Estimation of Normative Supply Function and Price Elasticity of Hazelnut: A Case Study in Turkey

Osman Kilic¹, Vedat Ceyhan, H. Avni Cinemre, and Mehmet Bozoglu
Ondokuz Mayıs University, Faculty of Agriculture, Department of Agricultural Economics, Kurupelit, Samsun 55139, Turkey

John Sumelius

Helsinki University, Faculty of Agriculture and Forestry, Department of Economics and Management, Helsinki, Finland

Additional index words. hazelnut, variable price programming, normative supply function, price elasticity

Abstract. In this study, a variable price programming model was developed to derive normative hazelnut function and calculate price elasticity of supply for hazelnut in Carsamba Plain of Samsun, Turkey. Economic analysis revealed that the composition of the total assets of hazelnut farms seemed to be unbalanced. In addition, the efficiency of resource use was not adequate in sample hazelnut farms. Research results also showed that hazelnut production would stop on the Carsamba Plain completely when the hazelnut price is less than \$ 0.57 per kilogram. Calculated price parities between hazelnut and corn, rice, and sugar beet were 3.87, 1.77, and 15.21, respectively. In conclusion, relying on market forces would increase land and labor use efficiency.

Agriculture is one of the most important sectors in Turkey. Traditionally, four agricultural products, which are hazelnuts, dried apricot, dried figs, and raisins, have played a crucial role in Turkish's economy because they provide income for a large number of farmers and export opportunities. Turkey dominates world export of the following products: hazelnuts (70%), dried apricots (74%), dried figs (63%), and raisins (27%) (FAO, 2007). Hatirli et al. (2004) stated that Turkey had remarkably higher comparative and competitive advantage for these fruits relative to other countries analyzed. Among these commodities, hazelnuts and dried apricots had higher advantage than raisins and dried figs for Turkey.

Turkey is one of the biggest producers of nuts in the world. Turkey provides ≈70% of the world's hazelnut production and 14% of pistachio production. In recent years, Turkey's share in the world hazelnuts production has increased. The countries responsible for almost the entire world's hazelnut production and exports are Turkey, Italy, the United States, and Spain. Among these countries, Turkey has the leading position in world hazelnut production and export, supplying ≈70% of world's production and export. However, the other nuts such as pistachio, almond, chestnut, and walnut production and export have decreased as a result of the policies of competing countries, especially Iran and the United States (FAO, 2007).

Bozoglu et al. (1996) pointed out that a high level of dependency on European Union countries, especially Germany, in nut export resulted in reduced marketing efficiency.

The Turkish government has supported hazelnut production since 1964 to stabilize hazelnut producers' income and the balance of trade resulting from the export value of hazelnut. Price support policy for hazelnuts and high prices on the free market in some years, together with the contribution of yield from more hazelnut plantations, has accelerated hazelnut production. Because export and internal consumption of hazelnut have not increased in parallel with production, hazelnut stocks have reached very high levels, especially since 1980. This situation caused the inefficient use of scarce resources and prevented the production of other cash crops. The increase in hazelnut stock expansion of hazelnut orchards to the plains prompted policymakers to develop control policies. Dramatically, policymakers banned the planting of new hazelnut orchards in 1983 under law 2844. Despite the law for limitation of hazelnut areas, the desired result has not been achieved and there has been a 22% increase in hazelnut areas (FAO, 2007). This problem arises mainly on the Carsamba Plain of Samsun in Turkey. Approximately half of the land on the Carsamba Plain is covered with hazelnut orchards (TKB, 2004). Currently, the government is trying to increase the conversion to other cash crops in this region by making compensatory payment to farmers who are willing to uproot their hazelnuts. However, there has been a lack of regional and farm-level data when deciding the amount of payment. Providing the necessary information to policymakers about

hazelnut farms and market conditions in the Black Sea region will be useful in changing production patterns in the area.

