were more than 1500 m^2 were too few but they would affect the averages disproportionately. Thus, the total questionnaire number was determined as 85. All of the 85 enterprises were involved in cucumber cultivation, while enterprises which were involved in tomato cultivation was determined as 21.

Theoretical Framework

Translog cost function was used in the study. Model solutions were performed by Seemingly Unconcerned Regression (SUR) (Chiang, 1984). Price and cross elasticity of the inputs were calculated by using these model solutions. Similarly, Morishima Technical Substitution Elasticities of the inputs were obtained by the numerator equalities models. Translog cost function was described as it was in the equation number 1 (Chambers, 1988).

$$\ln(m) = \alpha_0 + \sum_i \alpha_i \ln(w_i) + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln(w_i)\ln(w_j) + \beta_0 \ln(Q) + \tag{1}$$

$$\beta_1 (\ln Q)^2 + \sum_j \eta_j \ln(Q)\ln(w_j) + \delta_D + \sum_j \pi_j \ln 8w_j)D + \Phi_3 \ln(Q)(D)$$

Abbreviations in the equation are: *m*: Unit output cost. *w*: Input prices vector (labor, seedling, fertilizers and drugs). *Q*: Output quantity (productivity), *D*: Dummy variable.

If Shephard pre- theory is applied to Translog equation, cost function is obtained depending on the numerator equalities (Miran et al., 2002).

$$s_i = \alpha_i + \sum_i \gamma_{ij} \ln(w_i) + \beta_i \ln(Q) + \delta_i (D) \tag{2}$$

The cost numerator equality given in the equation No. 2, S_i, shows the numerator of the varying production factor within the cost. In the equation, described as numerator equalities, the cross price estimators should be symmetrical and the total of cost numerators should be equal to 1 according to the Young theorem. These features call for the addition of the restrictions shown in the parameters in equation No. 3 to the model when predicting the cost function (Miran et al., 2002).

$$\sum_i \alpha_i = 1; \gamma_{ij} = \gamma_{ji}; ve \sum_i \gamma_{ij} = \sum_i \beta_i = \sum_i \delta_{ik} = 0 \tag{3}$$

Cost numerator equalities provides the foundation for input demand and substitution elasticities determined in this study. After testing the usability of the numerator equalities model, price elasticities are calculated through the formulas no. 4 and 5:

$$\varepsilon_{ii} = \gamma_{ii} / S_i + S_i - 1 \tag{4}$$

$$\varepsilon_{ij} = \gamma_{ij} / S_i + S_i \tag{5}$$

Allen and Morishima substitution elasticities can also be calculated using the same model. Allen partial substitution elasticity (σij), is calculated by dividing the cross price elasticity between these inputs to the cost numerator of the j^{th} input (Sj). Morishima input substitution elasticities were calculated to measure the variance in usage rates of any two inputs depending on the variation of the price ratios of these inputs (Tanrıvermiş, 2000).

SUR (Seemingly Unrelated Regression) was used as estimator in this study. In order to avoid the matrix to be singular in the estimation of the equality system, drug input was excluded from the model for the estimation of the cost numerator equality. Labor, seedling and fertilizer price indexes were used in the equation system. The parameters required for the drugs which remained out of the equation system were calculated from total and homogeneity constraints. SHAZAM Professional Edition was used as an econometric software in the study.

Findings and Discussion

Farmer and parcel information

61% of the producers included in the research in the study area were in 15 - 49 age range and 35% were primary school graduates. Greenhouse farming shows the characteristics of family enterprises in the area. Average number of family members in the enterprises was 4.7. For both cucumber and tomato, 51% of the working population in the greenhouses were males and 49% females. In enterprises cultivating cucumbers and tomatoes, the labor forces

Table 1. Gross production value, variable expenses and gross margin for cucumber and tomato production Per m^2 Greenhouse (TL/m^2).

