Hedonic price analysis of the quality characteristics of the Anatolian Hard Red Wheat

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Abstract: The study analyses the relations between the quality characteristics and price of the Anatolian Hard Red Wheat. It uses a data set consisting of the price and eight quality characteristics of the Anatolian Hard Red Wheat traded in spot transaction in each month of 2011 in the Polatli Commodity Exchange. Marginal implicit values of the quality characteristics of the Anatolian Red Hard Wheat traded in the spot market of the Polatli Commodity Exchange are determined through the hedonic price model. This model is estimated from the linear-log functional form. Results of the hedonic price model demonstrate that the quality characteristics, which are statistically significant in the determination of price, namely, the protein content, the hectolitre weight, and the grain content damaged by pests and wheat bugs, are important factors in the purchasing decisions of flour millers. As the protein content and the hectolitre weight of wheat increase by 1%, the price increases by TL 0.005 and TL 0.006, respectively. As the grain content damaged by pests and wheat bugs increases by 1%, the price of wheat drops by TL 0.0002. These marginal implicit values are expected to encourage wheat producers to produce the higher quality wheat.

Key words: wheat policy, quality characteristics, Polatli Commodity Exchange, Turkey

The first attempts to price wheat according to its quality characteristics in Turkey began in 1998. At the time, it was necessary to reorganize the operations of the Commodity Exchanges in order to ensure that quality was the primary factor to be taken into account in the pricing of wheat. To that end, a project was proposed to the World Bank, and the loan borrowed was used to carry out the market regulation in the pilot Commodity Exchanges. During the project, the adoption of the system of pricing according to quality characteristics was achieved only in a few Commodity Exchanges where the trading of wheat was intense. The pricing of wheat generally without paying regard to the quality characteristics prevented the propagation of the production of high quality wheat in Turkey. The enterprises in the sector of bakery products in Turkey continued to import high quality flour, which was not being produced in the country. In 2011, the Turkish Grain Board initiated the system of the incentive payment according to quality characteristics with a view to reduce the wheat import and to promote the production of the high quality wheat. Currently, the Turkish Grain Board pays an incentive premium ranging between 1% and 3%, according to the protein content of wheat. While this system intends to encourage the production of the high quality wheat, it does not identify the marginal implicit price values of the quality characteristics of wheat. Although the literature contains numerous studies that present the quality demands of wheat and its marginal implicit price values, there are not enough studies at the national level. The studies at the national level focus on the quality of wheat, and the studies on the market value of the quality characteristics of wheat are rare. Fidan (2004) found that among the quality characteristics, the hectolitre weight and vitreousness were the major factors determining the price of durum wheat in the wheat market of Turkey, whereas (Karaman et al. 2009) found that the hectolitre weight and the sedimentation values were the major determinants of the price of bread wheat. Although the results of studies on this subject in the international literature differ, the protein content seems to be the common and most important characteristic quality in the determination of wheat prices (Veeman 1987; Mercier 1993; Uri and Hyberg 1996). Larue (1991) showed that the marginal implicit value of protein varied depending on the wheat classification and in time. Wilson (1989) demonstrated that it could change depending on the destination market (Stingert and Blane 1997) analysed the demand for the wheat protein in relation to five classes of wheat

in the Japanese import market. It was put forth that the marginal implicit value of the wheat protein was significantly connected to the stability, the water absorption and the extensibility of dough.

This study aims to estimate and improve the hedonic price model that gives the marginal implicit price values of the quality characteristics of wheat traded in the Polatli Commodity Exchange. It consists of two parts. The first part deals with the developments in the incentive policies for the wheat quality in Turkey as well as the functioning of the Polatli Commodity Exchange. In the second part, the hedonic price model is estimated to obtain the marginal implicit values of the quality characteristics of the Anatolian Hard Red Wheat traded in the Polatli Commodity Exchange. The marginal implicit price of a quality characteristic indicates its market value. In this regard, the determination of the marginal implicit values of the quality characteristics of wheat in Turkey, which is one of the countries that have the highest wheat and flour export in the world, will contribute to the production of the high quality crops. The results to be obtained from the study will be useful for the producers and traders in the marketing system, enterprises producing flour, and bakers that decide on the characteristics of the flour demanded.

