

# Hedonic Analysis of Retail Egg Prices

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The fast growth of product differentiation affects even the raw food product market and causes substantial price variations. The hedonic price technique is applied to examine raw-egg attributes because of a recent transformation from an undifferentiated to a highly differentiated market. The effects of product attributes, production methods, distribution, and product image on retail egg prices are considered. Results reveal that retail egg prices are influenced by specific product attributes including nutritional characteristics and unconventional production methods. Results provide knowledge useful in the development of marketing strategies and suggest areas for possible involvement of policymakers.

Two intriguing trends in the food market can be observed in developed economies. First, food markets are being split into smaller niches as consumer choices become highly differentiated due to income variations or socioeconomic changes. Second, a simple commodity market is gradually transformed into a highly differentiated product market in order to fulfill consumer preferences for product attributes (Barkema and Drabenstott 1995; Boehlje 1996). Food-chain actors are aware of these changes and try to develop new strategies using all available data on product differentiation.

Product-differentiation questions can be examined through various methods. The hedonic pricing approach, introduced by Rosen (1974), is recognized as one of the most appropriate. This method facilitates the analysis of the price structure of a commodity in relation to its specific attributes through the estimation of product-attribute shadow prices. Valuable information is thereby extracted for an effective product-differentiation strategy. It is generally argued that the hedonic pricing approach is suitable for substantially varied food products. Nevertheless, we assert that even in products with less variation, such as raw food products, the hedonic approach can be successfully applied.

The hedonic price approach has been applied to study various agricultural products and foods. Brorsen, Grant, and Rister (1984) studied the price

structure in the rice market in United States. Veeman (1987) and Larue (1991) also used this method to analyze product heterogeneity for wheat in the world market. Golan and Shalit (1994) examined the grape market and analyzed raw-product price structures in relation to the quality of the wines produced. Bowman and Ethridge (1992) worked with demand and supply characteristics in the cotton fiber market, and Misra and Bondurant (2000) identified the effect of cotton-seed quality attributes on product price. At the consumer level, Harris (1997) studied the value of frankfurters and Stanley and Tschirhart (1991) applied the hedonic methodology to investigate breakfast cereal demand.

The present study applies hedonic price analysis to identify attributes other than natural egg attributes that determine retail prices in the fresh egg market. The main ongoing change in of the fresh egg market is the transformation of eggs from a relatively homogeneous to a highly differentiated product. Although the egg market attracted the interest of several researchers, earlier studies did not focus on measuring the retail price structure. Roy (1971) studied shell egg prices as affected by product quantity supply and Maynard (1997) studied the effects of market conditions including industry concentration and market size on price efficiency. Schmit and Kaiser (1998) examined the egg-market integration of the six Pacific states, while Liu and Wang (2003) measured the effect of egg advertising and dietary-cholesterol concerns on demand.

The present study estimates a hedonic price model for the egg market and identifies the retail price structure of eggs by estimating the shadow prices of their attributes. The discussion of the theoretical underpinnings of the hedonic pricing technique is

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followed by a description of the model specification. Empirical findings are then presented.

### The Hedonic Model

The hedonic model is based on the assumption that products consist of sets of attributes (i.e., bundles of characteristics). Firms try to maximize profits by changing the product quantity and product attributes. Assume that each firm supplies only one set of attributes (product) per production line but the same firm may supply more products with different sets of attributes, produced from different production lines. An equilibrium is at the intersection of attributes' supply and demand functions of the product. This equilibrium facilitates understanding how sellers determine the value of the product they offer and how consumers value the product they buy. In the long-run equilibrium, a hedonic function represents boundaries: the minimum price at which attributes can be supplied and the maximum at which they will be purchased.

According to Rosen (1974), the hedonic supply (or demand) function can be expressed as

$$(1) P_i(Z) = G^i(Z_1, Z_2, \dots, Z_n, Y),$$

where  $P_i$  is the price of product  $i$  in the market and  $Z_1, Z_2, \dots, Z_n$  are product attributes.  $Y$  is an exogenous-supply cost-shift variable (or customer characteristics). In a case where there is reason to believe that no differences exist among firms (or among customers in terms of costs),  $Y$  can be omitted from the specified function. Otherwise, there is a possibility that supply (or demand) differentiation factors need to be considered (Rosen 1974; Besanko, Dranove, and Shanley 1996).

