Factor Demand Analysis for Canola Production in Turkey

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Abstract

The aim of this study is to investigate the situation of canola production which yields high quality and high yield vegetable oil seed in Trakya region, Turkey. For this purpose flexible cost function Translog model is utilized. Data was collected through surveys from 100 canola producers in Trakya region. The translog cost function was used to determine the relations among the production factors of canola. Price-demand, cross price-demand and Morishima technical substitution elasticities and Allen partial substitution elasticities were calculated by translog cost function.

The highest input price-demand elasticity is equal to -2.06 for pesticide. Canola producers are more sensitive to pesticide prices than the other input prices. Also, the lowest input price-demand elasticity is equal to -0.16 as regards fertilizer cost. The highest Morishima elasticity is equal to 2.46 between the pesticide and labour cost.

Keywords: Translog cost function, production price elasticity, Morishima technical substitution elasticity, Allen partial substitution elasticity.

Résumé

L'objectif de cette étude est d'analyser la production de canola qui permet d'obtenir des graines oléagineuses de haute qualité et à haut rendement en huile dans la région de la Thrace en Turquie. A cette fin, on a utilisé un modèle flexible de la fonction de coût translog. Les données ont été collectées à travers des enquêtes auprès de 100 producteurs de canola de la Thrace.La fonction de coût translog a été employée afin de déterminer les relations entre les divers facteurs qui interviennent dans la production de canola. Les élasticités prix, prix croisé et de substitution de Morishima ont également été calculées à l'aide de la fonction de coût translog.

L'élasticité-prix des intrants la plus élevée atteint -2.06 dans le cas des produits antiparasitaires. Les producteurs de canola sont en effet plus sensibles au prix des produits antiparasitaires qu'à celui des autres intrants. En outre, l'élasticité-prix des intrants la moins élevée atteint -0.16 dans le cas des engrais. L'élasticité de Morishima la plus élevée est égale à 2.46, entre le coût des produits antiparasitaires et le coût de la main d'œuvre.

Mots-clés: fonction de coût Translog, élasticité-prix de la production, élasticité de substitution de Morishima, élasticité de substitution de Allen.

1. Introduction

Vegetable oils have a significant role in human nutrition. However, because of the increase in population, vegetable oil seed production cannot meet the vegetable oil demand in Turkey. Therefore, Turkey has been dependent on the importation of vegetable oil seeds to meet this demand. Vegetable oil production in Turkey amounts to 1 million ton (Oilworld, 2006). While 40% of the raw material demand is met from domestic market, 60% of it is met through the importation of seed and crude oil from abroad. Vegetable oil consumption is around 19 kg/year per capita in Turkey. This consumption is well below the consumption in the European Union (EU), which has the average consumption of 42 kg/year per capita. World Health Organization (WHO) recommended that 1/3 of people's daily energy needs be met by oils and fats (Unakitan, 2003). However, vegetable oil consumption is not sufficient in this regard in Turkey.

34% of canola production in Turkey takes place in Trakya region (Tüik, 2008). Therefore, Trakya region is selected to have the information about the production in Turkey.

Canola, which is a winter product, has yielded over 300 kg/decare recently. In well-irrigated areas, canola yield reaches up to 400 kg/decare. Therefore, canola is an important oilseed and it may be an alternative product instead of sunflower seed.

The purpose of this study is to examine the development of canola highly efficient and high quality oil seed in the Trakya region and to reveal input-output analysis of the product in terms of production economy. For this purpose, we use the Translog cost analysis, a flexible cost function. This function is crucial for the determination of the relationship between production factors.