MATERIAL AND METHODOLOGY

Material

The study employs the data set containing the price and eight quality characteristics of the Anatolian Hard Red Wheat traded in the Polatli Commodity Exchange between 01. 01. 2011 and 31. 12. 2011. This data set is composed of the prices and quality characteristics of 10 different wheat sale transactions that took place in 2011. As no transaction of third grade wheat took place in June, the data of 8 sale transactions were obtained. A special attention was paid to include the quality characteristics of different grades of the Anatolian Hard Red Wheat. The data set consists of the prices and eight quality characteristics of wheat in 118 sale transactions.

Methodology

The Anatolian Hard Red Wheat is a heterogeneous product and is divided into three grades according to its quality characteristics in the Polatli Commodity Exchange. Quality characteristics of the Anatolian Hard Red Wheat are quite important for millers that process flour. They help to assess the purchased wheat in terms of the flour yield, cost and time. Each individual characteristic of the Anatolian Hard Red Wheat may be considered an input in the flour production process. According to this assumption, the inputs become useful in the production process thanks to the characteristics they possess. Thus, the levels of various quality characteristics defined as an input indicate their contribution to the production process. The total output depends on the sum of all quality characteristics considered an input (Ladd and Martin 1976). In this approach, the profit maximization is provided by the hedonic price function of wheat, which is a function of its quality characteristics. The hedonic price model has been used in numerous studies that explain how the quality characteristics of a product affect its price (Parker and Zilberman 1993; Mishili et al. 2009). Equation (1) indicates the basic hedonic price model:

$$P_{X_i} = \beta_0 \sum_{j=1}^{m} \beta_j \, x_{jiy}^{\lambda} x_{jiy} \tag{1}$$

where β_j is the marginal implicit price for characteristic j. This model expresses the price of the Anatolian Hard Red Wheat, which is an input in the flour production process, and equals to the sum of the hedonic prices of its characteristics and the products of marginal yields of the characteristics. This equation assumes that input prices are linearly related to the quantities and qualities of the characteristics. If we add an error term to Equation (1), it can be used to conduct a regression analysis, to test the hypotheses for the model and β_j and obtain estimates for β_j.

$$P_{X_i}^{\lambda_1} = \beta_0 + \sum_{j=1}^{m} \beta_j \, x_{jiy}^{\lambda_2} x_{jiy} + \sum_{j=1}^{k} \beta_j Z_j + \varepsilon_j$$

$$E[\varepsilon_j] = 0, Var[\varepsilon_j] = \sigma^2 \tag{2}$$

In Equation (2), m denotes the number of transformable variables, k denotes the number of non-transformable discrete variables, ε_j denotes the residuals that eliminate the constant variance restriction, and λ_1 and λ_2 denote the Box Cox transformation. The monthly dummy variable Zj is used to take into account the impact of time on the price variability. Dummy variables are important with a view to take into account the seasonal change in prices. July, which is one of the harvest period months of wheat, may be used as the reference month.

Since there is no restriction on the functional form of the hedonic price model in terms of the economic theory, the researchers need to select the functional form that fits best to the data. For this purpose, the *Box Cox* transformation is usually applied. In this approach, the non-linear parameter λ is included among the dependent and independent variables, and the alternative functional forms are assessed. *Box Cox* transformation is carried out through the maximum likelihood method. When all variables in the hedonic price model are transformed into the *Box Cox* form, it is called the Double *Box Cox* model, whereas when they are transformed into only dependent variables, it is called the semi-parametric *Box Cox* model. For instance:

$$P_i^{\lambda} = \begin{cases} \frac{P_i^{\lambda_1} - 1}{\lambda_1} & \lambda \neq 0 \\ lnP_1 & \lambda = 0 \end{cases} \text{ and } x_i^{\lambda} = \begin{cases} \frac{x_i^{\lambda_2} - 1}{\lambda_2} & \lambda \neq 0 \\ \ln x_1 & \lambda = 0 \end{cases} \quad (3)$$

This transformation is defined for the variables above 0, and the variables must be continuous. The functional pattern is determined depending on the values of λ_1 and λ_2. If any of the parameters λ_1 and λ_2 is assumed to be equal to 1, the transformation is linear. If the parameter equals to 0, the transformation converges to the natural logarithm. Thus, if $\lambda_1 = \lambda_2 = 1$, a linear form, if $\lambda_1 = \lambda_2 = 0$, a logarithmic form, if $\lambda_1 = 1$, $\lambda_2 = 0$, a linear logarithmic form, if $\lambda_1 = 0$, $\lambda_2 = 1$, a logarithmic linear form, if $\lambda_1 = 1$, $\lambda_2 = -1$, an inverse function, and if $\lambda_1 = 0$, $\lambda_2 = -1$, a logarithmic inverse functional form is obtained (Sakia 1992).

