Staff Paper Series

Staff Paper P93-16

June 1993

ESTIMATING MARGINAL IMPLICIT PRICES FOR SELECTED QUALITY ATTRIBUTES OF HYBRID SEED CORN

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ABSTRACT

The central objective of this study was to estimate the implicit marginal prices for the following attributes of hybrid seed corn: yield, moisture content, root lodging, stalk lodging, stand survival and ear drop.

This study fills an existent gap in the application of a hedonic price technique to agricultural commodities. A hedonic price equation was constructed and estimated using characteristics data on hybrid corn varieties obtained from the Iowa State University Extension Service. Seed price data were solicited from seed companies for the same set of hybrids. In total, fifty-nine seed companies were asked for suggested retail prices for their hybrids. Forty companies responded with 1991 price information which was used in estimating the parameters of the formulated models.

Six hypotheses relating the price paid for hybrid seed corn with the performance characteristics of interest were formulated and tested. Results indicate that the prices that farmers paid for hybrid seed corn were significantly related only to (1) the moisture content and (2) the root lodging characteristics of the resulting crop. Both results were significant at the 0.005 level. Surprisingly, seed price and yield were not significantly related. More research is needed to further analyze these relationships and to analyze farmer's response to the wide range of nonprice services provided by seed companies.

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INTRODUCTION

The Economic Importance of Corn Production

In terms of volume and value of production, corn is the most important grain commodity in the United States. In 1987, 627,602 farms produced 6.725 billion bushels of corn on 58.701 million acres (Table 1). As the result of a major drought, corn production declined about 31% between 1987 and 1988. Despite the short term decline between 1987 and 1988, corn still represented about 40% of the total value of all grain crops sold and about 20% of the total value of production of all harvested cropland. By 1989, total corn production was 7.5 billion bushels, increasing to 7.9 billion bushels in 1990. While the value of U.S. corn crop was $17.7 billion in 1989, the estimated value for 1990 was put at $18 billion.

Corn serves as an important input in the production of feed, food and other industrial products. Through genetic engineering and management practices (for example, seed selection, seed bed preparation, fertilization, choice of appropriate chemicals and the technique of application, proper timing of insect and weed controls), the quality of corn grain can be influenced. Seeds, however, remain a crucial input for corn production and influence, to a great extent, the attributes exhibited by the corn grain produced. One of the most important impetuses for the growth of the corn industry has been the development and introduction of hybrid seed.

Other factors that have generally contributed to productivity gains of corn through the decades have included: increased fertilizer and pesticide use, increased mechanization, higher corn seeding rates, more efficient cultural and management practices, and the increased acreage planted to the crop (Houck and Gallagher, 1976; Lin and Davenport, 1982; Sundquist, Menz and Neumeyer, 1982, Tiegen, 1985; Vroomen and Hanthorn, 1986; and Mercier, 1990)

Although livestock feed is by far the largest domestic end use for corn grain (118.1 million metric tons during the 1990/91 year)[1], food and industrial uses have increased substantially in recent years. Aside from seed uses, the three broad categories of corn usage in the United States can be identified as: (1) Food, (2) Industrial and (3) Feed.

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[1]USDA, Economic Research Service (1990) World Agricultural Supply and Demand Estimates. WASDE-243, June 12, 1990. USDA: Washington, D.C.

Table 1: Farms Producing Corn, Acres Planted, Total Production and Yield Per Acre for Major Corn Producing Regions and States in 1990.

Region and State	Farms Producing Corn (No.)**	Corn Acres Harvested For grain ('000)	Total Production ('000 bushels)	Yield (bushels/acre)
Northeast:				
Maryland	5,608	450	53,100	118.0
New York	9,301	620	60,760	98.0
Pennsylvania	26,968	970	109,610	113.0
Southeast:				
Alabama	7,413	240	13,920	58.0
Georgia	10,561	550	37,400	68.0
S. Carolina	6,292	320	14,400	45.0
Appalachia:				
Kentucky	25,067	1,200	120,000	100.0
N. Carolina	21,000	1,070	72,760	68.0
Corn Belt:				
Illinois	66,600	10,400	1,320,800	127.0
Indiana	45,383	54,500	703,050	135.0
Iowa	83,301	12,400	1,562,400	133.0
Ohio	45,702	3,450	417,450	121.0
Missouri	25,291	1,960	205,800	105.0
Lake States:				
Michigan	25,140	2,070	238,050	113.0
Minnesota	51,355	6,150	762,600	125.0
Wisconsin	48,665	3,000	354,000	118.0
Northern and Southern Plains:				
Kansas	8,944	1,450	188,500	130.0
Nebraska	34,717	7,300	934,400	128.0
S. Dakota	19,448	3,000	234,000	78.0
Texas	9,131	1,450	130,500	90.0
Mountain and Pacific:				
Arizona	166	7	13,920	160.0
Colorado	4,295	830	128,650	155.0
California	1,076	160	25,600	160.0
U.S. Total	**627,602**	**66,952**	**7,933,068**	**119.4**

Source: USDA (1991), Agricultural Statistics, Washington, D.C: Bureau of the Census Table 41, p. 32 (1989). 1987 Census of Agriculture: Volume 1, Part 51, United States Summary and State Data, Washington, D.C.: U.S. Government Printing Office, Table 24, p. 327. **1987 figures.

Of the 8.250 billion bushels of corn produced in 1986, food, seed and industrial uses were put at 1.191 billion bushels while 4.717 billion bushels were used for feed and residual uses, with exports taking about 1.504 million bushels. In the 1990/91 crop year, of the 7.933 billion bushels of corn produced, 1.33 billion bushels went into food, seed and industrial uses, 4.85 billion bushels for feed and residual uses and 1.7 billion bushels were exported (USDA, 1991).

The United States enjoys a competitive edge over many other countries in the international seed market. Purchases by Italy, Mexico, Japan, Canada, France and the Netherlands accounted for more than 50% of all U.S. seed exports in 1986. The total value of U.S. exports of corn seed increased steadily from $55 million in 1982 to $89 million in 1985, after declining to $46 million in 1984. In 1986 the total value of U.S. seed corn exports was $77 million. In 1991, U.S. field seed corn exports to twelve leading importers (about 87% of total U.S. exports) rose to 81,337 metric tons an increase of 35% from 1990 figures. While exports to Mexico and Spain dropped, increases in exports to Canada, France, Unified Germany, Netherlands and the former USSR were more than enough to offset the declines. For the first six months of 1992, overall corn seed exports of the U.S. fell 35% despite strong increases in exports to Spain, Turkey, Canada and Japan.

