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Rice Quality Factors: Implications for Management Decisions

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PREFACE

This research is an extension of research reported in Texas Agricultural Experiment Station Progress Report 4202 (Brorsen et al. 1984). Additional markets and years of data have been analyzed. Data from bid/acceptance markets in the western Texas Rice Belt are augmented by American Rice, Incorporated data from throughout the Texas Rice Belt. Analysis of the cooperative data is limited to identifying the different levels of rice quality attributes.

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Rice Quality Factors: Implications for Management Decisions

INTRODUCTION

The quality attributes of a given lot of rice affect the value. Many quality attributes are related to management practices, e.g., insect damage, weed seeds, red rice. Producers need to know the value of these quality attributes when making economic management decisions and in deciding whether or not to accept an offered price. Researchers could also benefit from this information by knowing where to concentrate research efforts. A 1984 Texas Agricultural Experiment Station progress report (Brorsen et al. 1984) indicated damage caused by rice stink bugs (peck) was a major cause of price discounts in three bid/acceptance markets in the Texas Rice Belt, suggesting a need for further research on stink bug control. This paper includes data from additional markets and years to verify these findings.

This paper analyzes quality differentials for rough rice prices observed in bid/acceptance markets on the western side of the Texas Rice Belt (i.e., west of Houston). The basic economic question investigated relates to the magnitude of discounts or premiums associated with differences in quality as implied by historical rice market data. Implications for production-related decisions are also developed. Cooperative sales data are used to relate the levels and frequencies of occurrence for the respective quality attributes within each county comprising the Texas Rice Belt.

DATA

United States rough rice is marketed through contracts with mills, bid/acceptance markets, negotiated sales, and cooperative mills on a pooled basis. Six cooperative mills handle over one-half of U.S. rice production (Mullins et al. 1981). Bid/acceptance markets are the second most important marketing channel in Louisiana and Texas, accounting for about one-third of the rough rice marketed annually (Mullins et al. 1981).

Milling of rough rice produces whole kernels and several byproducts: brokens, brewers, bran, millfeed, and hulls. Whole kernels (e.g., head rice yield) are the most important in terms of revenue. The value of rough rice should be directly related to its expected milling outturn, quality characteristics, and the general level of rice prices (i.e., supply/demand situation). Among the quality factors that grades are intended to measure are red rice, weed seeds, damaged kernels (including peck), off-color, chalk, and off-types of rice kernels. These factors should be negatively related to price, since they are all undesirable characteristics.

Graders evaluate each lot of rough rice before market day in a bid/acceptance market. The expected milling yield and quality characteristics are estimated, and an appropriate U.S. standard grade is assigned to each lot of rough rice marketed by producers. Applicable U.S. standards associated with the several available grades for rough rice are specified in Table 1. Inspectors generally adhere to these grade standards; however, across markets with different inspectors, some inconsistencies may be observed in grading techniques (Brorsen et al. 1984). Rice buyers participating in bid/acceptance markets use the available information regarding quality factors and grades and their own visual inspection of lot samples, as well as the needs of their mill to determine their respective bid price for a given lot.[1] The markets are open 1 day a week on an intermittent basis. Buyers make sealed bids which sellers have 24 hours to accept or reject. Lots on which bids are rejected are usually marketed at a later date either through the bid/acceptance market or a privately negotiated sale.

Sales records, grade sheets, and confirmed prices were obtained from five bid/acceptance rice markets in Texas for the 1981-82, 1982-83, and 1983-84 marketing years. These records accounted for 24, 26, and 27 percent, respectively, of Texas production during the years surveyed. The markets are located at Alvin, Danbury, Bay City, El Campo, and Ganado. Data were available from two other markets but were not used because of missing quality values. Each market in the study is located in the western side of the Texas Rice Belt (Figure 1). Only long grain rice varieties were included in the analysis. To determine the extent of rice quality across the region, bid/acceptance data are augmented by American Rice, Incorporated (ARI) data for 1982-83 and 1983-84.

PROCEDURE

Rice quality factors were analyzed to determine their effects on rough rice prices. The underlying assumption of the statistical procedure used in this analysis is that goods are valued for their utility-bearing characteristics and prices of goods vary directly with the specific amounts of each characteristic the goods contain (Lucas 1975). The observed product prices are, thus, a composite of the value of the product's characteristics.[2]

The analytical method discussed in Appendix A was used to derive the discount associated with a one-unit change in a quality variable. These

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[1] Determination of whether the lot was to be milled as white or parboiled rice was difficult because some buyers were buying for rice mills that use both processes. Only one firm is 100 percent parboiled rice, while several firms are 100 percent white rice. Mill processing was not considered in this analysis. Damaged kernels, especially those damaged by the rice stink bug (peck), are amplified more in parboiled rice than in white rice. Thus, premiums or discounts observed in the bid/acceptance markets may not be the same for producers who sell their rough rice where there is no competition between buyers for the two types of milling processes. From the perspective of the rice producer selling in the bid/acceptance markets, however, such distinctions between type of buyer are irrelevant since he/she cannot control who bids on the rice; in fact, the only point of concern is that several potential buyers bid in order to provide a competitive market atmosphere.

[2] A technical discussion of the analytical method used is presented in Appendix A.

Table 1. Federal grades and grade requirements for classes of rough rice

Grade	Maximum limits of-- Seeds and heat-damaged kernels[a] Total (singly or combined)	Heat damaged kernels and objectionable seeds (singly or combined)	Percent red rice and damaged kernels (singly or combined)[b]	Percent chalky kernels In long grain rice	In medium or short grain rice	Percent other types[c]	Color requirements
U.S. No. 1	4	3	0.5	1.0	2.0	1.0	Shall be gray or creamy
U.S. No. 2	7	5	1.5	2.0	4.0	2.0	May be slightly gray
U.S. No. 3	10	8	2.5	4.0	6.0	3.0	May be light gray
U.S. No. 4	27	22	4.0	6.0	8.0	5.0	May be gray or slightly rosy
U.S. No. 5	37	32	6.0	10.0	10.0	10.0	May be dark gray or rosy
U.S. No. 6	75	75	15.0[d]	15.0	15.0	10.0	May be dark gray or rosy
U.S. Sample grade[e]							

[a] Number in 500-gram sample.