The maximum likelihood ratio test may be employed to determine the functional form of the hedonic price model. Maximum values of the likelihood function of the restricted and unrestricted models are used to test the significance of the parameter transformation in the unrestricted model. The test statistic employed to determine the confidence interval for λ:

$$L_{\max}(\lambda) - L_{\max}(\lambda^*) \left\langle \frac{1}{2}\chi_1^2(0.05) \right. \quad (4)$$

where λ is the restricted lambda, λ* is the unrestricted lambda, $L_{\max}$ is the value of the likelihood function that is related to each model, and α is the level of significance (Halvorsen and Pollakowski 1981). This test statistic (4) may be used to test the H_0, which asserts that the correct functional form is double-log (λ = 0) or linear (λ = 1).

The individual and combined tests on the Box Cox parameters give unexpected results. Thus, the Voung (1989) test may be used as a complementary test to select a functional form among four alternatives. We can define the likelihood ratio for each individual observation *i* with the following formula:

$$LR^i\left(\lambda_{1j}\lambda_{2j}, \lambda_{1k}\lambda_{2j}\right) = ll_j^i - ll_k^i$$

$$Voung = \frac{\sqrt{n}\left[\frac{1}{n}\sum_{i=1}^{n} LR_i\right]}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(LR_i - \overline{LR_i}\right)^2}} \quad (5)$$

In the formula above, n is the number of observations. The Voung test has an asymptotic distribution as a standard normal distribution. While the positive values higher than the critical value $N_{a/2}$ (at a level of significance of a) confirm the model *j*, the negative values lower than $-N_{a/2}$ confirm the model *k*. |Voung| ≤ $N_{a/2}$ indicates that there is no significant difference between the two models.

The policies promoting quality wheat and the sale transactions in exchange commodities

Policies promoting quality wheat

The Turkish Grain Board (TGB) is responsible for operating the grain market mechanism in Turkey. The TGB monitors the domestic and foreign markets, and takes the necessary measures to ensure the price stability in the domestic market in line with the supply and demand equilibrium. The price policy may be intended both for ensuring the market equilibrium and enhancing the quality. In this framework, the TGB amended its governing regulations on the purchase and sale procedures for grains in 2010, and adopted a pricing method that is based on quality criteria. The new regulations explain in detail the minimum quality criteria for bread and durum wheat and for other grains as well as the quality methods relating to those grains. The minimum quality criteria to be applied in purchasing grains are different for the period between 2009/10 and 2016/17 and for the period following 2017/18. It is aimed to increase the minimum quality criteria in the period following 2017/18. In the purchases to be made between 2009/10 and 2016/17, pro rata discounts will be made if the hectolitre weight of the Anatolian Hard Red Wheat is below 76 kg, the ratio of broken grains is above 3%, the ratio of grains damaged by pests and wheat bugs is above 1%, the total ratio of defective grains is above 5%, the ratio of germinating and sprouting grains is above 2.5%, the ratio of other miscellaneous ingredients

is above 1%,the protein content is below 11.6%, and the humidity is above 13.5%. The TGB purchased 300 chemical analysis devices to implement the regulations, and sent them to the grain purchase centres. Thus, in all purchases made by the TGB in 2011, the intervention purchase prices were determined, which required the discount or increase in the prices of products that were found to have met the minimum quality criteria according to both the physical and chemical analyses. In the new wheat purchase system, the protein content is one of the most important criteria that determine the price. Assuming that the pest damage would degrade the protein quality, a different price was determined according to the ratio of the pest damage. The intervention purchase price was set to increase by 1–3% the price of bread wheat with a ratio of pest damage below 2% and the protein content above 12%.

Wheat sale transactions in the Polatli Commodity Exchange

The Polatli Commodity Exchange is a regional market where the grains are purchased and sold in line with the principles of free market. It has the conditions of a spot market. The products brought to be sold in the Commodity Exchange are subjected to the physical and chemical analyses in the Grain Technologies Laboratory so that they can be classified according to their quality. Grains have the highest percentage among the products traded in the Commodity Exchange. Therefore, the Polatli Exchange Market is considered to be a specialized exchange market for grains. The Anatolian Hard Red Wheat is the product for which the highest numbers of registration transactions are made.