Higher domestic seed stocks led to a 22% decline in U.S. seed corn imports in 1991 to 10,978 metric tons with a total value of $181 million. This represents a sharp increase from the 1990 value of $138 million (USDA, 1992). Seed imports from Canada, Chile, and Hungary showed strong increases during the same period.

Seed Use and Production Costs

Seed corn is an important input in corn production. The choice of which hybrid to plant is an important one from the farmers' perspective. However, the difficulty of not being able to save corn hybrid seeds from previous years or a previous planting season for a subsequent planting season poses a unique seed choice problem for the farmer. Table 2 shows the quantity of seeds used for corn crop production between 1981 and 1992 in the United States.

Table 3 documents the seeding rate (kernels per acre), corn plant population per acre and seed cost per acre for selected states in 1991. Seed costs are related to seeding rates, and for corn, the seeding rates vary widely across corn growing regions due to soil productivity, moisture availability and seed corn prices (Daberkow and Gill, 1988). The average seeding rate for corn in 1987 was 24,000 kernels per acre with an average seed cost of $18.30 per acre, a decline of about 4% from 1986 figures. The average seed cost per acre increased to $18.90, and $20.40 in 1988 and 1989 respectively. In 1991, however, the average seeding rate for corn increased to 24,906 kernels per acre with an average seed cost of $20.79 per acre, an increase of about 2% from 1989 (Table 3).

Table 2: Seed Use for U.S. Field Corn Crop Production, 1981 to 1992

Year	Seed Use (in '000 tons)
1981	566
1982	543
1983	406
1984	535
1985	594
1986	546
1987	437
1988	442
1989	515
1990	529
1991	540
1992	556

Source: USDA, ERS (1988), Agricultural Resources Inputs Situation and Outlook Report, AR-9, January, p. 28. 1988-1992 figures extracted from same 1992 USDA publication AR-25, February 1992, p. 30.

Table 3: Corn For Grain Seeding Rates, Total Corn Plant Population Per Acre, and Seed Cost Per Acre for Selected States for 1991

State	Seeding Rate (# of Kernels/Acre)	Plant Population/Acre	Seed Cost/Acre
Illinois	25,511	23,700	21.09
Indiana	24,027	22,400	20.26
Iowa	24,285	22,800	21.62
Michigan	24,279	21,800	20.49
Minnesota	26,602	23,900	22.98
Missouri	22,575	19,900	19.87
Nebraska	24,501	22,200	20.21
Ohio	27,397	23,200	22.51
S. Dakota	19,111	17,500	16.03
Wisconsin	25,611	23,400	19.16
Average			
1991	24,906	22,080	20.79
1990	24,700	21,040	20.50
1989	24,100	20,760	20.40

Source: USDA, ERS (1992), Agricultural Resources Inputs Situation and Outlook Report, AR-25, February, p. 31.

Seed, fertilizer, and chemicals represent the three largest categories of total variable expense incurred by farmers in all states where corn is produced. For example, in Alabama, of the $118.30 per acre in total variable costs incurred for corn grain production, $15.46 was spent for seed, $48.61 for fertilizer and $15.94 for chemicals during the 1988 year. The corresponding numbers in Iowa for the same year were $125.08 for total variable expense per planted acre with $21.14 of the total spent on seed, $43.35 on fertilizer and $23.88 on chemicals. In the United States between 1986 and 1988, an average of 16% of total variable expense on corn grain production was for seed, while 32.3% and 17% were spent on fertilizer and chemicals respectively. Seed corn prices averaged $52.60 per 80,000 kernels in 1980, $65.60 in 1986 and rose to $71.40 per 80,000 kernels in 1989. In 1990, the average seed price dropped to $69.9 per 80,000 kernels. In 1991 and 1992, the figures were $70.20 and $71.80 respectively (USDA, 1992).

Purpose of the Study

The price paid for seed corn by farmers is a measure of the farmer's willingness to pay for the attributes of the seed bought. Previous studies are lacking in modeling the relationship between the price paid for hybrid seed corn and the seeds' attributes or characteristics. Thus any information which can be provided on the marginal prices of selected attributes of seed corn should be of substantial value to both farmers and seed companies who are interested in how much seed attributes are worth.

In principle, farmer purchasers of seed corn should be interested in quality characteristics performance of seed corn at two levels: production performance in the farm field and price performance in the product market. At the farm production level, the common measure of seed corn performance is that of yield per acre or per hectare. But there are several other characteristics which interact with yield. These include plant population and plant performance including standability, harvestability and time to maturity.

In the farm product market, corn has remained an undifferentiated grain partly due to a grading system that has failed to expand the attributes used in grading. Williamson (1975: 20-21) noted that the U.S. corn grading system does not define quality broadly enough to incorporate all the physical, chemical and nutritive characteristics of corn.

If the demand for grain having those attributes increased, there would be increased and more targeted sales of the grain which would induce farmers to buy the seeds with these desirable attributes. Standards that incorporate published hybrid seed information on those attributes considered important to farmers would serve the corn industry well. A system of premiums and discounts applied to the corn industry (at both the seed and marketed grain levels) would almost certainly lead to an upgrade of corn quality, vis-a-vis its end product use.

Since there is currently no relationship between the market price of corn and quality characteristics vis-a-vis end products use of the grain, our study is limited to investigating the relationship between seed prices and quality characteristics in farm production. A hedonic modeling approach is utilized in modeling this relationship with the estimated coefficients used to estimate the marginal implicit prices for selected quality attributes of seed corn.

THEORY AND METHOD

A Review of Related Research

In recent years, much has been done in utilizing hedonic price modeling for agricultural commodities. Most of the attempts to apply the hedonic modeling technique to model price-quality relationships have focused on other agricultural commodities with little attention on corn. This modeling effort will, however, be applied to hybrid seed corn.

Our study adopts a goods characteristic approach applied by many researchers in analyzing consumer and producer behavior in the spirit of Lancaster's (1966) work on characteristics demand for consumer products. Ladd (1982) provides an excellent review of the economic theory behind the goods characteristic model. Ladd and Martin (1976); Ladd and Suvannunt (1976); Ethridge and Davis (1982); Brorsen, Grant and Rister (1984); Hyslop (1970), Lin and Mori (1991) and Menkaus and Kearl (1976), among others, have successfully extended previous theoretical models of consumer goods characteristics to agricultural products.