[b] Includes peck damaged kernels.

[c] These limits do not apply to the class mixed rough rice.

[d] Rice in grade U.S. No. 6 shall contain not more than 6.0 percent of damaged kernels.

[e] U.S. sample grade shall be rough rice which: (a) does not meet the requirements for any of the grades from U.S. No. 1 to U.S. No. 6, inclusive; (b) contains more than 14.0 percent of moisture; (c) is musty, sour, or heating; (d) has any commercially objectionable foreign odor; or (e) is otherwise of distinctly low quality.

Source: USDA 1977.

discounts were multiplied by average Texas rice yields to measure the per acre impact of each quality variable.

Data from ARI were grouped by regions and counties according to storage location (Figure 2). Each quality attribute was arrayed and summarized by county. Since ARI rough rice price is based on a pool price and predetermined formula, these data were not included in the price-quality analysis; rather, their use was limited to demonstrating the prevalence of the respective quality factors across the Texas Rice Belt beyond the west side counties represented by the bid/acceptance markets.

RICE QUALITY

The more important quality factors, such as whole kernel yield, brokens, peck, weed seed, heat damage, and test weight, were observed in each bid/acceptance market during the study period. The data set was incomplete, however, for red rice, smut (damage caused by fungus), chalk, green rice, and a miscellaneous "other" category. If values for peck, weed seed, heat damage, red rice, smut, and chalk were not recorded on the grade sheets for an individual lot, then values for these quality characteristics were assumed to be zero.[3] Where test weight was not recorded on the grade sheet for an individual lot, the average test weight for that market and year was assumed. Green rice and the miscellaneous "other" category were not included in the analysis since data were not recorded on the grade sheets in all markets. If no settlement price data were available for a given lot of rice, the observation was deleted before analysis. Data were weighted by the quantity (i.e., pounds of rough rice) in each lot.

Quality Variables

The quality factors which can be controlled with production management decisions are peck, red rice, weed seeds, smut, and green or immature rice kernels. Each of these quality factors gives unpleasant appearance on the grocery shelf. Thus, rice millers try to remove them in the milling process. This removal costs the rice miller additional processing expense and results in a loss in finished product volume. Rough rice prices are discounted to cover these additional costs.

Peck refers to damage caused by stink bugs, among other reasons (Luh 1980; Stansel 1983). Stink bug damage is a discolored mark or fissure on the kernel which sometimes results in breakage, thereby reducing head yield. Stink bug damage can prevent normal development of a grain, resulting in field yield loss (Parker 1983). Field yield loss is not measured in the bid/acceptance market data. Current recommendations for control of the rice stink bug include the insecticides methyl parathion and carbaryl (Drees 1983) (Table B.27).[4]

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[3] The bid/acceptance market managers indicated this is the appropriate approach.

[4] Tables B.1-B.38 are found in Appendix B.

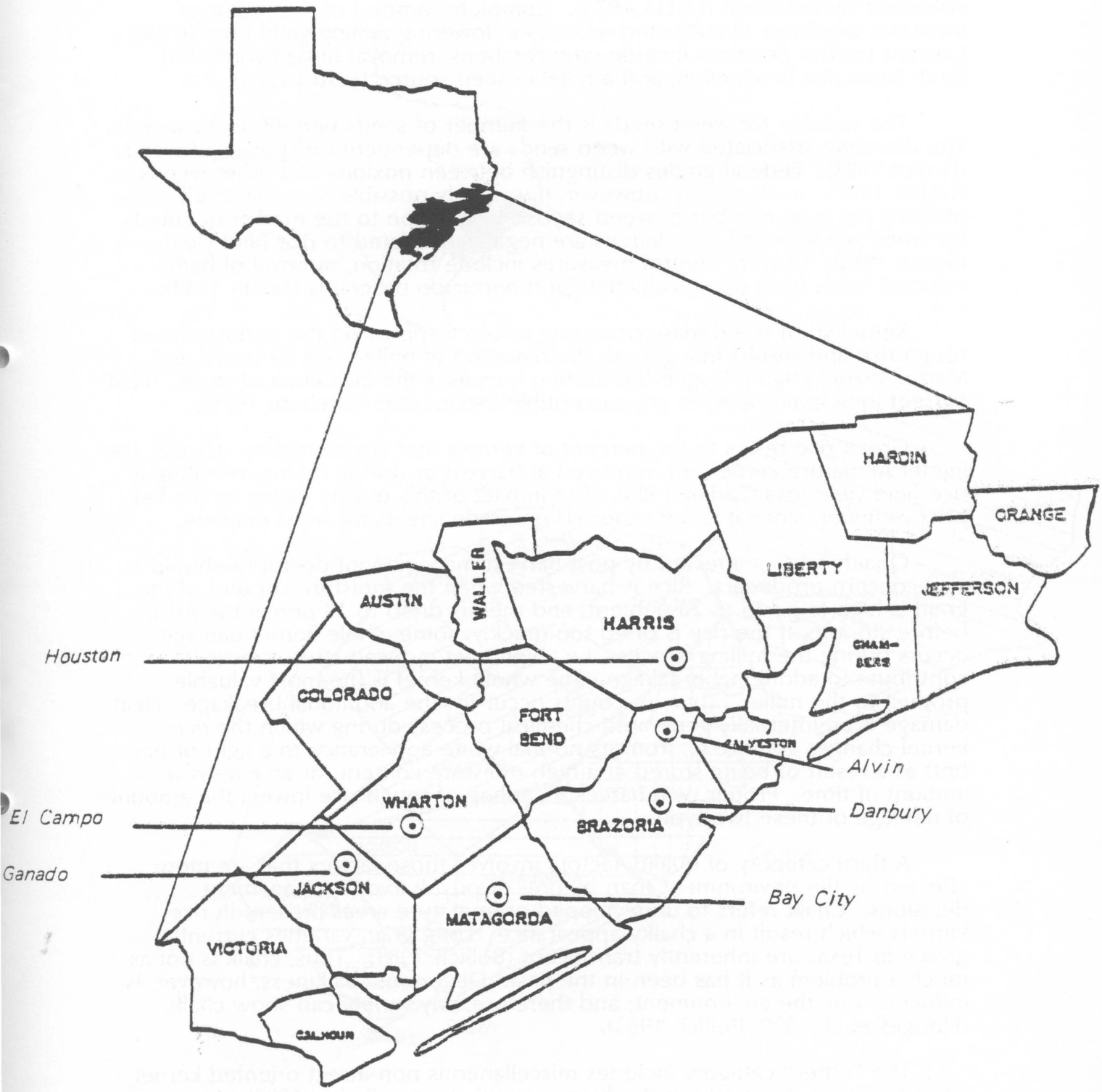

Figure 1. Location of the bid/acceptance markets within the Texas rice production area.