Products brought to be sold by producers or traders are weighed on the scale for the TL 2. They are also sent to the laboratory to be assessed in terms of the quality characteristics after the homogeneous samples are taken. Within the process, the information relating to the seller and product is entered into the exchange database. The TL 23 must be paid to classify the quality characteristics of the product in the Grain Technology Laboratory. Following the physical and chemical analyses, the quality information is registered in the database, and the product is included in the products to be offered for sale. The sale transaction of the product offered for sale by auction is carried out once the seller accepts the price proposed. The Polatli Commodity Exchange takes 0.5% from the sale transactions and a maximum charge of the TL 300 for registrations (Figure 1).

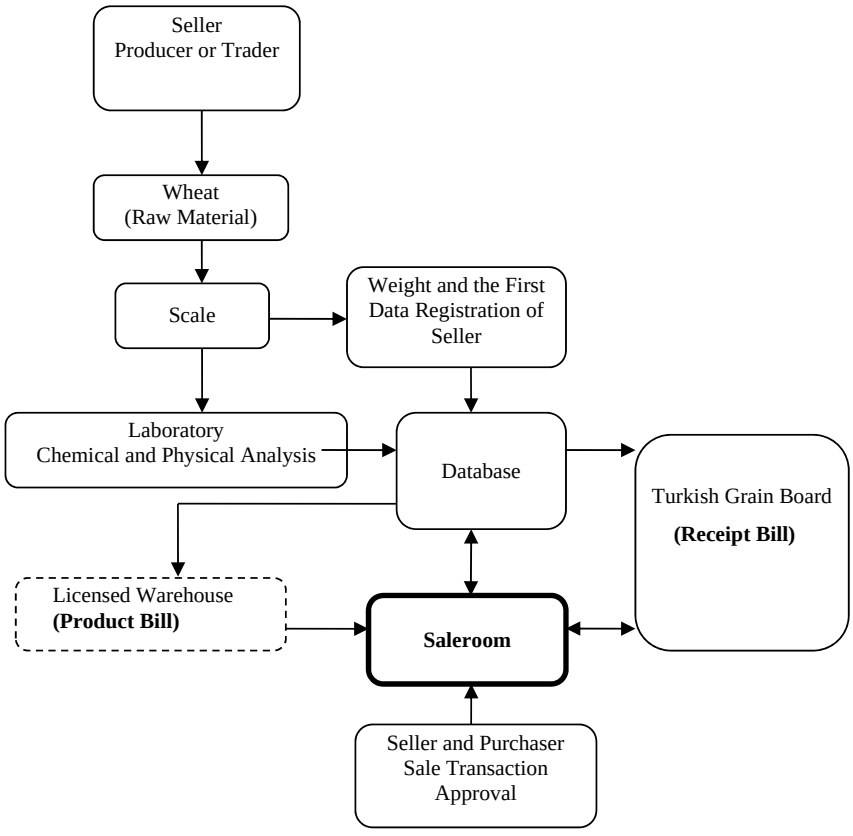

Figure 1. The Polatli Commodity Exchange wheat sale transactions

Wheat producers may be forced into selling their products in the harvest season as they are unable to store them. When the supply of wheat is in surplus in the harvest season, the prices decrease and the producers face revenue loss. The product preservation system should be improved to prevent the price instability. Aiming to establish a warehousing system for grains, the Polatli Commodity Exchange engaged in cooperation with the Turkish Grain Board. The purchase, sale and registration of the receipt bill received by wheat producers in return for their products delivered to the TGB were made tradable in the exchange. The Polatli Commodity Exchange initiated the Licensed Warehousing in 2010. In the warehouses, the products brought by producers are classified based on the results of the physical and chemical analyses conducted in the laboratory. Then, they are stored in silos. Thus, the licensed warehouses encourage the production of high quality wheat as they do not admit low quality products. Such warehouses make out the "Product Bills", which define the product, in return for the wheat delivered. As the Product Bills are sold through auction in the Exchange, they enable the high quality products to be sold at higher prices.