### The Empirical Model

According to Stanley and Tschirhart (1991), consumers gain utility from the services ( $S$ ) of the product attributes they buy. Let  $Z_i(Z_1, \dots, Z_n)$  be the vector of product attributes supplied by the typical retailer and  $S_j(Z_1, \dots, Z_n, Y)$  the vector of corresponding product attributes ( $j=1, \dots, m$ ). A product attribute may have a positive or negative effect on consumer utility. Attributes that have been positively or negatively evaluated in the market influence the price structure and product differentiation. Incorporating the attributes into

the hedonic function, it is possible to predict and to estimate a simple (hedonic) equation in which the price per egg depends on the summation of the marginal yields of characteristics multiplied by their respective marginal implicit prices.

We consider a retailing firm which supplies standardized eggs to the market. The eggs' attributes can be grouped in four attribute clusters: those considered relevant to consumer health and quality of life, characteristics associated with product convenience, attributes associated with purchase uncertainty, and attributes important for the image of the product in relation to consumer psychological needs (Stanley and Tschirhart 1991; Besanko, Dranove, and Shanley 1996). Features that strongly affect consumer health and quality of life are those derived from attributes such as natural product quality and production conditions. These attributes are referred to as organic aspects of the product (i.e., free from agrochemicals), which minimize consumer nutrition risks. Attributes related to product convenience are presently provided by the package size, while those relevant to purchase uncertainty can be derived from the quality systems adopted by the firm. Attributes related to product image are provided by the appearance of the product package design.

According to Rosen (1974), three preconditions must be met prior to the application of the hedonic price method. Because a large number of egg suppliers (i.e., producers, cooperatives, wholesalers, retailers) and a large number of supplied products and attribute combinations exist, all preconditions for applying hedonic pricing are met. Table 1 shows groups of attributes that may be considered product-differentiation attributes derived from relevant literature, existing regulations, and industry observations. Information in Table 1 also shows the product attributes offering consumers important benefits and the expected influence on price.

It is doubtful whether consumers can effectively evaluate all natural attributes of eggs, because many attributes cannot easily be assessed visually. Thus some natural product attributes lack the required variation and are excluded from the model. However, consumers can easily recognize attributes that are observable such as package size or are labelled on the package such as the egg size and the  $\Omega 3$  (omega-3) enrichment. Larger egg size (more quantity per package) provides more utility to consumers and is expected to have a higher shadow

**Table 1. Four Groups of Attributes Associated with Natural Egg Characteristics, Production Methods, Packaging and Quality, and Marketing.**

Clusters	Structure attribute	Provided benefits	Expected influence on price
Natural attributes	Product size ( $Z_1$ )	Health	Positive
	$\Omega 3$ enrichment ( $Z_2$ )	Health / nutrition	Positive
	Organic feeding ( $Z_3$ )	Health / quality of life	Positive
Poultry-feeding methods	Plant feeding ( $Z_4$ )	Health / quality of life	Positive
	Cereal feeding ( $Z_5$ )	Health / quality of life	Positive
	Free range ( $Z_6$ )	Health / quality of life	Positive
Packaging	Package size ( $Z_7$ )	Convenience	Negative
	Specific package ( $Z_8$ )	Image / uncertainty	Positive
	Eco-packaging ( $Z_9$ )	Quality of life	Positive
Quality-control system	Series ISO 9000 ( $Z_{10}$ )	Uncertainty	Positive
	HACCP ( $Z_{11}$ )	Uncertainty	Positive
	Individual firm quality control system ( $Z_{12}$ )	Uncertainty	Positive
Vertical integration by marketing	Producer ( $Z_{13}$ )	Supply cost	Negative
	Supermarket ( $Z_{14}$ )	Supply cost	Negative

price ( $\partial P / \partial Z_i > 0$ ) than smaller egg size. A similar effect is expected with regard to the  $\Omega 3$  enrichment.

Eggs are produced under different conditions (e.g., organic methods, plant feeding or cereal feeding), which affect the quality of the product and minimize the consumption uncertainty relevant to nutrition risks (Hunter 2000). In addition, egg production using organic feeding methods, plant or cereal feeding, and free-range feeding positively affect the environment. These methods reduce the use of agrochemicals or use less energy than do conventional methods, and consequently may (in consumer opinion) contribute to quality of life. The labeling of production method on product package, available at all retail outlets, is expected to have a positive effect on product price ( $\partial P / \partial Z_i > 0$ ,  $i = 3, 4, 5, 6$ ).