The fundamental principle of the goods characteristic model is that goods are demanded or supplied for the intrinsic or extrinsic (engineered) attributes that they possess. The characteristic model developed in this section follows that developed by Wilson (1984) for barley. Assuming a perfectly competitive market, and a multi-product firm with independent production functions, we can represent the production function of farmer k by equation (1):

$$q_y = G_y(q_{1y}, q_{2y}, \ldots, q_{My}) \tag{1}$$

where q_y = the yth output produced,
q_{iy} = the total amount of characteristic i used in the production of y, for all i = 1, 2, ... , M.

The farmer's profit function can be represented by equation (2) as follows:

$$\pi(.) = \sum_{y=1}^{Y} p_y * G_y(.) - \sum_{y=1}^{Y} \sum_{j=1}^{j=n} p_{zj} * z_{jy} \tag{2}$$

where p_y = price of output,
p_{zj} = price of seed input to grain production,
z_{jy} = quantity of input j used in producing y. q_{iy} is a function of input use, z_{jy}, and the quantity of characteristic i contained in each unit of z_{jy}.

With this formulation, we can fully express the production function as in equation (3):

$$q_{iy}=G_y(z_{1y},z_{2y},\ldots,z_{jy},z_{i1y},z_{i2y},\ldots,z_{iny}) \tag{3}$$

where z_{iny} is the amount of characteristic i contained in each unit of z_{jy}. This exposition allows us to rewrite equation (1) by the expression in equation (4):

$$q_y=G_y(z_{1y},z_{2y},\ldots,z_{ny},z_{i1y},z_{i2y},\ldots,z_{mny}) \tag{4}$$

Equation (2) can be maximized to get the following expression in equation (5) for p_{zj} by solving the first order necessary condition for a maximum:

$$p_{zj}=p_y*\sum_{i=1}^{M}\frac{\partial G_y(.)}{\partial q_{iy}}*\frac{\partial q_{iy}}{\partial z_{jy}} \tag{5}$$

where $\partial q_{iy}/\partial z_{jy}$ is the marginal yield of characteristic i in the production of y from input j, and $p_y*(\partial G_{iy}/\partial q_{iy})$ is the value of marginal product of characteristic i used in producing y. This can otherwise be referred to as the marginal implicit price of characteristic i or the imputed price of the ith characteristic used in the production of y. Equation (5) is the hedonic price function[2] which reflects a claim that the market price for inputs going into the production of y depends on the characteristics possessed by the inputs. The price of each input can be given as the sum of the values of the marginal yields of the input's characteristics to the product (Ladd and Martin, 1976).

Suppose that $p_y * \partial G_y(.)/\partial q_{iy} = \beta_i$ = constant, is substituted in equation (4) above, then the right-hand side of equation (5), representing the marginal yield of characteristic i from the jth input can be written as in equation (6) below:

$$p_{zj} = \sum_{i=1}^{M}\beta_i*(\partial q_{iy})/(\partial z_{jy}) \tag{6}$$

Secondly, we will suppose that $(\partial q_{iy}/\partial z_{jy}) = z_{ijy}$. This relationship represents the quantity of characteristic i contained in each unit of z_{jy}. If we assume that this is constant, then we can re-write equation (6) as:
where β_i is the marginal implicit price for characteristic i. Equation (7) implies that the price of each input used in production equals the sum of the products of the marginal implicit price

[2]A Hedonic Price Function is a behavioral expression relating the price paid for a product to the characteristics of its contents. As Ethridge (1982:23) noted, the approach is useful where "underlying products are measurable, but their impact is not necessarily obvious." See a further discussion of hedonic price methods in Palmquist (1991).

$$p_{zj}=\sum_{i=1}^{M} \beta_i * z_{ijy} \quad (7)$$

of characteristics. A regression of input prices p_{zj} on marginal yields of the inputs z_{ijy} allows the parameters, β_i, of equation (7) to be determined. After farmers have made the decision to purchase seed corn, they allocate expenditures on the basis of different characteristic contents (see discussion in Veeman, 1987). An assumption usually made in situations like this would be that the demand for characteristics is stable during subperiods investigated and that any variations in prices and quantities are generated by variations in supply rather than demand shifts. Morse (1991) and Bowman (1991) provide instructive discussions on the relevant issues and needs of the goods characteristic model in consumer demand.

Hypotheses Tested

The farm-level seed quality characteristics considered in this study are yield, moisture, stalk and root lodging, ears dropped, and standability. These inherent characteristics, in conjunction with other environmental factors under which the seeds are planted have been shown to affect the quality of the crop produced. For example, root lodging attributed to the presence of small root brace systems and a breakdown of the parenchyma cells in the brace root can also be the result of poor soil fertility or a potassium deficiency in the soil. Increasing the nitrogen and phosphorus nutrients, at low levels of potassium, significantly affects the extent of root lodging of the plant (Jugenheimer, 1976: 181-182). Disease and insects contribute more significantly than any other factor to root lodging in corn plants.

Measures of the extent of stalk lodging have included the breaking strength of stalks (crushing strength, for example) and specific gravity of corn stem sections (dry weight to green volume ratio).

The following six null hypotheses postulating the relationship between price and selected quality factors considered important were tested in this study:

H01: There is no significant relationship between the price paid for hybrid seed corn and the yield of the hybrid.

H02: There is no significant relationship between the price paid by the farmer for the hybrid seed corn and the percent of moisture content of grain at harvest.

H03: There is no significant relationship between the price paid for hybrid seed corn and the percentage of root lodging.

H04: There is no significant relationship between the price paid by the farmer for hybrid seed corn and the percent of stalk lodging.

H05: There is no significant relationship between the price paid for hybrid seed corn and percentage of ear drops.

H06: There is no significant relationship between the price paid for hybrid seed corn and the percentage of corn plants surviving.

Empirical Models Estimated

The hedonic price equation relating the price of hybrid seed corn paid by the farmer and the attributes of the seed can be represented by the following general functional form:

$$PRICE_{it}=f(MOIST_{it}, ROOTLDG_{it}, STALK_{it}, DROP_{it}, STAND_{it}, \varphi_{it}) \tag{8}$$

where,

$PRICE_{it}$	=	suggested retail price (in dollars/80,000 kernels) of hybrid seed corn i at time t,
$MOIST_{it}$	=	percent moisture content of hybrid i at time t,
$ROOTLDG_{it}$	=	percent root lodging of variety i at time t,
$STALK_{it}$	=	percent stalk lodging of variety i at time t,
$DROP_{it}$	=	percent of ear drop for variety i at time t,
$STAND_{it}$	=	percent of stands surviving for variety i at time t and,
φ_{it}	=	a random error term.