Quality characteristics playing role in the formation of spot prices

The wheat quality is identified in consequence of the grading carried out to determine the flour's purpose of use. Differences in the quality of wheat arise from genetic factors and environmental conditions. The impact of environmental conditions such as the climate and soil during the development period is generally higher than that of the genetic factors. It is quite hard to define the quality of wheat by a single aspect. Chemical and physical measures are used in determining the quality of wheat. The chemical measures are important in terms of meeting the characteristics statutorily required to be found in the wheat flour. They are also used to determine the characteristics required to be known to blend different flours. As to the physical measures, they are used to identify the physical characteristics required to be known in milling applications. Such measurements are made to have information on the flour yield. The price of wheat is formed based on the chemical and physical measures. Among the chemical measures, the protein content and humidity, and among physical measures, the hectolitre weight, the ratio of grains damaged by pests and wheat bugs, the ratio of foreign materials, the ratio of grains heated and burnt during drying, the ratio of other cereals and the ratio of tiny and broken grains are taken into account in the formation of the spot price in the Polatli Commodity Exchange.

Protein Content: It varies depending on the type and variety of wheat, environmental conditions and the production technique. It is one of the quality characteristics that indicate for which purpose the wheat will be able to be used. It is also one of the fundamental characteristics in terms of the production of bread and other bakery products. It is one of the most basic measures playing role in the determination of the wheat price, and it is expected to be positively related to the price. The minimum protein content should be 13% for the pasta production, 13–14% for the free bread production, 12–13% for the pan bread production, 8.5–10.5% for the biscuit production and 9–9.5% for the cake production (Unal 2003). In the data set of quality characteristics of the Anatolian Hard Red Wheat, the protein contents of the wheat sold are at least 10.5% and at most 16.3% (Table 1). 67.8% of the wheat sold is the first grade (I ≥ 12), 12.25% the second grade (12 >II ≥ 11) and 8.48% the third grade (III ≥ 10) in terms of protein content.

Humidity: It is the ratio of water contained in the wheat. Humidity is of a great importance in the storage of wheat and the preservation of its quality. Furthermore, the duration of the water absorption characteristic is prolonged during the heat treatment in the grinding of wheat. Wheat grains with a higher humidity are more inclined to be heated and mouldy, germinated and spoiled, and be to exposed to the pest attacks. When the water contents of wheat increases, its price is expected to decrease. The quality characteristics of the Anatolian Hard Red Wheat require a maximum humidity of 14.5%. In the data set, the minimum and maximum humidity ratios are 8.8% and 14.1%, respectively (Table 1).

Hectolitre Weight: It is the most basic and common measure used to determine the quality of wheat. It is the weight (in kg) of 100 litres of wheat. It is used in the wheat standards and the commercial classification. This weight varies depending on the amount of the foreign material. The Hectolitre Weight is expected to be positively correlated to the price of wheat. The Commodity Exchange divides the Anatolian Hard Red Wheat brought to be sold into three grades. The minimum and maximum hectolitre weights of different types of wheat in the data set are 74.60 and 85.70, respectively (Table 1). In terms of the hectolitre weight, 94.92% of the wheat in the data set is the first

grade (I ≥ 78), 4.24% the second grade (78 > II ≥ 76), and 0.84% the third grade (76 > III ≥ 73).

Ratio of Grains Damaged by Pests and Wheat Bugs: It is the percentage of grains damaged by pests and wheat bugs. Pest and bug damage alters the chemical and technological characteristics of wheat grains. Flour obtained from wheat damaged by pests degrades in quality, and the parameters indicating the amount and quality of gluten are affected. Thus, the ratio of grains damaged by pests and wheat bugs is expected to be negatively correlated to the price of wheat. The lowest and highest ratios of grains damaged by pests and wheat bugs in the different types of wheat contained in the data set are 0.80% and 3.5%, respectively (Table 1). 40.68% of those different types of wheat is the first grade, (I ≤ 1), 34.75% the second grade (1 < II ≤ 2) and 24.58% the third grade (2 < III ≤ 3.5).

Ratio of Foreign Material: After the grain sample is sifted through two sieves with holes of 3.55 mm and 1.0 mm, all material passing through the sieve with holes of 3.55 mm is considered to be the "foreign material". Furthermore, materials such as stone, soil, stalk or straw are the foreign material as well. The minimum and maximum ratios of the foreign material in different types of wheat contained in the data set are 0.40% and 1.90% (Table 1). In terms of the foreign material, 38.98% of the wheat is the first grade (I ≤ 0.5), 46.61% is the second grade (0.5 < II ≤ 1) and 14.41% the third grade (1 < III ≤ 2).