Red rice, or rice with a red colored pericarp, comes from an off-type rice that is considered a weed by rice producers and processors. It usually enters a field through impure seed and then becomes a continual problem through volunteer reinfestation (USDA 1973). Complete removal of the red layer increases breakage of cultivated white rice, lowering milling yield (Smith 1981). Current control practices include crop rotations, removal of badly infested fields from rice production, and a reliable seed source (Eastin 1983).

The variable for weed seeds is the number of seeds per 500-gram sample. The discounts associated with weed seeds are dependent on species of weed (Parker 1983). Federal grades distinguish between noxious and other weeds (USDA 1977). In this study, however, it was only possible to consistently observe the total number of weed seeds. In addition to the market discounts for weed seeds, weed populations are negatively related to rice field yields (Smith 1968). Current control measures include rotation, removal of badly infected fields from rice production, and herbicide programs (Eastin 1983).

Kernel smut is a disease occurring as black spores on the endosperm of rough rice and results in a grayish discoloration of milled rice (Leonard and Martin 1970). High nitrogen fertilization increases the incidence of smut. Most current long grain varieties are susceptible (Atkins and Marchetti 1979).

Green rice refers to the percent of kernels that are immature. Usually the lighter immature kernels are removed at harvest or during drying, resulting in rice field yield loss (Parker 1983). The impact of this quality factor on market price is minor, since it is not reported on grade sheets for most markets.

Quality factors affected by post-harvest management decisions should also concern producers. Rice is harvested when the moisture content of the grain is high (e.g., 13 to 20 percent) and then is dried to 13 percent moisture before storing. If the rice is dried too quickly, some whole kernel damage occurs during the milling process, i.e., high heat induced stress cracks contribute to additional breakage. The whole kernel is the most valuable product to the miller. Thus, discounts occur for the additional breakage. Heat damage is an internally generated chemical process during which the rice kernel changes color (e.g., from its normal white appearance to a light or dark tint) as a result of being stored at a high moisture content for an excessive amount of time. Proper post-harvest handling of rough rice lowers the amount of damage of these two types.

A third category of quality factors involves those factors that are more affected by the environment than by pre- or post-harvest management decisions. Chalk refers to undeveloped or immature areas present in rice kernels which result in a chalky appearance. Long grain varieties currently grown in Texas are inherently translucent (Bollich 1983). Thus, chalk is not as much a problem as it has been in the past. Degree of chalkiness, however, is influenced by the environment; and therefore, any variety can show chalk (Hodges et al. 1979; Bollich 1983).

The "other" category includes miscellaneous non-insect oriented kernel damage, i.e., water marks in the bran, sprouting, etc. (Parker 1983). Many of these damages are caused by lodging, a problem related to variety, high nitrogen fertilization, and weather conditions. Varietal selection and fertilization management help reduce these types of damage. However,