The farmer is an indispensable link between the seeds developed by the seed companies and the corn crop produced and sold on the market to grain elevators and other buyers. As profit maximizing agents, farmers seek to maximize their net returns from corn sold. We are interested in explaining the variations in hybrid seed corn prices paid by the characteristics of the hybrids.

Economic theory provides little or no guidance on the "correct" functional form for the hedonic price equation specified in a generalized functional form in equation (8). However, a form that best suits the data can be used (Halvorsen and Pollakowski, 1981; Rosen, 1974; and Bender, Gronberg and Huang, 1980; Cropper, Deck and McConnell, 1988; Parker and Zilberman, 1988).

In equation (8), price is hypothesized to be a function of moisture content, root lodging, stalk lodging, stand survival rate, and the percent of ear drop of the variety[3]. The yield of a variety, however, depends on the percent of moisture, the root and stalk lodging, the percent stand surviving, and the percent of ears dropped (Jugenheimer, 1987, Ch. 2; see also Butell and Naive, 1987, for a discussion of other factors affecting the yield of corn). The first equation to be estimated is of the form represented by MODEL 1 as follows:

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[3]The terms "hybrid" and "variety" will be used interchangeably throughout this text.

$$LPRICE_{it}=\gamma_0+\gamma_1*MOIST_{1t}+\gamma_2*ROOTLDG_{2t}+\gamma_3*STALK_{3t} + \gamma_4*DROP_{4t} + \gamma_5*STAND_{5t}+\gamma_6*VARWIDE_{6t} \tag{9}$$

The above formulation omits LYIELD as one of the independent variables. It is reasonable to expect yield to be a function of all the other independent variables of equation (9), and hence the relationship of equation (10) can be written as MODEL 2 below:

$$LYIELD_{it} = \beta_0+\beta_1*MOIST_{it}+\beta_2*ROOTLDG_{it} +\beta_3*STALK_{it} +\beta_4*STAND_{it}+\beta_5*DROP_{it}+\sum_{j=6}^{j=11} \beta_j*REG_{jt} \tag{10}$$

Including the predicted yield, LYIELDHAT, in the price-characteristic equation allows one to investigate the relationship between price and the other variables, particularly LYIELD, of the model. It also ensures that the estimated coefficients are unbiased and the estimators are the most efficient. The predicted yield variable is computed as: $LYIELD_{predicted}$ = LYIELD - RESIDUALS. The variable, LYIELDHAT, is used to represent predicted yield in all regressions reported. The residuals are obtained from the first estimation where LYIELD is regressed on the other variables in the model. The equation with LYIELDHAT as a variable can be written as MODEL 3:

$$LPRICE_{it}=\gamma_0+\gamma_1*LYIELDHAT_{it}+\gamma_2*MOIST_{2t}+\gamma_3*ROOTLDG_{3t} +\gamma_4*STALK_{4t}+\gamma_5*DROP_{5t}+\gamma_6*STAND_{6t}+\gamma_7*VARWIDE_{7t} \tag{11}$$

DATA AND ANALYSIS

Introduction

A hedonic price model reveals useful information regarding the value of the attributes of a commodity. Even though the hedonic approach has been well developed for non-agricultural products such as environmental amenity resources (Harrison and Rubinfeld, 1978; Murdock, 1988, Nelson, 1978;) housing and other consumer goods (Lerman and Kern, 1983), its extension to agricultural products is fairly new. Hedonic price models can be useful in designing commodity standards that incorporate useful and generally acknowledged characteristics of the commodity.

By assessing the marginal contributions of embodied characteristics, commodity standards formulation processes would reward the most valued characteristics. This leads to an efficient pricing system.

Data Sources

Data on yield, moisture content, stalk and root lodging, ear drop, percent of stand surviving of the hybrid seed corn planted by Iowa farmers from seven districts were obtained from Iowa State University Extension Service. The information on the agronomic characteristics listed above was extracted from various issues of Iowa State University publication, Iowa Corn Yield Test Report. The Iowa counties in the seven corn growing districts used for the present study are provided in Figure 1.

A questionnaire for information on recommended retail price of selected hybrids was sent to seed companies identified in the Test Reports for information on recommended retail price of their hybrids. Forty seed companies agreed to participate in the survey by returning the questionnaire sent to them giving a response rate of 74.0% (excluding undeliverable questionnaires). Special codes assigned to each brand name and variety of hybrid seed corn were used to organize the agronomic data for the hybrid seeds for regions 1 through 7 of the study area. Agronomic data for any varieties reported in more than one region were considered separate observations.

Description of Data

The data for hybrid seed corn price, yield, moisture content, stand percent, stalk and root lodging, and percent dropped ears for the varieties collected for this study were organized by the regions identified in Figure 1.

Producers of seed corn and Iowa State University entered their varieties in the corn yield tests organized by the University. Each participant is allowed a maximum of six paid entries per district. Hybrids are machine-planted at a rate of between 25,500 to 28,000 kernels per acre at each location. Maturity of the varieties entered ranged from early- to full-season. Samples of corn were collected from each field in each district and the numbers used for this study represent the averages of the four replicated plots in the field under consideration.

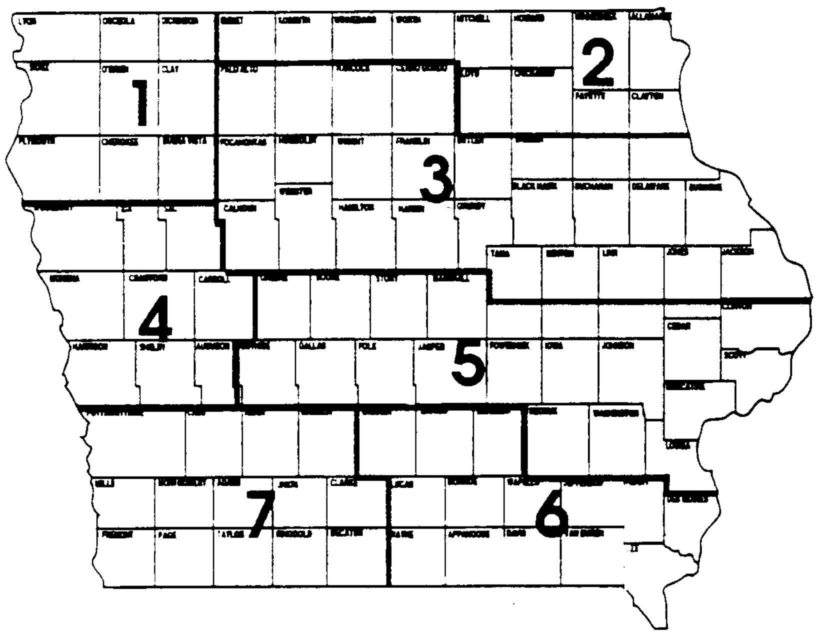
Considering all hybrids regardless of the region, the mean value of yield was 138.44 bushels per acre. The lowest recorded yield value was 91.0 bushels per acre while the highest recorded value was 180.0.