	Cucumber	Tomato
Gross production values (1)	10.827	10.112
Variable expenses (2)	5.822	6.809
Labor expenses	3.042	3.633
Seedling	0.692	0.906
Fertilizer	0.574	0.444
Drug	0.381	0.296
Other variable expenses	1.133	1.530
Gross margin (1 - 2)	5.005	3.303

Source: Original calculations

were 2.98 and 2.62 MLU (MLU: Male labour unit. Here, a male 15-49 eyars old is considered as 1 MLU, a female 15-49=0.75, a male >50= 0.75, a female >50=0.50 and a child=0.50 (Dağdemir 2004)., respectively. Cucumber is the main greenhouse product. Tomato is in the second place. However, since tomato's ripening time is longer, the producers prefer predominantly cucumbers. Since ripening time in cucumber cultivation is rather short, it can be ready for the market in a shorter time period. All enterprises were cultivating cucumbers, while 24.71% of them were cultivating tomatoes along with cucumbers. The producers use greenhouses with plastic material as covering and iron construction as frame. All the greenhouse cultivators were owners of the properties.

In the enterprises, average productivities of cucumbers and tomatoes were 24.06 and 16.00 kg/m^2, respectively. The average parcel sizes for cucumbers and tomatoes were 1015 and 270 m^2, respectively. Gross margins per m^2 were calculated as 5.005 TL for cucumber and 3.303 TL for tomato. Labor expenses were the biggest part in variable expense items. (Table 1).

Numerator equalities SUR model

In the study, the sensitivity of labor, seedling, fertilizer and drugs to the price changes in cucumber and tomato production was estimated via derived demand model. Derived demand model was described and estimated as the cost numerator equality system starting from translog cost function. It was understood that there is no positive value in Allen substitution elasticities eigenvalue vector in cucumber and tomato, and that the models show concavity. Thus, the models should be prepared in a way that unit cost should increase when input or inputs prices used in production also increase.

In order to accomplish cost minimization, cost function should also be a monotonic function. It was found that all estimation values obtained from the numerator equalities model in cucumber and tomato production were higher than zero (that is positive). Accordingly, it was determined that the models in both products were monotonic. That means, input substitution rates remain the same when the production increases. R^2 values of the equations regarding the cost numerators in cucumber and tomato production ranges between 37.00% and 48.50%, and between 58.30 and 69.20%, respectively (Table 2). It is understood that explanation levels for the horizontal cross section data are good in both products. The total of estimated cost percentages is equal to 1 and cross price estimators are the same. The highest rate among the cost numerators belong to the labor expenses, both in cucumber and tomato (Table 2).

Elasticities of input demand in cucumber and tomato, calculated by the cost numerator model, is given in Table 3. Self price elasticities of labor, seedling, fertilizer and drug of cucumber were estimated by cucumber input demand model as -0.170, -0.186, -0.371 and -0.467, respectively. Self elasticities of all inputs were inelastic. 10% increase in labor, seedling, fertilizer and drug prices will decrease the demands of these products by 1.70, 1.86, 3.71 and 4.67%, respectively.

According these values, in case of price increase inputs, the farmer will give up the input of drug the easiest, and this will be followed by fertilizer, seedling and labor, respectively. Labor prices had the hardest elasticity among the inputs used for cucumber production. The elasticities of the other inputs are also in low level. It means that, the reaction of the farmers who cultivate cucumbers in greenhouses to price changes are considerably low. Self price elasticities of labor, seedling, fertilizer and drug were estimated by tomato input demand model as -0.127, -0.342, -0.346 and -0.948 (Table 3). Self elasticities of all inputs were inelastic. 10% increase in labor, seedling, fertilizer and drug prices will decrease the demands of these products by 1.27, 3.42, 3.46 and 9.48%, respectively. According these values, in case of price increase of each input, the farmer will give up the input of drug the easiest, and this will be followed by fertilizer, seedling and labor, respectively. As it was in cucumber cultivation, labor prices had the hardest elasticity among the inputs used for tomato production. The values out of the main diagonal in Table 3 for cucumber and tomato are cross price elasticities.