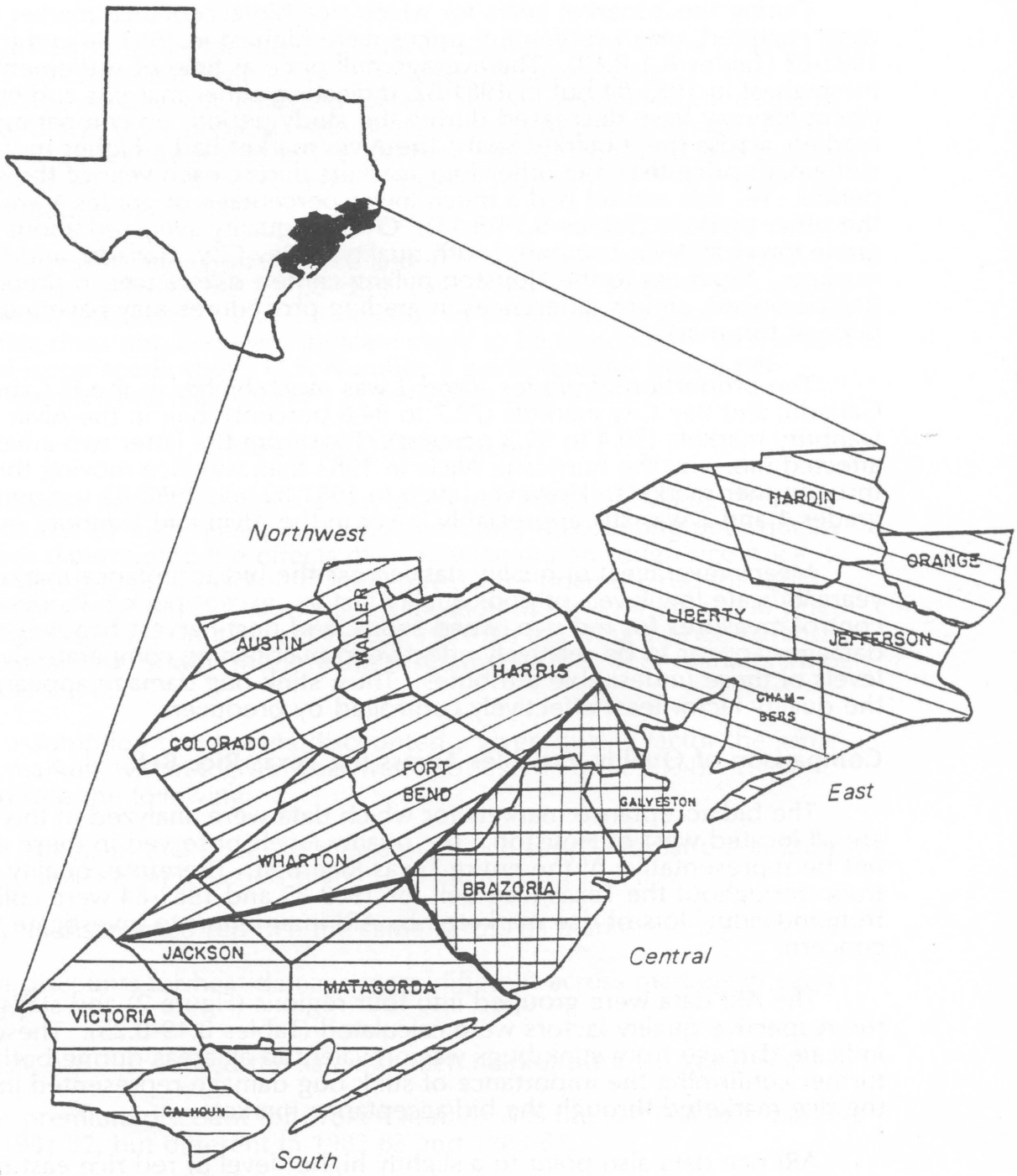

Figure 2. Texas Rice Belt production regions.

adverse weather (hurricanes) is still the major causal factor.

Comparison of Means Across Bid/Acceptance Markets

During the 3 market years for which rice bid/acceptance market data were analyzed, mean settlement prices were highest in 1983-84 and lowest in 1982-83 (Tables B.1-B.13). The average mill price at time of settlement was not the highest in 1983-84 but in 1981-82, indicating either margins and/or discounts may have decreased during the study period. In comparing the five markets across the 3 market years, the Alvin market had a higher mean final settlement price than the other four markets during each year of the study period. Yet this market had a much lower percentage of grades 1 and 2 than the other markets (Tables B.14-B.18). Overall, quality averaged about one grade lower at Alvin compared with quality at Bay City, Ganado, and El Campo markets. Nearness to the Houston milling center, differences in proportion of rice parboiled, and/or differences in grading procedures may have influenced price in this market.

The proportion of grades 1 and 2 was much higher in the El Campo, Ganado, and Bay City markets (79.7 to 94.8 percent) than in the Alvin and Danbury markets (30.4 to 55.3 percent). Rice from the latter two areas was affected more by the hurricane Alicia in 1983 than was rice moving through the three former markets. However, even in 1981-82 and 1982-83 the number of grades 1 and 2 was still appreciably lower in the Alvin and Danbury markets.

Means (averages) of quality data across the bid/acceptance markets and years indicate low levels of poor quality factors, except peck.[5] Producer control measures for red rice, weed seeds, and post-harvest handling-related damages appear to be relatively effective in maintaining comparatively low levels of these undesirable attributes. Thus, stink bug damage appears to be the quality factor least effectively controlled by producers.

Comparison of Quality Variables Across the Texas Rice Belt

The bid/acceptance markets for which data were analyzed in this study are all located west of Houston. The quality levels observed in these areas may not be representative of the entire Texas Rice Belt. Therefore, quality data from throughout the Texas Rice Belt for 1982-83 and 1983-84 were collected from individual lots of rice marketed by ARI in an effort to investigate this concern.

The ARI data were grouped into four regions (Figure 2) and statistics for the respective quality factors were calculated (Tables B.19-B.25). These data indicate damage from stink bugs was prevalent in all areas during both years, further confirming the importance of stink bug damage represented in data for the rice marketed through the bid/acceptance markets.

ARI rice data also point to a slightly higher level of red rice east of

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[5] Although the reported means indicate small levels of poor quality factors, several lots of rice exhibited quality problems. Proportionally, these lots were a small part of the total. Discounts could be severe at the maximum level of quality factors occurring in each market (Tables B.1-B.13).

Houston than in the other areas. The other quality factors do not appear to be different by regions, again, indicating producers are effectively controlling most of the quality limiting factors (except for peck in all areas and red rice on the east side).

Calculated statistics for ARI data indicate 36.6 percent of the 1982-83 and 1983-84 crops contained over 1.5 percent peck damage (Table 2). The bid/acceptance market data analyzed for all 3 market years indicate a slightly higher proportion (49.4 percent) with over 1.5 percent peck damage (Table 2). Percent peck damage reported in the ARI data ranged from 0 to 20.8 percent, and from 0 to 9.9 percent in the bid/acceptance market data. Means for the two sets of data are similar.

The frequency tables for red rice and smut indicate very little rice in either data source above the 1.5 percent level (Table 2). Chalk shows a large concentration, between 1.5 and 2.0 percent, in the bid/acceptance market data. The ARI data does not, however, indicate chalk to be a problem. Rice with the number of weed seeds above U.S. Number 2 grade (greater than 5 per 500-gram sample) was relatively low in both data sets (Table 3).

Modeling Quality Factors

The quality factor levels of a given lot of rice affect the value. Buyers offer premiums for high quality rice while generally discounting poor quality rice. Before determining the effects of quality factors on rough rice price it should be determined if market location affects the price offered for rough rice. Statistical tests indicate that market location made a difference in price received for rough rice in all years except 1981-82, implying a price advantage (or disadvantage) in one or more markets relative to the other markets in the study (Table B.34).[6]

The assumption that buyers discounted a given quality factor the same across all markets within a given year was also tested (Table B.34). These results indicate the following:

1) The effects of mill price, an indicator of rice supply/demand conditions, were not the same across markets in each year;

2) Buyers discounted red rice the same across all markets in a given year;

3) The discounts for heat damage were different across markets in each year;

4) Chalk was discounted the same in each market during a given year;

5) The premium/discount for broken kernels was the same across markets in 1981-82, but different in 1982-83 and 1983-84;

6) Buyers discounted for peck the same across markets in 1981-82, but differently across markets in 1982-83 and 1983-84;

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[6] This also implies that data cannot be combined across markets in 1982-83 and 1983-84 for the analysis.