The average price in dollars per 80,000 kernels of hybrid seed corn varied from a low of $68.60 for region 3 to a high of $71.80 for region 5 (Table 4). The average price for all regions was $70.17. The lowest recorded price was $40.00 dollars per 80,000 kernels while the highest observed was $115.00 per 80,000 kernels (Table 5).

The mean values for moisture content, percentage stand surviving, stalk and root lodging for the seven regions of this study were 18.59%, 91.19%, 2.47%, and 0.71%

FIGURE 1

Counties of the Seven Iowa Corn Growing Districts



Source: Iowa State University Extension Service (1991), Iowa Yield Test Report, 1991. Ames, Iowa State University.

Table 4: Mean Values of Yield, Moisture, Stand, Stalk and Root Lodging, Ear Drop, and Price for Hybrid Seed Corn Varieties by Region

Study Region	N	Yield	Moisture (%)	Stands Surviving (%)	Stalk Lodging (%)	Ear Drop (%)	Root Lodging (%)	Price
1	60	119.817	17.0	91.1	4.2	0.40	3.70	69.6
2	53	146.887	19.1	90.2	2.1	0.03	0.01	71.3
3	83	145.108	20.0	91.3	1.3	0.19	0.04	68.6
4	68	133.779	21.2	91.1	2.7	0.28	0.01	70.5
5	79	151.557	16.6	92.2	2.8	0.27	1.10	71.8
6	63	126.079	17.5	91.4	1.6	0.13	0.06	70.5
7	53	141.736	18.4	90.6	2.8	0.09	0.01	68.8

N = total number of data points
Price in $ per 80,000 kernels; Yield in bushels per acre

Table 5: Mean Values of Yield, Moisture, Stand, Stalk and Root Lodging, Ear Drop, and Price for Hybrid See Corn Varieties Used for All Districts*

Variable	Mean Value	Minimum Value	Maximum Value
YIELD (bushels/acre)	138.44	91.00	180.00
MOISTURE (%)	18.59	14.50	24.10
STANDS SURVIVING (%)	91.19	82.00	98.00
STALK LODGING (%)	2.47	0.00	17.00
ROOT LODGING (%)	0.71	0.00	14.00
EAR DROP (%)	0.21	0.00	4.00
PRICE ($/80,000 kernels)	70.17	40.00	115.00

N = 460, the number of entries used for the study.
*Mean Values based on all 7 corn growing districts.

respectively. On the average, for all the varieties considered in this study, 0.21% of ears were dropped.

Analysis

Estimates of the marginal implicit prices were made by using the Regression Analyzing using Time Series computer program. The following section provides descriptive statistics on the data used for the present analysis.

The pair-wise correlations between the variables used in this study were "reasonably" low. The signs of the correlations were as expected. Price, for example, shows negative correlations with moisture content, root and stalk lodging and percent of ears dropped. The positive correlation between percent of stands surviving and the yield is as to be expected. Yield is also found to be positively correlated with price, even though the relationship is an extremely weak one (r = 0.02). Yield was negatively correlated (r = -0.29) with the percentage of plants that root lodged. Other negative relationships obtained were those between yield and both stalk lodging and percent of ears dropped (r = -0.24, and -0.15) respectively. Nothing important, in a statistical sense, however, is revealed by the bivariate relationship as could be apparent in multivariate relationships. Table 6 below displays the simple correlations between the variables used in the study:

Table 6: Correlation Coefficient Matrix of Yield, Moisture, Stand, Stalk and Root Lodging, Ear drop and Price for Hybrid Seed Corn Used for All Districts

VARIABLE	LPRICE	LYIELD	MOIST	ROOT	STALK	DROP	STAND
LPRICE	1 .000						
LYIELD	0.019	1.000					
MOIST	-0.126	0.220	1.000				
ROOT	-0.096	-0.287	-0.278	1.000			
STALK	-0.004	-0.243	-0.168	0.318	1.000		
DROP	-0.021	-0.147	-0.050	0.060	0.202	1.000	
STAND	0.063	0.146	-0.112	0.005	-0.087	-0.046	1.000

The following definitions of variables will be adopted for the remainder of the text:

$YIELD_{it}$	=	the yield of variety i at time t, measured in number of bushels per acre,
$LYIELD_{it}$	=	the logarithm of YIELD for variety i, at time t,
$MOIST_{it}$	=	the percentage of moisture contained in variety i at time t, measured in %,
$ROOTLDG_{it}$	=	the percentage of roots lodging in variety i at time t, measured in %,
$STALK_{it}$	=	the stalk lodging of the variety measured in %,
$DROP_{it}$	=	the percentage of ears dropped for variety i, at time t, measured in %,
$STAND_{it}$	=	the percentage of variety i stands surviving at time t, measured in %,
$PRICE_{it}$	=	the price paid for seed variety i at time t, measured in dollars per 80,000 kernels,
$LPRICE_{it}$	=	the logarithm of PRICE of variety i at time t,
REG_{i}	=	regional dummy variable for regions i=1,...7 of the present study,
$VARWIDE_{i}$	=	an indicator of how widely grown a given variety is. The variable VARWIDE is a (0,1) dummy variable created to identify the varieties that were identified as widely grown or not widely grown. Widely grown varieties were those varieties grown on the most number of acres for a given region. If a particular variety is considered widely grown, then the variable, VARWIDE, takes on a value of 1 and 0 otherwise.

The estimates of the parameters of the specified equations are presented in Tables 7, 8 and 9. A discussion of the estimates are provided in the section on the interpretation of results.

Interpretation of Results

The first hypothesis investigated in this study is that there is no significant relationship between the price paid for hybrid seed corn and the yield of the hybrid. It was estimated that a 1% increase in the yield in bushels per acre of the corn hybrid would lead to a 0.015% increase in the price per 80,000 kernels of the hybrid seed corn (Table 9). The coefficient estimated here represents the price elasticity of yield. The t-statistic value of 0.176 indicates that the result is not significantly different from zero. This leads us to accept the null hypothesis that there does not exist a significant relationship between the price of hybrid seed corn and the yield of the hybrid.