Until now, considerable research has been conducted on hazelnut economics and policy in Turkey. Ceyhan et al. (1996) analyzed the hazelnut supply and demand based on the national-level time series data. Yavuz and Birinci (1996) also focused on hazelnut supply and demand. Farm-level studies followed this type of effort. Kilic (1997) performed the economic analysis in hazelnut farms and developed an alternative optimum farm plan for hazelnut farms. Similarly, Bozoglu (1999) compared the alternative policy instruments for improving the Turkish hazelnut market by using both farm and national-level data. Demiryurek (2000a, 2000b) inclined the organic hazelnut production and compared the economic performance and information system of conventional and organic hazelnut farms. Because the hazelnut planting area considerably increased during the early millennium, some researchers concentrated on the factors that affected the expansion of hazelnut orchards (Demiryurek and Bozoglu, 2002; Kilic and Ozyazici, 2003). There have been also adequate studies outlining the general situation and policy aspect of the Turkish hazelnut sector based on the national level of data (Bozoglu, 2005; Kilic, 1996; Kilic and Alkan, 2006; Yavuz et al., 2005). However, there have been no farm-level studies providing information such as price elasticity of hazelnut and normative supply functions.

To reduce this information gap, the objectives of this research were to: 1) derive the normative hazelnut supply function in Carsamba Plain, 2) calculate supply elasticity of hazelnut, and 3) generate data that may be used in reshaping the incentive payments policy applied to alternative crops.

Materials and Methods

The study area, representative farms, and data. Most of the data included in this study were gathered from 73 randomly selected hazelnut farms on Carsamba plain of Samsun, Turkey. Carsamba Plain is on the border of Samsun Province on the middle Black Sea coast of Turkey. This study, after identification of survey objectives, used a well-designed, state instrument to capture information that was of great interest and relevance to the questions under study. Regarding validity and reliability of the survey, focus group interview was used. Face and content validity was established by convening a focus group that included beneficiaries and individuals with subject matter expertise. Reliability was assessed using the test-retest method in which the survey administered the same group at two different times. Cronbach's (1951) alpha was used as an index of internal reliability or consistency for a set of questions and an alpha of 0.80 or higher was considered to indicate an acceptable level of internal reliability.

Received for publication 28 June 2007. Accepted for publication 6 Dec. 2007.

¹To whom reprint requests should be addressed; e-mail okilic@omu.edu.tr

In addition, time series and cross-sectional data for different crops cultivated in the research area were gathered from the regional production statistics and research station records and subjectively adjusted.

The variables analyzed in this study can be divided into three broad groups: socioeconomic characteristics of the farms (farm land, family size, total assets, return on equity, return on assets, liquidity of the farms, solvency of the farms, financial efficiency measures, and profitability); specific characteristics of hazelnut orchards (the size and age of hazelnut orchards, hazelnut varieties and yield); and input–output data (labor and capital requirements for each activity, resource availability, gross income for each activity, variable and fixed costs of each activity, marketing restrictions, and production coefficients).

Variable price programming approach. In this study, the variable price programming approach was used to derive a normative hazelnut supply function, which describes the quantity of product that should be produced to maximize income at different hazelnut prices.

Heady and Candler (1973) stated that a normative supply function indicates how farmers should behave to maximize their income. Generally, knowledge about the normative supply function allows the formulation of improved models for predicting positive supply function.

Variable price programming is the best known application for derivation of normative supply function. Because it requires only linear programming to generate solutions, it is the most widely used program in resource allocation and derivation of normative supply functions. Variable price programming allows the determination of the price range over which a particular plan is optimum and stable and may be used to derive normative supply functions when policy problems are the predominant consideration (Heady and Candler, 1973). Barnard and Nix (1993) suggested that variable price programming is most often used in farm policy research, namely to derive “normative supply functions,” that is, to predict how farmers should react to changes in the relative price of a commodity. It can also be used in farm planning, particularly by applying it to model farm situations.

In our one-price variable programming model, the price of hazelnut was varied over a given range with all other prices given. A supply row and selling activity was included for hazelnuts in the initial matrix. Then the optimum plan at the minimum hazelnut price in the required range was computed. Subsequently, the critical hazelnut prices at which the optimum plan changed were calculated. By this procedure, a series of hazelnut price ranges were obtained in each of which a given area of hazelnut remained optimal. Beyond each critical price level, the optimal hazelnut area increased.