Positive sign between to inputs shows substitution relationship between them, while negative sign between them shows complementary relationship. In case of a price increase of any input in cucumber cultivation, it can be substituted by another input in a very low rate. Accordingly, it can be assumed that each input is indispensable. The highest substitution was between drug and labor, followed by fertilizer-labor and seedling-labor. As it can be seen from Table 2, average cost percentage of labor in total cost for cucumber is very high. Therefore, an increase in labor price also increases the cost of cucumber. 10% increase in labor price increases seedling demand by 2.42%, while 10% increase in seedling price increases labor demand by 0.48%. 10% increase in labor price increases fertilizing demand by 3.74%, while 10% increase in fertilizer price increases labor demand by 0.50%. 10% increase in labor price increases drug demand by 5.99%, while 10% increase in drug price increases labor demand 0.073%. Price increases in drug, fertilizer and seedling increase labor demand. However, the effect of change in prices of these inputs on labor demand is very low, nearly zero. 10% increase in seedling price increases fertilizer demand by 0.17%, and 10% price increase in fertilizer increases seedling demand by 0.17%. These values show that, changes in seedling and fertilizer prices are very low, so that they can not change the demand to these inputs. All of minus signed cross elasticity coefficients are very close to zero. Accordingly, complementary relationship between the inputs is very low, nearly zero.

In case of a price increase of any input in tomato cultivation, it can be substituted by another input in a very low rate. Accordingly, it can be assumed that each input is indispensable. The highest substitution was between drug and labor, followed by seedling-labor and fertilizer-labor. As it can be seen from Table 2, average cost percentage of labor in total cost for cucumber is very high. Therefore, an increase in labor price also increases the cost of domato. 10% increase in labor price increases seedling demand by 2.37%, while 10% increase in seedling price increases labor demand by 0.42%. 10% increase in labor price increases fertilizing demand by 2.26%, while 10% increase in fertilizer price increases labor demand by 0.30%. 10% increase in labor price increases drug demand by 7.26%, while 10% increase in drug price increases labor demand by 0.056%. It can be seen that the effect of price changes of seedling, fertilizer and drug on labor demand is very low, nearly zero. Since the elasticities between seedling, fertilizer

Table 2. Numerator equalities model SUR solution for cucumber and tomato.

Independent variable (Ln)	Dependent variable: Cost numerators cucumber				Dependent variable: Cost numerators tomato			
	Labor	**Seedling**	**Fertilizer**	**Drug**	**Labor**	**Seedling**	**Fertilizer**	**Drug**
Constant term	0.814*	0.332*	-0.058	-1.088	0.094	0.354*	0.328*	-0.776
	(0.289)	(0.167)	(0.103)		(0.245)	(0.166)	(0.146)	
Ln (Productivity)	-0.159	0.009	0.086*	0.064	0.086	0.008	-0.022	-0.072
	(0.083)	(0.047)	(0.030)		(0.091)	(0.060)	(0.056)	
Ln (Labor price/drug price)	0.097*	-0.061*	-0.029*	-0.007	0.108*	-0.062*	-0.047*	0.001
	(0.034)	(0.019)	(0.012)		(0.029)	(0.018)	(0.017)	
Ln (Seedling price/drug price)	-0.061*	0.092*	-0.011	-0.020	-0.062*	0.068*	-0.005	-0.001
	(0.019)	(0.014)	(0.007)		(0.018)	(0.015)	(0.011)	
Ln (Fertilizer price/drug price)	-0.029*	-0.011	0.050*	-0.010	-0.047*	-0.005	0.053*	
	(0.012)	(0.007)	(0.008)		(0.017)	(0.011)	(0.014)	-0.001
D (Dummy variable)	-0.052	0.020	0.005	0.027	-0.071	0.010	0.038	0.023
	(0.032)	(0.018)	(0.011)		(0.038)	(0.025)	(0.023)	
R^2	0.373	0.485	0.370		0.637	0.585	0.692	
Average Cost Numerator	0.689	0.136	0.092	0.083	0.722	0.128	0.095	0.055

Source: Original calculations.
Standart errors are shown in brackets. [1] Calculated from Total constraint. *: Important for 5%.