Table 2. Percent of selected quality factors in lots of rice in American Rice, Incorporated and bid/acceptance markets

Percent range	American Rice, Incorporated[a]				Bid/acceptance markets[b]			
	Peck	Red	Smut	Chalk	Peck	Red	Smut	Chalk
0	2.8	78.4	34.4	0.0	6.5	73.0	48.2	60.4
0.01-0.50	14.1	15.5	47.1	93.8	6.7	16.4	31.0	0.0
0.51-1.00	27.1	2.9	10.2	5.0	19.2	7.2	13.3	0.2
1.01-1.50	19.4	1.0	3.8	1.1	18.2	0.8	3.7	0.0
1.51-2.00	15.0	0.6	2.0	0.1	20.9	0.3	1.3	32.0
2.01-3.00	13.9	0.5	1.8	0.0	18.7	1.4	1.0	6.7
>3.00	7.7	1.1	0.7	0.0	9.8	0.9	1.5	0.7

[a] Includes 1982-83 and 1983-84 combined.

[b] Bid/acceptance markets located at Alvin, Danbury, Bay City, El Campo, and Ganado. Includes 1981-82, 1982-83, and 1983-84 combined.

Table 3. Percent of weed seed in lots of rice in the American Rice, Incorporated and bid/acceptance markets

Percent range	American Rice, Incorporated[a]	Bid/acceptance[b]
Number		
0	80.8	77.3
0.01-2.50	0.5	0.4
2.51-5.00	9.4	9.0
5.01-7.50	1.0	0.2
7.51-10.00	0.9	4.7
10.01-15.00	1.0	3.0
>15.00	6.4	5.4

[a] Includes 1982-83 and 1983-84 combined.

[b] Bid/acceptance markets located at Alvin, Danbury, Bay City, El Campo, and Ganado. Includes 1981-82, 1982-83, and 1983-84 combined.

7) Discounts for weed seed were different across markets during 1981-82 and 1982-83, but the same across markets in 1983-84;

8) Test weight discounts were different across markets during 1981-82 and 1982-83; however, buyers reacted similarly across markets for test weight during 1983-84;

9) Buyers discounted for smut differently across markets only in 1983-84;

10) The premiums for head yield were different across markets in 1981-82 and 1983-84, but the same across markets in 1982-83.

The analytical method discussed in Appendix A, restricted by the assumption tests discussed above, was used to estimate the premium/discount associated with a one-unit change in a quality variable. The results from these estimates are discussed below.

Value of Quality Characteristics

A hedonic rough rice price function is a regression of the form:[7]

$$P_F = b_0 + b_1 MILL + b_2 HEAD + b_3 BROKENS + b_4 SEED + b_5 RED$$
$$+ b_6 PECK + b_7 SMUT + b_8 CHALK + b_9 HEAT + b_{10} TEST$$

where P_F is the observed final settlement rough rice price for a given lot of rice in the bid/acceptance markets, $b_1 ..., b_{10}$ are the premiums or discounts associated with each quality factor, MILL is the milled rice price in Houston during the week the rough rice was sold, and HEAD, BROKENS, SEED (weeds), RED, PECK, SMUT, CHALK, HEAT (damage), and TEST (weight) measure the level of the respective quality factors analyzed for each individual lot sold discussed earlier. The b_0 value is different if the market location made a difference in price. Test results shown in Table B.34 indicate the b_0 coefficient is different by market location in 1982-83 and 1983-84. The $b_1 ..., b_{10}$ values can be different across markets within a given year if rice buyers discount differently by market. Of the independent variables considered, only head yield and brokens are highly correlated (Table B.35).[8]

The estimated coefficients (i.e., premiums or discounts (dollars per hundredweight) for each quality variable) for the price-quality relationships associated with each market year are presented in Tables 4-6. Even though the statistical tests discussed above indicated the coefficients were not the same across markets in some situations, the hedonic price-quality relationships across all markets are also included in Tables 4-6. Because the pooled

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[7] See Appendix A for a technical discussion of the analytical method used in estimating the hedonic rough rice price function.

[8] The rice industry commonly perceives a relationship between test weight and brokens. However, the bid/acceptance market data for each year showed no strong correlation between the two factors.

Table 4. Estimated coefficients for the hedonic price equations for rough rice, 1981-82 (absolute t-ratios in parentheses)[a]

Quality variable	Alvin	Ganado	Bay City	All markets[b]
		$/cwt		
Intercept	-9.4588 (4.56)*	-9.4588 (4.56)*	-9.4588 (4.56)*	-9.2887 (4.54)*
Mill price	0.4478 (29.57)*	0.4478 (29.57)*	0.4478 (29.57)*	0.4515 (31.68)*
Head yield	0.1381 (4.07)*	0.0723 (2.01)*	0.1102 (2.82)*	0.1229 (3.92)*
Brokens	0.0359 (0.95)	0.0359 (0.95)	0.0359 (0.95)	0.0519 (1.47)
Seed	-0.0071 (3.04)*	-0.0197 (3.64)*	-0.0197 (4.46)*	-0.0122 (6.29)*
Red rice	-0.1716 (6.35)*	-0.1716 (6.35)*	-0.1716 (6.35)*	-0.1831 (6.74)*
Peck	-0.2897 (7.86)*	-0.2897 (7.86)*	-0.2897 (7.86)*	-0.2858 (8.03)*
Smut	0.0099 (0.24)	0.0099 (0.24)	0.0099 (0.24)	0.0027 (0.07)
Chalk	-0.1448 (0.82)	-0.1448 (0.82)	-0.1448 (0.82)	0.0506 1.17
Heat damage	-0.0037 (-2.82)*	0.0200 (1.84)	-0.1692 (1.02)	-0.0036 (2.64)*
Test weight	0.0534 (1.19)	0.1255 (2.73)*	0.0943 (1.96)*	0.0548 (1.34)

* Indicates rejection of the null hypothesis at the 5 percent level of significance. Rejection of the null hypothesis implies that the quality characteristic affected the rough rice settlement price by the estimated coefficient amount for each unit change in the quality factor.