Ratio of Grains Heated and Burnt during Drying: Grains spontaneously heated or burnt during drying due to the exposure to extreme heat are classified as the "damaged grains". The colour of the outer surface of heated grains is between greyish brown and black, and the colour of the cross-section of the grains between yellowish grey and brownish black. Regarding different types of wheat contained in the data set, the maximum ratio of grains heated and burnt during drying is 0.05% (Table 1). 69.49% of those different types of wheat do not contain grains heated or burnt during drying. The ratio of grains heated or burnt during drying in 30.51% of different types of wheat is 0.5% or less.

Ratio of Other Cereals: This ratio covers all cereals except the species of wheat. The maximum and minimum ratios of other cereals in different types of wheat contained in the data set are 4.5% and 0.4% (Table 1). 86.44% of those different types of wheat are the first grade, which means the ratio of other cereals is 2% or less. The ratio of different types of wheat in the second and third grades in terms of such quality characteristics is 6.78%.

Ratio of Tiny and Broken Grains: It is the percentage of grains passing through a sieve with holes of 2.0 mm after the analysis sample is cleared from materials other than the grains. Furthermore, wheat grains damaged by frost are considered tiny. Grains with partially seen endosperm and grains that were damaged during the harvest and dropped their embryos are considered broken grains. The maximum and minimum ratios of tiny and broken grains in the different types of wheat contained in the data set are 6.80% and 0.90%, respectively (Table 1). In terms of the quality characteristics, 79.66% of different types of wheat is the first grade (I ≤ 3), 18.64% the second grade (3 < II ≤ 6) and 1.70% the third grade (6 < III ≤ 8).

Table 1. Descriptive statistics

Variable	Name of variable	Unit	Expected sign	Average	Max	Min	Standard deviation
P_{x_i}	Producer or Trader Sale Price	kg/TL	dependent variable	0.68	0.81	0.51	0.07
Chemical measures							
x_1	Protein	%	+	12.69	16.3	10.5	1.31
x_2	Humidity	%	–	11.09	14.1	8.80	1.2
Physical measures							
x_3	Hectolitre Weight	kg/hl	+	81.60	85.70	74.60	1.88
x_4	Grains Damaged by Pests and Wheat Bugs	%	–	1.46	3.50	0.80	0.69
x_5	Foreign Material	%	–	0.73	1.90	0.40	0.31
x_6	Grains Heated or Burnt During Drying	%	–	0.01	0.05	0.00	0.02
x_7	Other Cereals	%	–	1.22	4.50	0.40	1.08
x_8	Tiny and Broken Grains	%	–	2.42	6.80	0.90	1.07

Hedonic price model estimation

Marginal implicit values of the quality characteristics of the Anatolian Hard Red Wheat were estimated through the hedonic price model. The Box Cox transformation and the Voung test were carried out to select the functional form used to estimate the hedonic price model. The likelihood ratio tests was used to test the hypotheses that the Box Cox parameter is –1, 0, and 1. Results of the Box Cox regression do not display certainty in the selection of the best functional form to be used in the applied analysis. In order to make a selection among the alternative functional forms, it was decided to conduct the Voung test, which is very common in the hedonic price model literature. The results of the Voung test show that there is no difference between the Log-Log model and the Log-Lin and Linear models (Table 2). This Voung test fails to present certainty regarding the selection of the functional form, either. Then, the Sum of Residual Squares was made use of to eliminate the uncertainty in the selection of the functional form. Among the alternative functions, the Linear Logarithmic form with the lowest Sum of Residual Squares was selected (Table 3). As this function gives the absolute change in price in return for % change in the quality characteristics of wheat, it is suitable in terms of the interpretation (Gujarati 2004).

Table 2. Results of the Voung test

H_0:	Voung Statistic	*p*-value
Lin model is alternative to Lin-Log	20.042	0.000
Lin model is alternative to Log-Lin	–0.115	0.909
Lin model is alternative to Log-Log	24.655	0.000
Lin-Log model is alternative to Log-Lin	14.024	0.000
Lin-Log is alternative to Log-Log	23.665	0.000
Log-Lin is alternative to Lin-Log	–0.570	0.570

The Jarque-Bera asymptotic normality test was used to check whether the residuals of the hedonic price model in the Linear Logarithmic form, estimated through the use of the Least Squares Method. The hypothesis H_0 of this test assumes that the error terms are normally distributed. As the marginal probability value of the Jarque-Bera test is 0.96, the hypothesis H_0 asserting that the error terms are normally distributed cannot be rejected. The specification test of the hedonic price model was conducted through the Ramsey RESET test. At the end of the test, the *F*-statistic was found to be 0.29 ($p = 0.59$). This value suggests that the hypothesis H_0 asserting that there is no specification error in our model at a level of significance of 5% should not be rejected.