Both the objective function and the first set of constraints were identical to a standard

linear programming formulation; gross revenues are maximized subject to a set of farm-level constraints. The hazelnut price variable programming model was:

$$\text{maximize } E = cx$$

Subject to

$$Ax \leq b$$

$$X \geq 0$$

where E is gross farm income; c is a 1 by n vector of activity expected net revenues; x is an n by 1 vector of activity levels; A is the technical coefficients matrix; and b is the vector of resource stocks.

The model built for a representative farm in the research area included land, rotational constraints, and seasonal constraints on labor, seasonal working capital, and barn and feed requirements for a dairy herd. Activities in the model included hazelnut, rice, soybean, sunflower, rape seed, maize, wheat, maize for silage, sugar beet, bean, aubergine, cucumber, pepper, tomatoes, water melon, strawberry, peach, kiwi, walnut, cherry, hay, and dairy. Additional activities labor hire (monthly), hazelnut uprooting and making straw were also included (Appendix 1).

Results and Discussion

Basic characteristics of sample farms. Research results showed that small-sized farms were dominant in the research area. The size of their business was not sufficient to remain competitive in the market. As a result of the low level of current and intermediate assets, and the presence of excess labor and productivity, the efficiency of hazelnut farms was unsatisfactory. Hazelnut farms had three cattle on average and 3.8 ha of farm land, 55% of it hazelnut orchards, and conducted their activities with approximately four people. Size of hazelnut orchards was 2.1 ha on average and split into two plots, each ≈ 1.1 ha. The age of hazelnut orchards ranged from 4 years to 42 years (average, 24 years). The number of bushes per hectare was 390 (Table 1). In the research area, hazelnut yield per ha of 1260 kg was higher than Turkey's average of 950 kg (Fiskobirlik, 2007).

Economic analysis showed that the composition of the total assets seemed to be unbalanced. The total asset of the average hazelnut farm was \$79,973 (91% of total assets was farmer-owned assets). The percentage of current assets was less than 1% of total assets, whereas long-term assets constituted 74% of total assets. Current ratio was 1:1 and indicated that sample hazelnut farms did not face serious liquidity problems. Similarly, solvency measures indicated that sample farms had no serious solvency problems. Profitability measures showed that the return on equity (0.8%) was smaller than that of total assets (1.5%). It might be inferred that hazelnut farms paid more interest on debt than their returns. Return on unpaid family labor and operators' labor, management, and capital was \$2516. Unpaid family labor,

Table 1. Some basic characteristics of sample hazelnut farms.

Characteristics	Mean value
Socioeconomic characteristics	
Farm land (ha)	38.03
Family size (persons)	3.81
Education level of operators (years)	4.78
Total assets (\$)	79,974.00
Liquidity	
Current ratio	1.10
Solvency	
Debt/total assets	0.09
Debt payout	0.52
Profitability	
Return on farm assets (%)	2
Return on farm equity (%)	1
Financial efficiency measures	
Labor efficiency ^a	3.45
Capital turnover ratio	0.08
Hazelnut orchard characteristics	
Size of orchards (ha)	2.10
Age of orchards (years)	24.00
Number of plots	2.00
Size of plots (ha)	1.10
The number of bushes (per ha)	390.00
Yield (kg·ha ⁻¹)	1,260.00

^aGross income/hired and family labor expenses.

operators' labor, and management totaled $\approx$ \$1317. Farm cash expenses constituted 62% of total farm expenses, whereas 38% of the total expenses was interest payment and depreciation. Financial efficiency measures showed that sample hazelnut farms did not use their resources such as labor and capital effectively (Table 1).

Normative hazelnut supply functions and price elasticity. The results of variable price programming revealed eight optimum plans for different hazelnut prices. Initially used price for hazelnut is \$0.98 per kilogram. Hazelnut production is excluded from the optimum plan if the price is less than \$0.57 per kilogram. Beyond this price level, hazelnut entered the optimum plan with ≈ 0.3 ha and remained at the same area to \$0.88 per kilogram. When the price increased to \$1.09 per kilogram, the area of hazelnut reached 1.43 ha because sunflower, rice, and soybean could not compete and were excluded from the optimum plan. Following the critical hazelnut price of \$1.10 per kilogram, hazelnut area reached 2 ha, and corn was not able to compete. Hazelnut area reached the maximum level when the price was \$1.16 per kilogram, and this plan did not change, even at very high prices (Appendix 2). Interestingly, for several decades, the hazelnut price in Turkey was never lower than \$1 per kilogram. In the last decade, hazelnut price averaged \$1.83 per kilogram with a \$0.66 standard price deviation. This reduced the competitive power of other cash crops.