Because the use of a larger package implies economies of scale, in pricing the various package sizes the larger quantity is expected to correspond to lower the price per item. In addition, a large package is inconvenient and is expected to have a negative shadow price ( $\partial P / \partial Z_i < 0$ ). The appearance of the package (design) enhances the image of the product and reduces the purchase uncertainty (Besanko, Dranove, and Shanley 1996; Orth

2004). Ecological packaging (e.g., biodegradable) is an attribute appealing to consumers because it is consistent with the quality of life. Consequently, the package appearance is expected to positively affect product price ( $\partial P / \partial Z_i > 0$ ,  $\partial P / \partial Z_j > 0$ ).

There is an uncertainty in egg-quality assessment since consumers can judge some quality attributes (e.g., salmonella-free label) only after purchase and consumption. Firms choose to introduce quality systems—for example, a firm's own system or international systems like HACCP or ISO—to minimize consumer concerns, and they label product packages accordingly. When a firm applies a HACCP system, uncertainty reduction implies risk reduction stemming from consumption. Hence the higher the producer cost in providing attributes to consumers, the higher the equilibrium price level and the shadow price ( $\partial P / \partial Z_i > 0$ ,  $i = 10, 11, 12$ ).

A vertical integration of production and marketing processes leads to reductions in transaction, transfer, and storage costs and to economies of scale (Besanko, Dranove, and Shanley 1996; Kotler, Jain, and Maesine 2002). These cost reductions are higher in fragile and vulnerable products such as eggs. That is to say, a firm that adopts a vertical integration of production and distribution (e.g., a

farmer cooperative) or of wholesaling and retailing can reduce product prices for the identical set of attributes ( $\partial P/\partial Z_{13} < 0$ ,  $\partial P/\partial Z_{14} < 0$ ).

## Results and Discussion

Data were obtained from labels of egg packages found on the shelves of representative retail shops in the metropolitan areas of Athens and Thessaloniki, Greece, during the summer of 2004. Product prices obtained from retailers were measured in euros per egg. The package price was divided by the number of eggs per package. A total of 175 observations were gathered.

The estimation of a linear form of Equation 1 was completed using the ordinary least-squares method (OLS). The model included 14 independent variables. The variable that represents the egg size assumes values between 50 and 76 grams per egg (mean of size classes), and the variable relevant to package size ( $Z_7$ ) ranged from two to 30 eggs per package. All remaining independent variables were dummies. Variable 'Ω3 enrichment' ( $Z_2$ ) equaled 1 when the egg was enriched with Ω3 and 0 in any other case. The next four variables ( $Z_3$ – $Z_6$ ) equaled 1 when the product was organic or produced under specific feeding conditions (plant or cereal feeding, free-range) and 0 otherwise.<sup>1</sup> The variables  $Z_8$  and  $Z_9$  take the value 1 in the case of specific package design or eco-packaging and 0 in any other case. The variables  $Z_{10}$ ,  $Z_{11}$ , and  $Z_{12}$  were equal to 1 if the firm implements a quality-control system (individual, ISO 9000, HACCP) and 0 otherwise. Since, all the firms adapted both an individual or ISO 9000 quality control system in addition to HACCP, variables  $Z_{10}$ ,  $Z_{11}$ , and  $Z_{12}$  were combined into a new variable,  $Z_{15}$ . Two additional variables represented the firm's vertical integration and took the value of 1 when the marketing process was undertaken by the producer ( $Z_{13}$ ) or by the retailer ( $Z_{14}$ ), and the value of 0 in any other case.<sup>2</sup>

Table 2 shows results of the estimation. The hypothesis for homoskedasticity in error terms was rejected and a test for correction of heteroskedasticity was applied. The significant effect of each

independent variable on the price of eggs was tested with a t-statistic. The hypothesis of a coefficient not different from zero is rejected for six out of 14 variables at  $\alpha=0.01$ , whereas at  $\alpha=0.10$  one variable ( $Z_7$ ) is rejected. The remaining variables are found statistically insignificant. Insignificant coefficients of these variables suggest that consumers either do not have adequate information to incorporate the characteristics into their buying decisions or that they place no value on such attributes when they buy eggs.

The result of the F-test ( $F=56.3556$ , significant at one percent) indicates that the independent variables as a set significantly affect the dependent variable. The high value of the adjusted R-square (0.778) indicates that a high percentage of retail egg-price variability is explained by the empirical model.