Multicollinearity is a data problem that makes it more difficult to estimate a model. In a model with more than one independent variable, some of the variables may correlate, resulting in larger variances and thus causing the problem of multicollinearity. When there is multicollinearity, the assumptions of the Least Squares Method become invalid. The variance Inflation Factor (VIF) is used to test the presence of multicollinearity. As the VIF values of the independent variables in the hedonic price model are below 5, there is no problem of multicollinearity (Studenmund 2011).

As the cross-sectional data are inclined to display heteroscedasticity, the presence of heteroscedastic error terms in the regression model was tested. For this purpose, the White's general test for heteroscedasticity was conducted. The Chi-Square value (2.644) indicates that the H_0 asserting no heteroscedasticity should be rejected at a level of significance of 1%. The model is heteroscedastic, but since the form of heteroscedasticity is unknown, the White's robust standard error methods were employed to estimate the model. Thus, against the problem of heteroscedasticity, the equations were made robust via the White estimators.

The determination coefficient $R^2 = 0.906$ indicates that the specific model and data are relatively in a

Table 3. Hypothesis results of the functional form for the hedonic model and the values of the likelihood function

Unrestricted λ value	Values of the likelihood function				LR statistic chi-square value			Result H_0:		
	$\lambda_{kısıtsız}$	λ = –1	λ = 0	λ = 1	λ = -1	λ = 0	λ = 1	λ = -1	λ = 0	λ = 1
2.778 (left)	231.571	213.179	221.522	227.444	36.78	20.10	8.25	reject	reject	reject
0.460 (right)	282.064	282.157	281.866	281.573	–0.19	0.40	0.98	accept	accept	accept
1.667 (both)	282.994	267.485	274.934	281.572	31.02	16.12	2.84	reject	reject	reject

good accord. At the same time, this value demonstrates that 91% of the changes in the price is explained by the quality characteristics and the seasonal dummy variables included in the hedonic price model.

There may be seasonal effects on the price of the Anatolian Hard Red Wheat in terms of the supply and demand equilibrium and the storage costs. Time (monthly) dummy variables were included in the hedonic model to determine the seasonal effect. Time dummy variables show different price patterns. Prices drop in the harvest months of July and August, and increase afterwards. Thus, prices depend on the time, and the change in time is important. When the new harvest starts, the producers sell their wheat at the lowest price. The seasonal price pattern was found to be significant in other months than August at a level of significance of 1%. If the price of wheat in August is compared to that in July, which is addressed as the

Table 4. Estimation results of the hedonic price model (White heteroscedasticity – consistent standard errors & covariance)

Variables (x_i)	Coefficients (β_i)	Standard error	t-statistic	Marginal probability (p)	Elasticities
x_1	0.502	0.033	15.390	0.000***	0.740
x_2	0.578	0.185	3.130	0.002***	0.852
x_3	−0.020	0.008	−2.617	0.010***	−0.029
x_4	−0.010	0.007	−1.508	0.135	−0.015
x_5	0.0001	0.002	0.052	0.959	0.0002
x_6	−0.003	0.004	−0.845	0.399	−0.005
x_7	0.031	0.043	0.731	0.467	0.046
x_8	−0.009	0.009	−0.943	0.348	−0.013
Monthly dummy variables					
D_1	0.110	0.017	6.784	0.000***	0.168
D_2	0.132	0.016	8.771	0.000***	0.195
D_3	0.109	0.015	7.386	0.000***	0.161
D_4	0.110	0.020	5.611	0.000***	0.162
D_5	0.112	0.018	6.215	0.000***	0.165
D_6	0.086	0.021	4.102	0.000***	0.126
D_8	0.023	0.014	1.682	0.096*	0.034
D_9	0.040	0.016	2.478	0.015**	0.059
D_{10}	0.047	0.014	3.474	0.001***	0.069
D_{11}	0.052	0.015	3.510	0.001***	0.077
D_{12}	0.048	0.016	2.902	0.005***	0.071
c	1.649	0.185	8.912	0.000***	2.432

	Descriptors	Test	Value	Level of significance
1.	Heteroscedasticity	F-statistic	2.644	0.00***
2.	Normality Test	Jarque-Bera χ^2	0.07	0.96
3.	Determination Coefficients	R^2 adjusted R^2	0.906 0.888	– –
4.	Ramsey RESET	$F_{(1,97)}$-statistic	0.29	0.59*
5.	Durbin-Watson Statistic	DW	2.004	
6.	Sum of Residual Squares	RSS	0.05816	

*significant at 10%, ** significant at 5%, *** significant at 1%

basic month, it varies slightly. The dummy variable representing August was found to be insignificant. The hypothesis H_0 asserting that the coefficients of all dummy variables sum up to zero was rejected at a level of significance of 1% ($F_{(11,98)}$ – statistic = 9.76 (p = 0.00)). Thus, the information that the deterministic seasonality of the price of wheat was significant was confirmed.