Despite the fact that there is a great number of articles in Turkey in which translog cost function is used in agricultural sector, there is no study in which the factor demand of canola is analyzed. Therefore, such a study in which factor demand flexibilities of canola production were estimated was conducted for the first time. When the studies in Turkey are examined, it could be obviously seen that Şengül (1999), Akçay and Esengün (2000), Şengül (2001), Miran *et al.,* (2002), Unakıtan (2003), Aktaş and Yurdakul (2005) made use of translog function to various products. When the studies abroad are examined, it could be noticed that the literature reports studies in which translog cost function was used together with cobb douglas production function (Binswanger, 1973; Nadolnyak *et al.,* 2002), studies conducted in various countries for various products (Ray, 1982; Huang, 1991; Grisley and Gitu, 1985; Erikson *et al.,* 2003; Tchale and Sauer, 2007, Agüero and

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Gold, 2004; Yang and Jeffrey, 2005; Kirimi and Swinton, 2004; Ma and Rae, 2004; Guttormsen, 2002; Lachaal *et al.,* 2005; Sauer *et a.l,* 2007; Zavale *et al.,* 2006), a study in which a multiproduct translog model was used (N'Guessan *et al.,* 2006), a study in which dynamic specification was used (Moss *et al.,* 2003). It is also possible to find many studies in which translog cost function was utilized in sectors other than the agricultural sector.

2. Material and Methods

2.1. Sampling Method

In this study, input usage data of canola farmers in Trakya region are obtained by surveys. According to information received from "*Leader Farmers Association*" in 2007, the total number of canola farmers is 270 in the Trakya region where average farm size is 83 decares and standard deviation is 53.2 decares. A random sampling method was used. The sample size was calculated using the sampling formula given below (Newbold, 1994). The permissible error in the sample size was defined to be 10% of the mean for a 95% confidence interval.

$$n = \frac{N.\sigma^2}{(N-1)\sigma_{\bar{x}}^2 + \sigma^2}$$

where; n: sample size, N: population volume, d: sampling error, σ: standard deviation : standard deviation of sample mean (= $d/Z_{\alpha/2}$).

Sample size was found 100 and distributed homogeneously in the provinces.

2.2. Translog Cost Function

In this study we used translog cost function that was estimated to reveal the substitution flexibilities among the variable cost elements. Translog (*transcendental logarithmic*) cost function is a flexible function form offered by Christensen, Jorgenson and Lau (1973) for the first time. Translog cost function is a function form that makes it possible to calculate variable substitution and scale flexibilities and is commonly used in the production economy area.

Translog cost function equation 1 is illustrated as follows:

$$\ln(m) = \alpha_0 + \sum \alpha_i \ln(w_i) + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln(w_i)\ln(w_j) + \beta_0 \ln(Q) + \beta_1 (\ln Q)^2 + \sum_j \eta_j \ln(Q)\ln(w_j) + \delta D + \sum_j \pi_j \ln(w_j) D + \varphi_3 \ln(Q)(D) + u \quad \text{(Equation 1)}$$

In Equation 1, *m* is unit production cost (TL/kg), *w* is vector of input prices (*labor, diesel, fertilizer, pesticides*), *Q* is the amount of output (production = output hectares), *D* is dummy variable (for different regions and areas), *u* is error term.

When Shephard's Lemma[2] was applied in translog cost function illustrated in Equation 1, cost function is obtained depending on share equality (Equation 2). This equation can be estimated compatible with constraints of micro-economic theory. Furthermore, its econometric estimation is easy.

$$S_i = \alpha_i + \sum_j \gamma_{ij} \ln(w_j) + \beta_i \ln(Q) + \delta_i (D) \quad \text{(Equation 2)}$$

The defined input cost function of Equation 2 is homogeneous from zero degree according to the input prices. In other words, if the prices of inputs increase at the same rate, cost shares do not change. Moreover, according to Young's theorem, cross-price elasticities must be symmetric and the sum of the cost share is equal to 1 (*adding-up*) in equation 2. When estimating the cost function, this feature is added to the model as restrictions (Equation 3).

$$\sum_i \alpha_i = 1; \gamma_{ji} = \gamma_{ij}$$
$$\sum_i \gamma_{ij} = \sum_i \beta_i = \sum_i \delta_{ik} = 0 \quad \text{(Equation 3)}$$

After the model estimating, elasticities are calculated by the following formulas.