[a] The covariance analysis across markets had R^2 =0.8148 and F-ratio = 109.53; the critical F value is 1.66 (5 percent level of significance). Ordinary least squares analysis for all markets combined had R^2 = 0.8006 and F-ratio = 183.09; the critical F value is 1.91 (5 percent level of significance). There were 467 observations in the data set.

[b] All data pooled and coefficients estimated by ordinary least squares.

Table 5. Estimated coefficients for the hedonic price equations for rough rice, 1982-83 (absolute t-ratios in parentheses)[a]

Quality variable	Alvin	Danbury	El Campo	Ganado	Bay City	All markets[b]
			$/cwt			
Intercept	10.1042 (1.79)	-2.9066 (0.48)	-8.5372 (3.59)*	-3.1690 (1.28)	2.3944 (0.26)	-4.5194 (2.84)*
Mill price	0.4173 (2.29)*	0.7104 (2.95)*	0.6560 (9.81)*	0.0419 (0.65)	0.3451 (6.84)*	0.3127 (9.24)*
Head yield	0.0920 (5.32)*	0.0920 (5.32)*	0.0920 (5.32)*	0.0920 (5.32)*	0.0920 (5.32)*	0.1249 (7.58)*
Brokens	0.1339 (2.91)*	0.0272 (0.91)	0.0394 (1.84)	0.0539 (2.64)*	0.0352 (1.61)	0.0759 (4.07)*
Seed	-0.0259 (1.42)	-0.0015 (0.26)	-0.0083 (6.07)*	c	-0.0120 (4.15)*	-0.0083 (6.55)*
Red rice	-0.2267 (4.11)*	-0.2267 (4.11)*	-0.2267 (4.11)*	-0.2267 (4.11)*	-0.2267 (4.11)*	-0.1010 (2.18)*
Peck	-0.3676 (2.14)*	-0.0895 (1.28)	-0.2179 (4.67)*	-0.0367 (1.12)	-0.1057 (4.67)*	-0.0815 (4.67)*
Smut	-0.0002 (0.01)	-0.0002 (0.01)	-0.0002 (0.01)	-0.0002 (0.01)	-0.0002 (0.01)	-0.0023 (0.10)
Chalk	0.1627 (3.10)*	0.1627 (3.10)*	0.1627 (3.10)*	0.1627 (3.10)*	0.1627 (3.10)*	0.0187 (0.71)
Heat damage	0.0052 (0.39)	-0.0357 (2.70)*	0.0068 (0.54)	0.0321 (0.42)	c	0.0012 (0.16)
Test weight	-0.3299 (2.74)*	-0.1537 (1.76)	0.0064 (0.18)	0.1230 (3.14)*	-0.1113 (0.56)	0.0006 (0.02)

* Indicates rejection of the null hypothesis at the 5 percent level of significance. Rejection of the null hypothesis implies that the quality characteristic affected the rough rice settlement price by the estimated coefficient amount for each unit change in the quality factor.

[a] The covariance analysis across markets had R^2 = 0.5102 and F-ratio = 18.67; the critical F value is 1.50 (5 percent level of significance). Ordinary least squares analysis for all markets combined had R^2 = 0.4002 and F-ratio = 44.76; the critical F value is 1.91 (5 percent level of significance). There were 682 observations in the data set.

[b] All data pooled and coefficients estimated by ordinary least squares.

[c] Data not reported.

Table 6. Estimated coefficients for the hedonic price equations for rough rice, 1983-84 (absolute t-ratios in parentheses)[a]

Quality variable	Alvin	Danbury	El Campo	Ganado	Bay City	All markets[b]
			$/cwt			
Intercept	19.8324 (4.12)*	5.1323 (0.56)	-2.0116 (0.47)	-4.0747 (0.78)	-4.1047 (0.85)	9.9906 (2.78)*
Mill price	-1.0276 (5.75)*	-0.6588 (1.58)	0.2611 (1.66)	-0.0736 (0.37)	-0.2839 (1.43)	-0.5374 (5.71)*
Head yield	0.1393 (3.80)*	0.2230 (4.73)*	0.2203 (5.82)*	0.1951 (5.23)*	0.2624 (6.72)*	0.2041 (5.56)*
Brokens	0.1795 (4.40)*	0.1795 (4.40)*	0.1795 (4.40)*	0.1795 (4.40)*	0.1795 (4.40)*	0.2047 (4.59)*
Seed	-0.0077 (4.81)*	-0.0077 (4.81)*	-0.0077 (4.81)*	-0.0077 (4.81)*	-0.0077 (4.81)*	-0.0070 (3.97)*
Red rice	-0.1701 (2.16)*	-0.1701 (2.16)*	-0.1701 (2.16)*	-0.1701 (2.16)*	-0.1701 (2.16)*	-0.2973 (3.41)*
Peck	-0.6572 (7.13)*	-0.0313 (0.28)	-0.2664 (3.11)*	-0.3845 (3.35)*	-0.1672 (2.44)*	-0.3521 (8.20)*
Smut	-3.3430 (10.46)*	-1.3706 (3.10)*	-0.1352 (0.62)	0.1620 (0.74)	-0.2286 (1.92)	-0.4757 (4.86)*
Chalk	0.0641 (0.60)	0.0641 (0.60)	0.0641 (0.60)	0.0641 (0.60)	0.0641 (0.60)	0.2113 (4.11)*
Heat damage	-0.0033 (1.29)	c	c	-0.0366 (3.00)*	c	-0.0113 (4.12)*
Test weight	0.0773 (1.51)	0.0773 (1.51)	0.0773 (1.51)	0.0773 (1.51)	0.0773 (1.51)	-0.0478 (0.94)

* Indicates rejection of the null hypothesis at the 5 percent level of significance. Rejection of the null hypothesis implies that the quality characteristic affected the rough rice settlement price by the estimated coefficient amount for each unit change in the quality factor.

[a] The covariance analysis across markets had R^2 = 0.4451 and F-ratio = 21.81; the critical F value is 1.55 (5 percent level of significance). Ordinary least squares analysis for all markets combined had R^2 = 0.2770 and F-ratio = 33.11; the critical F value is 1.91 (5 percent level of significance). There were 875 observations in the data set.