The coefficient of each quality characteristic of the Anatolian Hard Red Wheat, obtained by the means of the hedonic price model, expresses the implicit price of that characteristic. Al these coefficients show how the characteristics affect the final price of the Anatolian Hard Red Wheat. According to the hedonic pricing model, the price of the Anatolian Hard Red Wheat is the sum of implicit prices of its various characteristics. The heterogeneous Anatolian Hard Red Wheat possesses many combined characteristics and is sold as the sum of those characteristics. Such characteristics are important for the producers of flour and bakery products in terms of meeting the demands of end consumers.

It was found that in the hedonic price model estimated; only the protein content, the hectolitre weight and the ratio of grains damaged by pests and bugs have a significant influence on the decision of the purchasers to purchase the Anatolian Hard Red Wheat. The basic characteristic taken into account regarding the quality of wheat by purchasers in the Polatli Commodity Exchange is the protein content. The coefficient of the protein content indicates that for each increase in the protein content by 1%, the purchasers are ready to pay an extra amount of TL 0.005. This value was found to be TL 0.008/kg in a study conducted by (Ahmadi-Esfahani and Stanmore 1994). It may be said that the value of the wheat protein is below than that in the studies on the international flour market.

The hectolitre weight is affected by the plumpness, density, size, form and homogeneity of wheat grains. The hectolitre weight of small and long grains with a large cavity in the middle is low. As the hectolitre weight increases, the quality of wheat, that is the flour yield, increases. Due to this feature, it has a positive effect on the price of wheat as expected, and it was found to be statistically significant at a level of significance of 1%. As the hectolitre weight increases by 1%, the price of wheat rises by TL 0.006.

The coefficient of the pest damage has a negative sign, and it has a quite significant influence on the price of wheat. As the ratio of grains of the Anatolian Hard Red wheat damaged by pest increases by 1%, the kilogram price of wheat decreases by TL 0.0002. Since the damage by pests and wheat bugs degrades the quality of the flour obtained from wheat, it causes the spot market price to fall.

CONCLUSION

This study researches investigates the relations between the price and quality characteristics of the Anatolian Hard Red Wheat as well as the marginal implicit values of those quality characteristics in the spot market of the Polatli Commodity Exchange. Results of the hedonic price model estimated for this purpose show that the protein content, the hectolitre weight and the ratio of grains damaged by pests and wheat bugs, which are statistically significant in the determination of wheat price, have a significant influence on the flour millers' decision to purchase wheat. As the protein content and the hectolitre weight of wheat increases by 1%, the price rises by TL 0.005 and TL 0.006, respectively. As the ratio of grains damaged by pests and bugs increases by 1%, the price of wheat drops by TL 0.0002. In the case that the producers know the marginal implicit values relating to the quality characteristics of wheat in the market, they will be able to take rational decisions to maximize their profit. The marginal implicit values found in the study are expected to be important indicators for the marketers, processors and bakers. Moreover, this study will contribute to the improvement of the pricing system in the wheat market according to the quality characteristics and to the fulfilment of the flour processing industry (millers') need for the high quality wheat.

As the number of samples in the commodity exchanges, where high amounts of wheat are purchased and sold in Turkey, is too high, simple analysis methods are employed to identify several quality characteristics, and the product prices are formed accordingly. This constitutes an impediment to the production of the high quality wheat in Turkey. Therefore, the Turkish wheat market needs detailed analyses, which cover different quality characteristics of wheat and enable pricing according to the measurements of quality characteristics determining the suitability of flour for bread making in addition to the physical and chemical (only protein content and humidity) measurements. Thus, it will be possible to establish a more reliable pricing system for wheat with various characteristics. The agricultural policy makers may clear the way for the production of higher quality types of wheat

by establishing a system that grants the incentive premium according to the quality characteristics.

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