Results also showed that the price parity between hazelnut and corn was more than 3.87 to remove hazelnut completely from the optimum cropping pattern. The price parities between hazelnut and rice, sugar beet, soy bean, and sunflower were 1.77, 15.21, 3.09, and 1.55, respectively. Because the price of

Fig. 1. Normative hazelnut supply curve.

crops fluctuates widely in other countries with a transition economy, focusing on the price parity among crops is vital when policymakers assess the amount of incentive payment. Currently, the incentive payment is \$0.19 per kilogram for cereals, \$0.10 per kilogram for oil crops, and \$696 per hectare for fodder crops in the research area. Until now, policymakers have followed the compensatory payment policy to control hazelnut supply, giving no attention to price parities of cash crops. One of the main reasons for this was lack of information. Taking into account the price parities of alternative crops may increase the likelihood of success of this policy.

The results of the ordinary least squares estimation indicated a linear positive relationship between hazelnut price and supply in the research area and the equation is:

$$Q = 227 + 619P$$

(348.6) (178) $n = 13$

where Q is the quantity and P is the price. The adjusted coefficient of determination of 0.43 is statistically significant at the level of 1% ($F = 12.10$). The slope of the equation, statistically significant at the level of 1%, infers that increase in hazelnut price per dollar might be caused by the 619 kg increase in hazelnut quantity supplied to the market in the research area (Fig. 1).

The price elasticity of hazelnut supply calculated based on the average values is 0.82 and indicates that hazelnut supply is inelastic. This confirmed the results of previous studies based on time-series data (Bozoglu, 1999; Ceyhan et al., 1996; Yavuz and Birinci, 1996). The price elasticity coefficient showed that a 1% decrease in hazelnut price might cause a 0.8% decrease in hazelnut production in the research area.

Conclusion

Research results revealed that the efficiency of hazelnut farms was unsatisfactory as a result of the low level of current and intermediate assets and the presence of excess labor and productivity. Hazelnut farms also did not use their resources such as labor and capital effectively. The results of variable price programming showed that hazelnut disappeared from the optimum farm plan completely when the hazelnut price was less than \$0.57 per kilogram. Another outcome of the study was that hazelnut supply was inelastic.

Under the light of the study, it was clear that hazelnut price was not the sole consideration when controlling hazelnut supply. There were other factors such as sufficiency of working capital, availability of labor, technical capacity of farmers, and so on. Demiryurek and Bozoglu (2002) stated that low level of working capital and inadequate labor were main barriers to remove hazelnut from lowland rather than hazelnut price.

Taking into consideration price parities between hazelnut and other cash crops simultaneously, other barriers are imperative when designing hazelnut policy. After stable policy development on the basis of regional farm-level data, hazelnut area on the plains may decrease and more efficient use of land instituted. Because there is a need for information about hazelnut supply control, further research should focus on the hazelnut supply control and its barriers.

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Appendix 1. Initial matrix.^z