[b] All data pooled and coefficients estimated by ordinary least squares.

[c] Data not reported.

all-markets regression (ordinary least squares) imposes restrictions which may not be true (i.e., the coefficients are the same across markets) the results are sometimes quite different from the covariance analysis.

Mill prices, a general indicator of the changes in supply/demand during the marketing year, impacted all markets in 1981-82, all markets except Ganado in 1982-83, and only the Alvin market in 1983-84. The general level of rice prices fell abruptly during 1981-82, continued a modest decline in 1982-83, and held relatively stable in 1983-84. The relative stability in rice prices during 1983-84 could explain why mill prices were not important during this season. A coefficient of 0.4478 for mill price in 1981-82 indicates a $1/cwt change in the mill price during the year affected rough rice prices $0.4478/cwt in the same direction. The negative coefficients for milled rice prices in 1983-84 for many markets were not expected.

Whole kernel yield (head rice yield), the most important quality characteristic in terms of revenue derived from milling, was statistically significant in all markets and years. Whole kernel yield coefficients varied from 0.0723 in the Ganado market in 1981-82 to 0.2624 in the Bay City market in 1983-84, indicating that the value of a one unit increase in head yield (i.e., 1 lb whole kernels) varied from $0.0723 to $0.2624. Price of U.S. No. 2 milled long grain rice, free on board (FOB) mill, Houston, ranged from $17.75 to $22.00/cwt during the study period.

The impact of broken rice quantity in a milled sample, the difference between total mill yield and whole kernel yield, was insignificant on rough rice prices at the bid/acceptance markets during 1981-82. However, the amount of brokens affected prices in the Alvin and Ganado markets during 1982-83 and in all markets during 1983-84.

Discounts for weed seed occurred in all markets during 1981-82 and 1983-84. During 1982-83, however, this quality factor was significant only in the El Campo and Bay City markets. The discounts measured by dollars per hundredweight in rough rice price per one weed seed per 500-gram sample, varied from $0.0071 to $0.0197. Discounts during 1983-84 were the same across markets, but nearer the lower portion of the 1981-82 range.

Red rice affected the rough rice price in all markets during all years of the study period. Discounts measured by dollars per hundredweight for a 1 percentage point increase in red rice in a sample, were the same across markets in a given year, but varied from $0.1701 in 1983-84 to $0.2267 in 1982-83. In the bid/acceptance markets studied, average red rice levels were low. Some individual lots ran as high as 25 percent red rice, however, bringing sizeable price discounts, i.e., for a 25-percent level of red rice, the estimated discount in the rough rice price was $5.67/cwt during 1982-83.

Peck damage, primarily caused by stink bugs, affected rough rice prices in all markets during all years except at Danbury and Ganado during 1982-83 and at Danbury during 1983-84. Discounts for peck were more variable than those for red rice, but the average levels of these discounts were similar. Thus, a kernel with peck damage results in about the same discount as a kernel of red rice if all other factors are the same, i.e., in either case the kernel is undesirable. In the data analyzed, reported peck damage ranged from 0 to 9.9

percent. Buyers discounted rough rice prices appreciably in the upper levels of this range.

Smut was not a significant quality factor except in the Alvin and Danbury markets during 1983-84. Hurricane Alicia moved through these areas in August 1983, creating quality problems with unharvested rice. Rice harvested west of these two market areas suffered less quality damage. Chalk, heat damage, and test weight impacted on rough rice price only on a limited basis.

Indirect Effects of Peck

In addition to the direct discount associated with the visible kernel damage caused by stink bugs, there is also an indirect discount which is a result of the loss in whole kernel yield, increase in quantity of brokens, and decline in test weight caused by stink bug damage. The same procedure used to estimate the hedonic price functions was used to estimate the indirect effects of peck damage on whole kernel yield, quality of brokens, and level of test weight. Market location was significant in all situations, indicating the intercepts are not equal across markets (Table B.36). The coefficients for the impact of peck on head yield and brokens are not significantly different across markets during 1981-82, indicating equal slopes across markets for those two relationships in 1981-82 (Table B.37).

Head yield was negatively related to peck in all years and at all markets except Alvin during 1982-83 and El Campo and Ganado during 1983-84 (Tables 7-9). For each additional percentage point increase in peck, decreases in head yield range from 0.5653 percentage points at the Bay City market to 2.4335 percentage points at the Alvin market during 1983-84. This range in head yield declines translates into an indirect discount in rough rice prices ranging from $0.1483 to $0.3390/cwt for a one-unit increase in peck.[9]

The level of peck affected the level of brokens at all markets during 1981-82; at the El Campo, Ganado, and Bay City markets during 1982-83; and at the Alvin and Danbury markets during 1983-84 (Tables 7-9). This impact varied from 0.2977 to 1.9212 per unit of change in peck. Since the effect of peck on brokens is positive and the effect of brokens on rough rice price is positive as shown in Tables 4-6, the indirect effect of peck (through brokens) on rough rice price will be positive. Brokens and head yield are inversely related, however. The net effect of an increase in peck damage is a decrease in rough rice price, since whole kernels are of greater value than broken kernels.

Peck damage affected test weight at Alvin and Ganado markets during 1981-82; at the Danbury, El Campo, and Ganado markets during 1982-83; and at the Alvin, Danbury, El Campo, and Ganado markets during 1983-84 (Tables 7-9). Peck damage lowers the weight of the grain in a bushel of rice, since peck damaged individual kernels are lighter than normal kernels for the same volume. Test weight was reduced from 0 to 0.6142 lb per each percentage point increase in peck. Since a standard bushel of rough rice weighs 45 lb, a

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[9] The effect of peck on head yield (0.5653 and 2.4335) in Table 8 multiplied by the premium for each unit of head yield ($0.2624 and $0.1393) in Table 5 gives the indirect discount in rough rice price ($0.1483 and $0.3390).