$$\varepsilon_{ii} = \gamma_{ii}/S_i + S_i - 1 \quad \text{(Equation 4)}$$

$$\varepsilon_{ij} = \gamma_{ij}/S_i + S_j \quad \text{(Equation 5)}$$

Allen and Morishima elasticities of substitution are calculated from the model that was defined as per equality of share (Equation 2). For example, Allen partial elasticity of substitution between the labor and fertilizer is obtained (σ_{ij}) by the division of cross-price elasticities of fertilizer-labor to share of labor costs (S_j) (Binswanger, 1973). Morishima elasticity of input substitution can be calculated to measure the change in utilization rates of these inputs depending on the change in the price ratio of two inputs (Huang, 1991). Equation 6 is used to calculate Morishima elasticity of input substitution (Chambers, 1998).

$$\sigma_{ij}^M = \varepsilon_{ij} - \varepsilon_{jj} \quad \text{(Equation 6)}$$

3. Oilseed Production in the EU and Turkey

Canola production equals 59 million tons, it ranks second in the world following soybean production with 253 million tons. Canola oil is the driver of the complex, pushed by the demand for biodiesel use in the European Union (EU) (Fapri, 2010). Also, canola production is 19 million tons in the EU (Table 1). Canola is the most important oilseed grown in the EU followed by sunflowers and soybeans. Canola oil is the primary source of biodiesel processing, accounting for more than 75 per cent, while the share of soybean oil is estimated at 15 per cent.

EU oilseeds crushing capacity expanded considerably in recent years in response to growing vegetable oil (mainly canola oil) demand from the biofuels industry. Much of the

[2] Shephard's Lemma: $\frac{\partial c}{\partial P_i} = y_i$

Table 1 – *Oilseed Production in the EU (1000 MT).*		
	2007	2008
Rapeseed	18358	19006
Sunflower	4792	7156
Soybeans	723	653
Cottonseed	643	475
Total	24516	27290

Source: Fao 2010. Agriculture Statistical Database.

new crushing capacity consists of soft-seed (canola/sunflower seeds) or multi-seed crushing plants. Because of better canola availability in the world market and its continuing expansion, the EU role as a net importer of canola is expected to increase. Soybean crush is expected to continue its decline because of lower crush margins compared to canola.

France and Germany are significant producers as can be seen from Table 2. Germany ranks fourth in the world in canola production, while France ranks fifth (Fao, 2010). In Turkey, canola oil is used for nutrition; in contrast, in the EU, it is used for biodiesel production. This is the most important difference between these two regions. About yields per country, canola yields are higher in Germany, Denmark and France. In Turkey, canola yield is 300 kg/da which is comparable to many countries in terms of productivity and is seen to be advantageous.

Table 2 – *Rapeseed in the EU (2007) (1000 mt).*

Country	Production Seed	Yield (kg/da)	Import Seed	Import Crude oil	Export Seed	Export Crude oil
France	4719.05	332	296.00	196.45	1716.50	3370.04
Germany	5320.52	376	2199.13	1086.49	405.07	318.57
Czech Rep.	1031.92	293	22.28	7.09	435.89	88.25
U.K.	2108.00	329	63.40	92.56	264.21	355.57
Poland	2129.87	273	43.28	15.81	508.46	247.24
Denmark	588.60	365	206.19	49.46	142.55	103.64
Hungary	498.20	265	21.92	9.82	398.81	-
Italy	32.65	260	38.48	235.95	4.31	6.00
Spain	21.40	182	62.63	20.68	11.46	11.26
Greece	7.00	140	8.80	4.74	-	0.48
Portugal	-	-	102.75	7.50	-	-
Turkey	83.96	302	245.26	0.46	0.15	2.54

Source: Fao 2010. Agriculture Statistical Database.

Table 2 – *Rapeseed in the EU (2007) (1000 mt).*

Product	Production Seed	Import Seed	Import Crude oil
Sunflower	900	456	411
Cotton seed	1200	20	-
Soybean	34	1240	20
Rapeseed	82	216	-
Palm	-	-	568
Total	2216	1932	999

Source: Fao 2010. Agriculture Statistical Database.

Agricultural area is approximately 22 million hectares in Turkey. The area of vegetable oil seed production is about 1.3 million hectares. This figure is approximately 6% of the total agricultural area. About 2-2.5 million tons of oil seeds are produced per year in Turkey. Canola is a quality oil seed whose production has become popular in recent years. Sunflower seed production is 900 thousand tons, cottonseed production 1200 thousand tons and canola production only 82 tons yet in Turkey, as reported in Table 3 (Tüik, 2008).