The estimated coefficients can be used to estimate the respective elasticities to formulate firm priorities. Thus the larger the egg size, the higher the price expected by the seller (e.g., producer, cooperative, wholesaler). The estimated price elasticity equals 0.86 in this study, implying that if the average egg size increases 20 percent, the retail price will increase 17.2 percent. Knowledge of the price elasticity helps the producer establish the feeding regime, and helps a cooperative or a wholesaler determine the producer price.

The Ω3-enriched eggs and organically produced eggs share higher shadow prices. The shadow price is positive and significant when eggs are produced by a free-range feeding system. However, eggs labeled as produced by any other feeding system do not affect the retail prices. The indication of using a quality system does not influence egg prices.

The small-size package is found to increase the product price, as expected. When the total cost of size reduction is lower than the resultant price increase, the seller's profit margins rise. Both the producer and the wholesaler can use package size as a product-differentiation attribute. The specific design of the package positively influenced the price and can also be considered a product-differentiation attribute. The statistically significant and positive effect of the variable reflecting supermarket-controlled egg marketing ( $Z_{14}$ ) means that egg retail prices are reduced as a result of a retailer involvement in both wholesaling and distribution (i.e., vertical integration). However, reduction in egg retail prices is not observed when producers themselves are involved in the distribution.

<sup>1</sup> Plant-feeding method does not include cereals. The two variables ( $Z_4$ ,  $Z_5$ ) are not a linear combination.

<sup>2</sup> It should be noted that for variables  $Z_8$ ,  $Z_9$  and  $Z_{13}$ ,  $Z_{14}$  mutually exclusive categories do not exist.

**Table 2. Estimation Results of the Egg Price Model.**

Structure attribute	Variable	Coefficient	t-statistic
Product size	(Z <sub>1</sub> )	0.0030 <sup>a</sup>	24.9014
Ω3-enriched	(Z <sub>2</sub> )	0.1246 <sup>a</sup>	9.7801
Organic feeding	(Z <sub>3</sub> )	0.2300 <sup>a</sup>	8.8441
Plant feed	(Z <sub>4</sub> )	0.0144	1.5430
Cereal feed	(Z <sub>5</sub> )	0.100	1.1042
Free-range feeding	(Z <sub>6</sub> )	1.1138 <sup>a</sup>	5.4775
Package size	(Z <sub>7</sub> )	-0.0011 <sup>a</sup>	-1.8255
Package design	(Z <sub>8</sub> )	0.0427 <sup>b</sup>	4.4196
Eco-packaging	(Z <sub>9</sub> )	0.0110	0.5389
Quality-control system	(Z <sub>15</sub> )	0.0002	0.0280
Marketing controlled by producer	(Z <sub>13</sub> )	-0.0031	-0.3452
Marketing controlled by supermarket	(Z <sub>14</sub> )	-0.0337 <sup>a</sup>	-3.8790
R <sup>2</sup>	0.792		
Adj. R <sup>2</sup>	0.778		
F-statistic	56.356		
Number of obs.	175		

<sup>a</sup> Significant at  $\alpha=0.01$ .

<sup>b</sup> Significant at  $\alpha=0.10$ .

## Conclusion

The hedonic pricing approach was applied to examine retail egg prices in Greece. Eggs have become a highly differentiated product in recent years, and the objective was to identify the product attributes that affect egg prices. Using primary data collected for this study, the retail price was studied in relation to product attributes, production and distribution methods, and packaging.

Findings suggest that the retail price is influenced by specific natural attributes of eggs indicative of their quality. The main attributes that positively affect the retail price of eggs are egg size, Ω3 enrichment, poultry feeding system (i.e., organic and free-range feeding methods) and package appearance. By considering these attributes, suppliers of eggs—for example, a farmer or retailer—can enhance the opportunities to develop an effective marketing mix.

Findings support vertical integration in egg production and marketing, which leads to lower retail prices. Distribution through retail chains

reduces egg retail prices and weakens producer bargaining power. Under these conditions, egg producers have to make their own choices on pricing policy and marketing strategies. In order to be competitive, egg producers either have to improve marketing mix components, such as the enhancement of specific egg attributes, or collaborate in the formulation and implementation of a single price policy.

The implementation of quality systems or alternative poultry-feeding regimes do not affect prices; therefore, the market mechanism is not expected to promote such improvements. Thus additional policy measures must be implemented in order to improve the quantity and quality of information provided to consumers and product promotion through mandatory implementation of quality-assurance systems such as HACCP.

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