The second hypothesis tested revealed that there is a very small but significant relationship between the price paid for hybrid seed corn and the moisture content of the variety. Increasing the moisture content of hybrid seed corn by 1% decreases the price of the variety by $0.04 per 80,000 kernels (Table 9). This relationship was statistically significant at the 0.001 level (t-value = 3.02) leading to a rejection of the second hypothesis of no relationship between price and moisture content. One would have suspected that this relationship would be positive if one hypothesized that a higher moisture corn would be higher yielding and consequently higher priced. Maturity of corn is determined by its percentage content of moisture (or dry matter) at the time of harvest. Other measures of

Table 7: Results of Ordinary Least Squares (OLS) Estimates of the β Coefficients of Equation 12

Dependent Variable: Log YIELD ($LYIELD_{it}$)

Variable	β Coefficients (t-statistics)
CONSTANT	4.100 (34.967)*
MOIST	0.021 (9.047)*
ROOTLDG	-0.003 (-1.523)*
STALK	-0.006 (-3.030)*
STAND	0.005 (4.583)*
DROP	-0.012 (-2.034)*
REG1	-0.121 (-8.326)*
REG2	0.020 (1.683)**
REG3	-0.020 (-1.731)**
REG4	-0.117 (-9.067)*
REG5	0.101 (8.386)*
REG6	-0.110 (-9.386)*
R^2	0.675
F(11,447)	33.215*
Sum of Squared Residuals	1.645

*significant at $p \leq 0.005$.
**significant at $p \leq 0.100$.

Table 8: Results of Ordinary Least Squares Estimation of the γ Coefficients of Equation 11

Dependent Variable: Log Price (LPRICE)

Variable	γ Coefficients (t-statistics)
CONSTANT	4.409*
	(17.07)
MOIST	-0.010**
	(-3.046)
ROOTLDG	-0.012**
	(-3.324)
STALK	0.003
	(0.773)
DROP	-0.002
	(-0.147)
STAND	0.000
	(0.004)
VARWIDE	0.141*
	(7.903)
R^2	0.154
Sum of Squared Residuals	8.818
F(6,452)	13.758*

* Significant at $p \leq 0.001$.
** Significant at $p \leq 0.005$.

Table 9: Ordinary Least Squares Estimation of Equation 13

Dependent Variable: Log Price (LPRICE)

Variable	γ Coefficients (t-statistics)
CONSTANT	4.345*
	(9.722)
LYIELDHAT	0.0153
	(0.176)
MOIST	-0.010**
	(-3.017)
ROOTLDG	-0.012**
	(-3.087)
STALK	0.003
	(0.791)
DROP	-0.002
	(-0.122)
STAND	-0.000
	(0.032)
VARWIDE	0.141*
	(7.886)
R^2	0.154
Sum of Squared Residuals	8.818
F(7,452)	11.772*

*Significant at $p \leq 0.001$.
**Significant at $p \leq 0.005$.

maturity commonly used include days from planting to maturity, growing degree days (GDD)[4], and days from planting or emergence to midsilking or midtasseling, for example. Maturity ratings using GDD vary widely due to the influence of temperature, length of days and growing season, rainfall rate, date of planting and soil fertility. Because of these varied influences, interpreting the stage of maturity is difficult. The number of growing days is an important factor to be considered in choosing what hybrid to plant. Farmers can select a short season hybrid to capture the full benefits of a relatively early maturity hybrid or select a full-season hybrid seed suitable for a longer growing season. This result would seem to suggest that the producers of seed corn may be assigning some premium on seed corn depending on the expected moisture content of resulting crop. Evidence exists to suggest why the moisture content of corn grain is quite an important one. See, for example, Christensen (1975) for a discussion of the impact of excessive moisture in corn grain.

Next, the hypothesis on the relationship between the root lodging of the hybrid seed corn and the price of the seed corn was investigated. The analysis shows a very small but, statistically significant relationship. By increasing the amount of root lodging in the hybrid seed corn by 1%, there is a $0.04 reduction in the price of the hybrid variety. The hypothesis of no significant relationship between price of hybrid seed and root lodging is rejected at $p \leq 0.002$.

The analysis indicates no significant relationship between the percentage of stalk lodging and the price of the hybrid seed corn. In addition to being insignificant, the estimated STALK coefficient exhibits the wrong sign from that expected.

The fifth hypothesis of interest in this study is that there is no significant relationship between the price of hybrid seed corn and the percentage of ear drop of the hybrid. Based on our estimates, we accept the null hypothesis that there does not exist a significant relationship between price charged for the hybrid seed corn and the percent of ears dropped.

The percentage of corn plants surviving does not have any significant relationship with the price charged for the hybrid. There is, however, a very significant relationship between the percent of stand of a variety surviving and the yield of the variety.

Although not mentioned as one of the six hypotheses to be tested, we expected that the most widely grown varieties would have a significant relationship with the price charged for the seed. The seed companies can ride on the wide acceptability of hybrids that are so

[4]Growing Degree Days, GDD = (maximum daily temperature + minimum daily temperature)/2 - 50. Actual maximum daily temperature cannot exceed 86^{o}F and actual minimum daily temperature cannot fall below 50^{o}F. These numbers are substituted for actual maximum and minimum temperatures outside of these limits (Jugenheimer, 1976, p. 172).

classified and charge higher prices for them. The coefficients of the VARWIDE variable (Table 9) indicated that the widely grown varieties command a $0.60 higher price per 80,000 kernels than the not-widely grown varieties. The t-statistic of 7.886 showed a highly significant relationship at the $p \leq 0.001$ level. The marginal price of the characteristics that have significant relationships to the the price charged for the seeds are presented in Table 10.

Table 10: Calculated Marginal Implicit Prices of Identified Corn Attributes

(1) Hybrid Characteristic	(2) Characteristic Coefficient (Table 9)	(3) Marginal Price = [∂LPRICE/∂CHARACTERISTIC] in $/80,000 kernels
Moisture	-0.01	-0.04
Root Lodging	-0.01	-0.05
Brand Acceptance	0.14	0.60

Mean Value of the dependent variable, LPRICE = 4.24.
The negative numbers show by how much price received for the hybrid seed corn decreases with a 1% increase in the characteristic listed. Similarly, positive numbers show by how much hybrid seed price increases with a 1% increase in the corresponding characteristic.