4. Results

For the determination of elasticities of input demand and substitution regarding canola production in Trakya region, share of equality model was estimated through the utlilization of SUR. The results are shown in Table 4. There are 24 estimators in the system with dummy variables. In order to provide overall constraint in the estimation of demand system, equality of pesticide demand was excluded from estimation. Therefore, coefficients of explanatory variables of equality for pesticide cost share were calculated from overall constraint and their statistcs were not provided.

Labor, machinery and fertilizer prices were deflated with pesticide prices to maintain homogeneity in the estimated demand model. Hence, it was ensured that shares of input costs would not change if all the variable input prices in the estimated demand system increased at the same amount. Sum of estimated average cost shares is 1. Maximum input share is fertilizer as 40% while the minimum input share is labour with 15%. Due to the restrictions over symmetry in the estimation of demand model, coefficients by cross price estimators in the model are all equal to one another.

Estimated price equality model is monotonic. In other words, one unit increase in the production can be possible through increase of inputs utilized in production at the same rate. The absence of positive values in Allen elasticity of substitution eigenvalue vector suggests that model has concavity. This absence also signifies that when the prices of inputs utilized in production increase, unit cost will increase as well.

R-squares of equalities regarding the shares of cost were estimated to be (R^2) 55%, 64% and 53%.

Elasticities are the most fundamental data that reveals the production technique and production structure. Demand-price elasticities, Morishima technical substitution elasticities and Allen partial substitution elasticities are shown in the following table that are calculated through the estimation of input-demand system.

Elasticity of price-demand demonstrates the sensitivity of input demand amount in contrast to the change in input prices. In Table 5 values in the main diagonal of matrix are price elasticities of inputs, other values are cross price e-

Table 4 – *Results of Factor Demand Model.*

	Dependent Variable: Cost Shares			
	Labor	Draw Force	Fertilizer	Pesticide[1]
Constant	0.5971***	1.2657*	-0.4862	-0.3766
	(1.63)	(4.31)	(-1.24)	
Canola Yield	-0.0972**	-0.1603*	0.1735*	0.0840
	(-2.29)	(-5.63)	(3.58)	
Labor Price / Pesticide Price	0.0191	0.0037	-0.0680	0.0451
	(0.35)	(0.10)	(-1.37)	
Draw Force / Pesticide Price	0.0037	-0.0400	0.0987**	-0.0625
	(0.10)	(-0.44)	(2.10)	
Fertilizer Price / Pesticide Price	-0.0680	0.0987**	0.2031*	-0.2338
	(-1.37)	(2.10)	(2.63)	
Dummy (+310 kg/da=1)	0.0869**	-0.0273	-0.0467	
	(1.94)	(-0.91)	(-0.91)	
Dummy (Edirne=1)	0.1618*	0.0044	-0.0041	
	(3.24)	(0.12)	(-0.07)	
Dummy (Tekirdağ=1)	-0.0813*	0.0622*	0.0617**	
	(-3.00)	(3.47)	(2.02)	
R^2	0.55	0.64	0.53	
Average Cost Share	0.15	0.26	0.40	0.19

Values in parenthesis are t statistics. 1calculated from overall constraint
* significant at α=0.01, ** significant at α=0.05, *** significant at α=0.10
Source: Unakıtan, G., Kumbar, N. 2009. Trakya Bölgesinde Kanola Üretiminin Ekonomik Analizi, NKÜBA800.24.Yl.08.01 Nolu Araştırma Projesi, Tekirdağ.

Table 5 – *Elasticities of input price-demand.*

Labor	-0.7213	0.2823	-0.0378	0.4767
Draw Force	0.1702	-0.8973	0.7826	-0.0556
Fertilizer	-0.0147	0.5051	-0.1662	0.8131
Pesticide	0.3973	-0.0768	-0.6940	-2.0614

Source: Unakıtan, G., Kumbar, N. 2009. Trakya Bölgesinde Kanola Üretiminin Ekonomik Analizi, NKÜBA800.24.Yl.08.01 Nolu Araştırma Projesi, Tekirdağ.

lasticities. If cross price flexibilities are positive, then there is a competition between two inputs or they substitute each other. If these are negative, then there is a complementary relationship between one another.