Table 3. Input demand elasticities.

	Cucumber					Tomato			
	Price elasticities								
	Labor	**Seedling**	**Fertilizer**	**Drug**		**Labor**	**Seedling**	**Fertilizer**	**Drug**
Labor	**-0.170**	0.048	0.050	0.073	Labor	**-0.127**	0.042	0.030	0.056
Seedling	0.242	**-0.186**	0.011	-0.067	Seedling	0.237	**-0.342**	0.049	0.056
Fertilizer	0.374	0.017	**-0.371**	-0.020	Fertilizer	0.226	0.066	**-0.346**	0.054
Drug	0.599	-0.109	-0.022	**-0.467**	Drug	0.726	0.130	0.093	**-0.948**
	Morishima technical subtitution elasticities (MES)								
Labor	-	0.218	0.220	0.243	Labor	-	0.169	0.157	0.183
Seedling	0.428	-	0.198	0.119	Seedling	0.579	-	0.391	0.398
Fertilizer	0.746	0.388	-	0.351	Fertilizer	0.572	0.412	-	0.400
Drug	1.066	0.358	0.445	-	Drug	1.674	1.078	1.041	-

Source: Original calculations.

and drug factors themselves are nearly zero, the substitution relationship between them is very low.

Morishima Technical Substitution Elasticities (MES) are shown in Table 3. As can be seen on the table, the substitution elasticities are higher than zero. Accordingly, it is understood that there is an incomplete substitution between all input pairs in cucumber cultivation. Here, technical substitution elasticity between seedling and labor was found as 0.428. If labor prices increase when seedling prices are stable, labor use will decrease, and more seedlings (the production factor with lower cost) will be used instead. The decrease in the use of labor will be 0.428% of seedling-labor use ratio. Similarly, the decrease in labor use will be 0.746% of fertilizer-labor use ratio, or 1.066% of drug-labor use ratio. A similar situation is also valid for the other inputs, and it appears that these inputs are substitutable inputs, one for the other, for cucumber. Substitution elasticities are higher than zero also in tomato cultivation (Table 3). Accordingly, it is understood that there is an incomplete substitution between all input pairs. Here, technical substitution elasticity between seedling and labor was found as 0.579. If labor prices increase when seedling prices are stable, labor use will decrease, and more seedlings (the production factor with lower cost) will be used instead. The decrease in the use of labor will be 0.579% of seedling-labor use ratio. Similarly, the decrease in labor use will be 0.572% of fertilizer-labor use ratio, or 1.674% of drug-labor use ratio. A similar situation is also valid for the other inputs, and it appears that these inputs are substitutable inputs, one for the other, for tomato.

RESULTS

Gross margin calculated for cucumber is higher than the one calculated for tomato. The biggest part in variable expense items are labor expenses in both products. In cost numerators of both products, labor is followed by seedling, fertilizer and drug expenses, respectively. Self elasticities of labor, seedling, fertilizer and drug price were estimated by the cucumber input demand model as -0.170, -0.186, -0.371 and -0.467, respectively. Therefore, the reaction of farmers who cultivate cucumbers in greenhouses to price changes is considerably weak. Self elasticities of labor, seedling, fertilizer and drug price were estimated by the tomato input demand model as -0.127, -0.342, -0.346 and -0.948, respectively. According to these values, the input which the farmer will give up easiest when the price of the input itself increased is drug, followed by fertilizer, seedling and labor, respectively.

The highest substitution in cucumber cultivation is between drug and labor, followed by fertilizer-labor and seedling-labor. The highest substitution in tomato cultivation is between drug and labor, followed by seedling-labor and fertilizer-labor. Substitution relationship level between seedling, fertilizer and drug factors are very low. There is incomplete substitution between all input pairs in production of both cucumber and tomato.

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