The characteristics of the seed corn identified for this study are listed in column (1) of Table 10 while column (2) lists the coefficients of the characteristics estimated equation 13 and displayed in Table 9. Brand acceptance indicates whether the variety is widely grown or not. Since the market for hybrid seed corn, relatively speaking, is a small one, and since only very few of the seed companies have a significant share of the market, then one is interested in how widely grown a variety is. The dummy variable, VARWIDE, is a (0,1) variable used to represent brand acceptance in the models used in this study.

The marginal price of a characteristic, defined as the ratio of the change in hybrid price to the change in the characteristic under consideration multiplied by the average value of the dependent variable, LPRICE. The marginal prices of root lodging, moisture content, of the varieties used in the study are, respectively, -$0.05 and -$0.04 per 80,000 kernels of the hybrid seed bought (Table 10). Brand acceptance showed the biggest marginal contribution to overall price with an estimated value of $0.60 per 80,000 kernels of the seed. This result is not surprising given the fact that seed companies can carry out effective advertising campaigns using farmers who are willing to tell other farmers how much trust they have in the seed of any particular company.

Yield variability of selected hybrids was posited as one of the variables that can be used to explain the differences in the price of the hybrid. Including this variable could improve the percentage of price variability explained by the variables included in equation 13. Farmers would be expected to pay a higher price for a hybrid with low variability as opposed to hybrids with high variability. With this in mind, it is then possible to model the price relationship with yield variability included as a variable. Yield variability, across the different hybrids, was computed as the coefficient of yield variation and designated as:

$$CV_{yield} = \frac{SD_{yield}}{MY} \tag{12}$$

where CV = coefficient of yield variation for each variety, MY = Mean Yield for each variety, and SD = Standard Deviation.

Note: SD = $\sqrt{[\{((\Sigma^{i=N}_{i=1} YIELD_i^2)/N) - MY_i^2\}]}$.

The inclusion of this variable in equation 13 failed to yield any significantly different results from that obtained earlier. The results of this regression are not reported.

CONCLUSIONS, STUDY LIMITATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

Summary and Conclusions

This study is an application of the hedonic price modeling technique to value quality characteristics of hybrid seed corn. Data are used from seed companies located in the Corn Belt and Great Plains regions of the United States. The Iowa State University data on planted corn hybrid characteristics including yield, moisture content, root and stalk lodging, stand survival rate, and percentage of dropped ears were collected for each hybrid planted in Iowa's seven corn growing districts. Forty seed companies provided the price data needed to run the regression analysis.

The findings of the study provide insight into the attributes of seed corn that are significantly related to the price of the seed used. Of the six null hypotheses relating the price charged for hybrid seed corn and the characteristics mentioned earlier, four were accepted and two rejected. While prices charged for hybrid seed corn by the seed companies were significantly related to moisture content and the root lodging characteristics of the hybrids, there were no statistically significant relationships between price and the yield, stalk lodging, dropped ears and stand survival rate characteristics of the hybrid seeds.

The most surprising result obtained from the present study is that of no significant relationship between price and the yield attributes of individual hybrids. This finding should be of interest to both farmers and seed companies and suggests that farmers must be purchasing seeds for reasons other than simply yield expectations. The significance in this study of a variable measuring the prevalence with which individual hybrids were grown suggests that farmers probably respond in their decisions to such non-price factors as advertisements of the seed companies, technical support services offered, and/or brand loyalty (sometimes translatable into a measure of supply reliability). The role of seed company agronomic support for the farmer could be a proxy for "brand loyalty" which could be a significant factor for farmers in their decision on which hybrids to plant. Further research to account for this loyalty should improve the relationship among the variables used and improve the R^2 from that obtained in the present study.

Limitations of the Study

As with any study, limitations ensure that a generalized statement on implications will be modest. There is one important limitation of this study: the use of company-recommended retail prices as a proxy for the price that the farmers pay for the hybrid seed corn. Recommended prices may represent poorly the actual prices charged to farmers. Price discounting of seed to farmers is known to occur in some instances. Data availability, however, does not permit a complete documentation of such discounts. Four of the seed companies surveyed acknowledged that they offer some quantity discounts to the farmers who buy from them. Two of the companies offered an early purchase/early pay price discounts to farmers while yet another provided a farmer-price discount schedule that was quite detailed and elaborate. While the volume discounts varied from a low of 5% to a high of 16% of the retail price, the early payment discount varied from 3% to 12%.

Suggestions for Further Research

This study had been an effort at developing and estimating a farmer hedonic price function for hybrid seed corn. Retail prices listed by the seed companies were taken as a proxy measure of what the farmers pay for their hybrid seeds.

First of all, by using this retail price, the study does not consider any measurable impacts of volume discounts that farmers might enjoy from their local dealers. It is the assumption of this study that such discounts will not have significant impacts to alter the obtained results. But study that incorporates farmer discounts would expand the number of variables used in estimation and might significantly improve the results.

The lack of a uniform set of attributes considered important by a majority of the consumers is, perhaps, one of the biggest handicaps to hedonic price modeling. Uniformity of characteristics used in defining the product would, however, be more relevant in the product output market than in the seed corn market. Farmers are aware of the costs of the seed inputs into the production of grain and would be quite cognizant of the specific seed attributes that will guarantee a consistent grain harvest. While researchers generally observe only transactions prices, agricultural commodity buyers and sellers have explicit and more defined values of characteristics--a situation which may be quite different from buyers and sellers of most other commodities (see discussion in Bowman, 1991).

BIBLIOGRAPHY

Bender, B., T. J. Gronberg and H. Huang. 1980. "Choice of Functional Forms and Demand for Air Quality." Review of Economic Statistics 62:638-643.

Bowman, Kenneth R. 1991. "Hedonic Studies on Agricultural Commodities." In Proceedings of An American Agricultural Economics Association Symposium on Hedonic/Characteristics Price Analysis in Agricultural Economics: Progress, Issues and Needs. College of Agricultural Sciences Publication No. T-1-347, Texas Tech University.

Brorsen, B. W., W. R. Grant and M. E. Rister. 1984. "A Hedonic Price Model for Rough Rice Bid/Acceptance Markets." American Journal of Agricultural Economics 66(2):156-163.

Butell, R. and J. J. Naive. 1978. "Factors Affecting Corn Yields." Feed Outlook and Situation. Bulletin FdS-269, May, pp. 14-16. Economics, Statistics and Cooperative Service, USDA.

Christensen, C. M. 1975. "Fungi and Grain Quality." In Corn Quality in World Markets, ed. Lowell D. Hill, 65-73. Danville, Illinois: The Interstate Printers and Publishers.