Pesticide has the highest flexibility of input demand with -2.06 while fertilizer has the lowest flexibility with -0.16. Canola producers show quite a negative reaction to the increase in pesticide prices. A 10% increase in pesticide prices will decrease the demand for pesticide by 20.6%. If the machinery demand decreases by 8.9%, machinery prices increase by 10. Similarly, a 10% increase in wages of agricultural laborers will decrease the demand of labor by 7.2%. As a consequence, farmers meet their demand for labor from the family labor. A 10% increase in the prices of fertilizers will bring about a 1.6% decrease in the demand for fertilizers. Farmers have little sensibility to the changes in the prices of inputs excluding pesticides. The reason for this is that the vast majority of the farmers raising canola in Trakya region are members of Leader Farmer Project and pay attention to the suggestions provided by the Leader Farmer Project when they utilize inputs. When cross price flexibilities are examined, it can be seen that the most important complementary relationship among the inputs is the one between fertilizers and pesticides. The demand for pesticides decreases by 6.9% and the demand for machinery increases by 7.8% when the price of fertilizers increases by 10%. Pesticides have the highest cross price flexibility. When the price of pesticides increases by 10%, demand for labor and fertilizers increases by 3.7% and 8.1%, respectively. In case of machinery, prices increase by 10%, demand for labor and fertilizers increase by 2.8% and 5%, respectively. If prices of pesticides decrease by 10%, the demand for pesticides increases by 2.06%. Since negative results are close to 0, it would not right to assert that an important complementary relationship exists.

Morishima elasticity of technical substitution reveals that the change in the utilization rates of these inputs is stemming from the change in the proportion between the prices of two inputs. Positive Morishima technical substitution coefficient signifies that there is a partial substitution between inputs. As noticed in Table 6, partial substitution between input pairs is in question. The highest elasticity was estimated to be between pesticides and labor. While the price of pesticides is stable, if the proportion between the prices of pesticides and labor changes relatively by 1%, the decrease in the utilization rate of labor amounts to 2.46% of the utilization rate of pesticides and labor. On the contrary, while the price of pesticides is stable, if the proportion between the prices of pesticides and labor changes relatively by 1%, the decrease in the utilization rate of machinery amounts to 1.2% of the utilization rate of pesticides and labor. While the price of pesticide is stable, if the proportion between the prices of pesticide and machinery changes relatively by 1%, decrease in the utilization rate of machinery amounts to 1.98% of the utilization rate of pesticide and machinery. While the price of machinery is stable, if the proportion between the prices of pesticides and machinery changes relatively by 1%, the decrease in the utilization rate of pesticides amounts to 0.98% of the utilization rate of pesticides and machinery.

Allen elasticity of partial substitution has similar economic connotations with elasticity of price-demand. However, cost share of input with changing price of Allen elasticity of price-

Table 6 – *Morishima Elasticity of Technical Substitution.*

	Labor	Draw Force	Fertilizer	Pesticide
Labor	0	1.0035	0.6835	1.1980
Draw Force	1.0675	0	1.6799	0.8417
Fertilizer	0.1515	0.6713	0	0.9793
Pesticide	2.4587	1.9846	1.3674	0

Source: Unakıtan, G., Kumbar, N. 2009. Trakya Bölgesinde Kanola Üretiminin Ekonomik Analizi, NKÜBA800.24.Yl.08.01 Nolu Araştırma Projesi, Tekirdağ.