	Uprooted hazelnut	Hazelnut	Wheat + silage maize	Barley + corn	Rapeseed + silage maize	Alfalfa	Corn	Rice	Sugarbeet	Soybean	Sunflower	Fresh bean	Tomato	Pepper	Aubergine	Cucumber	Watermelon
Objective function (YTL)																	
Total area		-115.0	-189.53	155.96	-171.32	-107.83	80.59	92.01	93.77	68.38	64.54	142.98	150.05	144.09	128.20	134.02	149.14
Uprooted hazelnut-hazelnut area	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Land for field crops			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Land for vegetable																	
Land for fruit																	
Wheat + silage maize			1														
Barley + corn				1													
Rapeseed + silage maize					1												
Clover						1											
Corn							1										
Rice								1									
Sugar beet									1								
Soybean										1							
Sunflower											1						
Fresh bean												1					
Tomatoes													1				
Pepper														1			
Aubergine															1		
Cucumber																1	
Watermelon																	1
Strawberry																	
Peach																	
Kiwi																	
Walnut																	
Cherry																	
Hazelnut transfer		-123.96															
Wheat transfer			-400.00														
Corn transfer				-400.00													
Rapeseed transfer					-300.00												
Total feed (Mcal)			6,983.00	-1,016.00	-6,983.00	-1,915.00											
Dry grass (Mcal)				-1,016.00													
Straw			-190.00														
Barn (m ²)																	
Working capital		115.03	189.53	155.96	171.32	107.83	109.03	194.64	188.02	99.46	67.46	346.81	369.54	395.68	351.80	339.62	302.66
January (h)																	
February (h)																	
March (h)																	
April (h)		1.65	0.33		3.16	3.80		11.87	3.56			9.38	18.98	14.11	21.70	19.48	11.09
May (h)		1.08	0.50	0.90		3.18	2.13		1.78			9.23	14.35	38.63	23.96	24.82	13.72
June (h)				4.16		3.04		4.09	19.24	1.92	2.13	60.20	35.93	42.87	32.34	36.40	23.74
July (h)		3.55	3.75	13.10	2.32	3.04	15.38	18.00	18.45	0.67	4.68	27.86	6.12	4.07	4.15	3.06	22.16
August (h)		36.30	1.60		1.60	5.01		18.00	3.11	8.09	4.09	22.77	27.41	15.69	16.90	38.36	13.86
September (h)		0.61	4.23		4.23	4.81					1.98		26.38	14.67	14.84		12.82
October (h)			2.52	29.98	2.36	0.27	28.78	8.22	4.25	4.19	1.88						
November (h)						0.02			4.25								
December (h)		15.20															

(Continued on next page)

Appendix 1. (Continued) Initial matrix.^z

	Strawberry	Peach	Kiwi	Walnut	Sour cherry	Hazelnut sale	Wheat sale	Corn sale	Rapeseed sale	Cow	Straw making	Labor hire (1)	Labor hire (2)	Labor hire (3)	Labor hire (4)	Labor hire (5)	Labor hire (6)	Labor hire (7)	Labor hire (8)	Labor hire (9)	Labor hire (10)	Labor hire (11)	Labor hire (12)	RHS
Objective function (YTL)	177.94	187.03	216.20	194.58	196.56	1.615	0.30	0.24	0.36	515.62	-18.33	-0.78	-0.78	-0.78	-0.78	-0.78	-0.78	-0.78	-0.78	-0.78	-0.78	-0.78	-0.78	Maximum
Total area	1	1	1	1	1	1																		38.03
Uprooted hazelnut-hazelnut area																								= 20.72
Land for field crops																								<= 29,2831
Land for vegetable																								<= 9,5075
Land for fruit	1	1	1	1	1																			<= 4,5636
Wheat + silage																								<= 3,0424
maize																								<= 3,0424
Barley + corn																								<= 1,9015
Rapeseed + silage																								<= 1,9015
maize																								<= 5,7045
Clover																								<= 3,8030
Corn																								<= 2,2818
Rice																								<= 5,7045
Sugar beet																								<= 1,9015
Soybean																								<= 1,9015
Sunflower																								<= 1,9015
Fresh bean																								<= 1,9015
Tomatoes																								<= 1,9015
Pepper																								<= 1,9015
Aubergine																								<= 1,9015
Cucumber																								<= 1,9015
Watermelon																								<= 1,1409
Strawberry	1	1	1	1	1																			<= 0.7606
Peach																								<= 0.7606
Kiwi			1	1	1																			<= 1.5212
Walnut																								<= 0.7606
Cherry																								<= 0.7606
Hazelnut transfer																								<= 0
Wheat transfer																								<= 0
Corn transfer																								<= 0
Rapeseed transfer																								<= 0
Total feed (Mcal)																								<= 0
Dry grass (Mcal)																								<= 0
Straw																								<= 0
Barn (m ²)																								<= 34.19
Working capital	297.06	269.01	383.80	182.27	243.43																			<= 0
January (h)																								>= 0
February (h)																								<= 596
March (h)	0.80	2.36	0.90	2.09	9.08																			<= 570
April (h)	9.40	4.92	0.03	3.79	4.96																			<= 622
May (h)	27.90	11.25	12.70	3.79	4.96																			<= 596
June (h)	27.30	3.45	17.60	3.79	4.96																			<= 674
July (h)		17.82	5.10	1.09	55.08																			<= 674
August (h)																								<= 726
September (h)																								<= 726
October (h)																								<= 674
November (h)																								<= 648
December (h)																								<= 570
																								<= 622

^zAfter analysis, all values were transformed from New Turkish Lira (YTL) to \$ U.S. according to the exchange rate.