Cropper, M. L., L. B. Deck, and K. E. McConnell. 1988. "On the Choice of Functional Form For Hedonic Price Functions." Review of Economics and Statistics 70:668-675.

Daberkow, Stan and Mohiner Gill. 1988. "Quantifying the Relationship Between Commodity Prices and Seed Prices." Agricultural Resources Inputs Situation and Outlook Report, AR-11, July, pp. 22-26. ERS, USDA.

Ekanem, Enefiok P. 1992. Farmer Preference for Seed Corn: Estimating a Hedonic Price Model for Special Quality Attributes of Hybrid Seed Corn. Unpublished Ph.D. Dissertation, University of Minnesota, December.

Ethridge, D. E. and B. Davis. 1982. "Hedonic Price Estimation for Commodities: An Application to Cotton." Western Journal of Agricultural Economics 7(2):293-300.

Halvorsen, R. and H. O. Pollakowski. 1981. "Choice of Functional Form for Hedonic Price Equations." Journal of Urban Economics 10:37-49.

Harrison, D. Jr. and D. L. Rubinfeld. 1978. "Hedonic Housing Prices and the Demand for Clean Air." Journal of Environmental Economics and Management 5:81-102.

Houck, J. P. and P. W. Gallagher. 1976. "The Price Responsiveness of US Corn Yields." American Journal of Agricultural Economics 58(4):731-734.

Hyslop, J. D. 1970. Price-Quality Relationship in Spring Wheat. Technical Bulletin 267. Agricultural Experiment Station, University of Minnesota, St. Paul, Minnesota.

Jordan, Jeffery L., R. L. Shewfelt, S. E. Prussia and W. C. Hurst. 1985. "Estimating Implicit Marginal Prices of Quality Characteristics of Tomatoes." Southern Journal of Agricultural Economics 17(2):139-146.

Judge, George G., R. Carter Hill, William E. Griffiths, Helmut Lutkepohl and Tsoung-Chao Lee. 1988. Introduction to the Theory of Econometrics, 2nd Edition. New York: John Wiley and Sons.

Jugenheimer, Robert W. 1976. Corn Improvement, Seed Production and Uses. New York: John Wiley and Sons.

Ladd, George W. and Marvin B. Martin. 1976. "Prices and Demands for Input Characteristics." American Journal of Agricultural Economics 58(1):21-30.

Ladd, George W. 1982. "Survey of Promising Developments in Demand Analysis: Economics of Product Characteristics." In New Directions in Econometric Modeling and Forecasting in U.S. Agriculture, ed. Gordon C. Rausser, Chap. 2. New York: Elsevier Science Publishing.

Ladd, George W. and Veraphol Suvannunt. 1976. "A Model of Consumer Goods Characteristics." American Journal of Agricultural Economics 58(3):504-510.

Lancaster, Kelvin J. 1966. "The New Approach to Consumer Theory." Journal of Political Economy 74(2):132-157.

Lerman, Steven R. and Clifford R. Kern. 1983. "Hedonic Theory, Bid Rents, and Willingness-to-Pay: Some Extensions of Ellickson's Results." Journal of Urban Economics 13(3):358-363.

Lin, W. and G. Davenport. 1982. "Analysis of Factors Affecting Corn Yields: Projection to 1985." Feed Outlook and Situation Report. Bulletin FdS-285, May, pp. 9-14. ERS, USDA.

Lin, Biing-Hwan and Hiroshi Mori. 1991. "Implicit Values of Beef Carcass Characteristics in Japan: Implications for the U.S. Beef Export Industry." Agribusiness 7(2):101-114.

Menkaus, D. J. and W. G. Kearl. 1976. "Influence of Breed, Size, Lot Size and Weight on Feeder Cattle Prices." Journal of Animal Science 42(6):1389-1396.

Mercier, Stephanie. 1990. "Corn." In U.S. Feed Grains: Background for 1990 Farm Legislation, ed. Linwood Hoffman. Washington, D.C.: ERS, USDA.

Mercier, Stephanie. 1989. Corn: Background for 1990 Farm Legislation. Washington, D.C.: USDA-ERS.

Morse, Steve. 1991. "Characteristics Models and Analysis of Consumer Demand." In Proceedings of An American Agricultural Economics Association Symposium on

Hedonic/Characteristics Price Analysis in Agricultural Economics: Progress, Issues and Needs. College of Agricultural Sciences Publication No. T-1-347, Texas Tech. University.

Murdoch, J. C. and M. A. Thayer. 1988. "Hedonic Pricing Estimation of Variable Urban Air Quality." Journal of Environmental Economics and Management 15:143-146.

Nelson, J. P. 1978. "Residential Choice, Hedonic Prices, and the Demand for Urban Air Quality." Journal of Urban Economics 5:357-369.

Parker, Douglas D. and David Zilberman. 1989. Price Transmission Across Marketing Levels in a Hedonic Framework. Working Paper No. 515, Department of Agricultural and Resource Economics, University of California-Berkeley and California Agricultural Experiment Station.

Rosen, Sherwin. 1974. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." Journal of Political Economy 82:34-55.

Sundquist, W. B., K. M. Menz and C. F. Neumeyer. 1982. A Technological Assessment of Commercial Corn Production in The United States. Agricultural Experiment Station Bulletin SB-546, University of Minnesota, St. Paul, MN.

Teigen, L. 1985. "Fertilizer Use and Weather Effects on Corn and Soybean Yields." Feed Outlook and Situation Report. Bulletin FdS-296, May pp. 15-20. ERS, USDA.

USDA. 1989. Agricultural Statistics. Washington, D.C.: U.S. Government Printing Office. Table 41, p. 32.

Veeman, M. M. 1987. "Hedonic Price Functions for Wheat in the World Market: Implications for Canadian Wheat Export Strategy." Canadian Journal of Agricultural Economics 35(3):535-551.

Vroomen, Harry and Michael Hanthorn. 1986. "1986-88 Corn Yield Projections for the 10 major Producing States." Feed Outlook and Situation Yearbook. Bulletin FdS-301, November, pp. 15-21. ERS, USDA.

Williamson, J. L. 1975. "Nutritional Requirements of Livestock as Related to Corn Quality. In Corn Quality in World Markets, ed. Lowell D. Hill, 17-21. Danville, Illinois: The Interstate Printers and Publishers.

Wilson, W. W. 1984. "Hedonic Prices in the Malting Barley Market." Western Journal of Agricultural Economics 9(1):29-40.