Table 7 – *Allen Elasticity of Partial Substitution.*

	Labor	Draw Force	Fertilizer	Pesticide
Labor	-4.8084	1.0857	-0.0944	2.5092
Draw Force		-3.4511	1.9566	-0.2925
Fertilizer			-0.4156	4.2794
Pesticide				-10.8495

Source: Unakıtan, G., Kumbar, N. 2009. Trakya Bölgesinde Kanola Üretiminin Ekonomik Analizi, NKÜBA800.24.Yl.08.01 Nolu Araştırma Projesi, Tekirdağ.

demand was weighted. Therefore, there is certainly no symmetry in elasticity of price-demand, while elasticity of partial substitution is symmetric in terms of input pairs. Allen elasticity of partial substitution measures the reaction of one input in the face of the change in the price of another input. Elasticity coefficients with positive marks point out the relationship of substitution, those with negative marks point out complementariness relationship. The highest elasticity coefficient 4.28 was estimated to be between fertilizers and pesticides. This coefficient shows that there will be a 42.8% increase in the utilization rate of fertilizers, when the prices of pesticides increase by 10%. The producers' high sensitivity to the price of pesticides can be deemed to be the cause of this rate being so high. Producers will prefer to use more fertilizers to increase the yield while the prices of pesticides are increasing. Elasticity of partial substitution coefficients of all inputs are shown in Table 7.

5. Discussion

Making use of the alternative oil plants is crucial in meeting the oil deficiency in Turkey. In particular, canola plants with their high efficiency and high quality oil have a potential that could play an important role in this area. In Turkey, canola yield changes between 250 kg/decare and 300 kg/decare. In Trakya region, average yield of canola is over 300 kg/decare. With its average 40% oil rate, having the same oil rate as sunflower seed, canola is a major competitor of sunflower seed. It is especially indicated by the farmers in the Trakya region, sown area of field crops has been shifting from sunflower to canola.

Pesticides have the highest flexibility of input demand with -2.06 while fertilizers have the lowest flexibility with -0.16. Canola producers show quite a negative reaction to the increase in pesticide prices. When cross price flexibilities are examined, it can be seen that the most important complementary relationship among the inputs is the one between fertilizers and pesticides. The highest elasticity was estimated to be between pesticides and labor. The highest Allen elasticity coefficient 4.28 was estimated to be between fertilizers and pesticides.

In the Trakya region, canola plants should be sowed as early as possible in order to ensure that they will not be hampered by weather conditions during the winter. Optimal sowing period was determined as 15 September-15 November in Tekirdağ. In Edirne and Kırklareli, optimal sowing period should be determined wisely taking into consideration climatic conditions. When oil plants are sown for winter, they become ripe enough to be harvested in June and for that reason it is impossible to harvest them in those months. Therefore, oil and factories do not operate with full capacity. Canola plants enable factories to operate with full capacity by meeting their raw material reqirement. They are also suitable for mechanization from sowning period to the harvest and yield more seed and oil than other oil plants. These are among their positive qualities.

Provided that optimal input use can be achieved, the rate of substitution between inputs is expected to approach zero in agricultural production. Many years ago, canola production was stopped due to varieties with erusic acid in Trakya region. With the new varieties, zero erusic acid goes into production. Therefore, according to price elasticities, the optimum input use has not been reached yet. Especially, farmers are more sensitive to pesticides. Price policy in favour of the farmers should be organized for optimum input usage. Especially, subsidies may be offered for the low price of diesel fuel used in agricultural production.

The failure to well define the price parity between the oilseeds and other crops has a negative impact on the production of oilseeds. Agricultural production requires land alternation for the efficiency of production. Because of the alternation, farmers should produce oilseeds and other crops by rotating. To avoid fluctuations of farmers' income, considering the yields of alternative crops, protection of price parity between these crops is important.

Therefore, government should undertake provisions from relevant circumstances in order to reduce production costs, provide purchase guarantee for the produced seeds, create economic incentives and provide ensurance for widespread canola seed production prior to sowing.

Canola has a higher profit than sunflower and wheat in Trakya region. Wheat, sunflower and canola compete with each other in Trakya region and the net profit of these products is 35, 50 and 68 Euro, respectively (Unakitan and Kumbar, 2007). Canola in terms of net profits is showing a huge difference with respect to other products.

Canola production must be encouraged and increased. By adding canola oil to other vegetable oils used for cooking, it can be relased to the markets in this mix. Thus, canola oil would take the place of imported palm oil and import costs of palm oil would be saved (Unakitan 2006). By increasing the canola production, import demand of oilseeds and crude oil will drop in Turkey.

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