Appendix 2. Optimum farm plans for critical levels of hazelnut price.^z

	Gross farm income (\$)	Critical hazelnut price (\$/kg)	Hazelnut area (ha)	Hazelnut (kg)	Corn (ha)	Sugar beet (ha)	Rice (ha)	Common vetch/barley + corn (ha)	Corn (kg)	Soybean (ha)	Alfalfa (ha)	Sunflower (ha)	Wheat + silage maize (ha)	Wheat (kg)	Cucumber (ha)	Watermelon (ha)	Tomato (ha)
1	3,168.13	0-0.5657	—	—	0.5705	0.2282	3,3803	—	—	0.5705	0.0986	0.1902	—	—	0.1141	0.0761	0.1902
2	3,168.15	0.5658-0.8832	0.2902	359.7	0.5705	0.2282	3,3803	—	—	0.5705	0.0986	0.1902	—	—	0.1141	0.0761	0.1902
3	3,282.38	0.8833-0.9020	0.4803	595.4	0.5705	0.2282	3,3803	—	—	0.5705	0.0986	—	—	—	0.1141	0.0761	0.1902
4	3,293.60	0.9021-1.0413	0.9137	1132.7	0.5705	0.2282	3,3803	—	—	0.1371	0.0986	—	—	—	0.1141	0.0761	0.1902
5	3,451.65	1.0414-1.0885	1.0508	1302.6	0.5705	0.2282	3,3803	—	—	—	0.0986	—	—	—	0.1141	0.0761	0.1902
6	3,512.87	1.0886-1.1014	1.4311	1773.9	0.5705	0.2282	—	—	—	—	0.0986	—	—	—	0.1141	0.0761	0.1902
7	3,535.85	1.1015-1.1662	2.0015	2481.1	—	0.2282	—	—	—	—	0.0986	—	—	—	0.1141	0.0761	0.1902
8	3,696.71	1.1663- α	2.0770	2574.6	—	0.1527	—	—	—	—	0.0986	—	—	—	0.1141	0.0761	0.1902
Gross farm income (\$)																	
1	3,168.13	0-0.9277	1.9015	1.9015	1.9015	1.9015	0.7606	1.5212	0.7606	0.7606	0.7606	3.0746	20.77	0.6759	202.78	—	—
2	3,168.15	0.9278-1.4484	1.9015	1.9015	1.9015	1.9015	0.7606	1.5212	0.7606	0.7606	0.7606	3.0746	17.8681	0.6759	202.78	—	—
3	3,282.38	1.4485-1.4793	1.9015	1.9015	1.9015	1.9015	0.7606	1.5212	0.7606	0.7606	0.7606	3.0746	15.966	0.6759	202.78	—	—
4	3,293.60	1.4794-1.7078	1.9015	1.9015	1.9015	1.9015	0.7606	1.5212	0.7606	0.7606	0.7606	3.0746	11.6326	0.6759	202.78	—	—
5	3,451.65	1.7079-1.7851	1.9015	1.9015	1.9015	1.9015	0.7606	1.5212	0.7606	0.7606	0.7606	3.0746	10.2621	0.6759	202.78	49.75	—
6	3,512.87	1.7852-1.8063	1.9015	1.9015	1.9015	1.9015	0.7606	1.5212	0.7606	0.7606	0.7606	3.0746	6.4591	0.6759	202.78	119.34	—
7	3,535.85	1.8064-1.9126	1.9015	1.9015	1.9015	1.9015	0.7606	1.5212	0.7606	0.7606	0.7606	3.0746	0.7546	0.6759	202.78	326.42	—
8	3,696.71	1.9127- α	1.9015	1.9015	1.9015	1.9015	0.7606	1.5212	0.7606	0.7606	0.7606	3.0746	—	0.6759	202.78	353.81	—

^zAll values are expressed in U.S. dollars.