Table 7. Impact of peck on selected quality variables at specified Texas rice bid/acceptance markets during 1981-82 (absolute t-ratios in parentheses)[a]

Item	Alvin	Ganado	Bay City	All markets[b]
Head yield:				
Intercept	60.4222	56.3198	57.9692	56.6044
	(83.39)*	(131.28)*	(77.49)*	(128.55)*
Peck	-1.1860	-1.1860	-1.1860	-0.5057
	(5.41)*	(5.41)*	(5.41)*	(2.57)*
Brokens:				
Intercept	10.6686	13.0379	11.9423	12.8603
	(17.20)*	(35.49)*	(18.64)*	(34.91)*
Peck	0.6547	0.6547	0.6547	0.2543
	(3.49)*	(3.49)*	(3.49)*	(1.55)
Test weight:				
Intercept	45.7308	46.2103	45.8756	46.0282
	(239.83)*	(388.50)*	(177.66)*	(522.46)*
Peck	-0.3482	-0.5456	-0.1653	-0.3857
	(5.44)*	(6.84)*	(1.63)	(9.80)*

* Indicates rejection of the null hypothesis at the 5 percent level of significance. Rejection of the null hypothesis implies that peck affected the quality characteristic by the amount of the estimated coefficient for each unit change in peck.

[a] The covariance analysis across markets had R^2 = 0.10 and F-ratio = 16.44 for peck-head yield; R^2 = 0.04 and F-ratio = 7.19 for peck-brokens; and R^2 = 0.21 and F-ratio = 24.76 for peck-test weight. Ordinary least squares analysis for all markets combined had R^2 = 0.01 and F-ratio = 6.61 for peck-head yield; R^2 = 0.01 and F-ratio = 2.39 for peck-brokens; and R^2 = 0.17 and F-ratio = 96.05 for peck-test weight. The critical F value is 3.92 (5 percent level of significance). There were 467 observations in the data set.

[b] All data pooled and coefficients estimated by ordinary least squares.

Table 8. Impact of peck on selected quality variables at specified Texas rice bid/acceptance markets during 1982-83 (absolute t-ratios in parentheses)[a]

Item	Alvin	Danbury	El Campo	Ganado	Bay City	All markets[b]
Head yield:						
Intercept	61.9614	62.6049	59.6911	57.0590	56.9703	58.1136
	(42.57)*	(64.39)*	(127.09)*	(174.23)*	(158.32)*	(257.20)*
Peck	-1.3369	-1.8440	-1.8361	-1.3330	-0.7408	-0.8776
	(1.78)	(4.03)*	(6.37)*	(5.96)*	(4.87)*	(7.61)*
Brokens:						
Intercept	10.5203	9.1515	10.0311	11.5255	12.2911	11.2583
	(8.14)*	(10.60)*	(24.04)*	(39.62)*	(38.45)*	(59.65)*
Peck	0.1469	0.7981	1.3024	0.9289	0.2977	0.5225
	(0.22)	(1.96)	(5.09)*	(4.67)*	(2.20)*	(5.43)*
Test weight:						
Intercept	45.3479	46.5073	46.1729	45.6822	45.4701	45.6592
	(133.87)*	(205.51)*	(422.38)*	(600.39)*	(542.91)*	(870.66)*
Peck	-0.3227	-0.2789	-0.6142	-0.1365	0.0007	-0.1342
	(1.85)	(2.62)*	(9.16)*	(2.62)*	(0.02)	(5.02)*

* Indicates rejection of the null hypothesis at the 5 percent level of significance. Rejection of the null hypothesis implies that peck affected the quality characteristic by the amount of the estimated coefficient for each unit change in peck.

[a] The covariance analysis across markets had R^2 = 0.26 and F-ratio = 27.28 for peck-head yield; R^2 = 0.13 and F-ratio - 11.74 for peck-brokens; and R^2 = 0.22 and F-ratio = 21.89 for peck-test weight. Ordinary least squares analysis for all markets combined had R^2 = 0.08 and F-ratio = 57.98 for peck-head yield; R^2 = 0.04 and F-ratio = 29.45 for peck-brokens; and R^2 = 0.03 and F-ratio = 25.17 for peck-test weight. The critical F value is 3.92 (5 percent level of significance). There were 708 observations in the data set.

[b] All data pooled and coefficients estimated by ordinary least squares.

Table 9. Impact of peck on selected quality variables at specified Texas rice bid/acceptance markets during 1983-84 (absolute t-ratios in parentheses) [a]

Item	Alvin	Danbury	El Campo	Ganado	Bay City	All markets [b]
Head yield:						
Intercept	59.7797	60.7835	59.6286	57.5194	57.8434	59.2981
	(78.21)*	(92.78)*	(112.09)*	(93.90)*	(97.71)*	(213.64)*
Peck	-2.4335	-1.1594	-0.6501	-0.2122	-0.5653	-1.3590
	(7.29)*	(3.24)*	(1.92)	(0.47)	(2.11)*	(9.28)*
Brokens:						
Intercept	10.6821	9.8308	10.0537	11.6613	11.3608	10.3007
	(16.89)*	(18.14)*	(22.84)*	(23.01)*	(23.19)*	(43.43)*
Peck	1.9212	0.8857	0.2100	-0.2565	0.2342	1.0191
	(6.96)*	(2.99)*	(0.75)	(0.68)	(1.06)	(8.14)*
Test weight:						
Intercept	44.9782	46.2986	46.3160	46.3757	45.4690	46.0216
	(331.98)*	(398.71)*	(491.16)*	(448.15)*	(433.31)*	(814.35)*
Peck	-0.3214	-0.3044	-0.4922	-0.4979	0.0000	-0.4194
	(5.43)*	(4.80)*	(8.20)*	(6.46)*	(0.00)	(14.06)*

* Indicates rejection of the null hypothesis at the 5 percent level of significance. Rejection of the null hypothesis implies that peck affected the quality characteristic by the amount of the estimated coefficient for each unit change in peck.

[a] The covariance analysis across markets had R^2 = 0.18 and F-ratio = 21.67 for peck-head yield; R^2 = 0.22 and F-ratio = 26.96 for peck-brokens; and R^2 = 0.44 and F-ratio = 77.69 for peck-test weight. Ordinary least squares analysis for all markets combined had R^2 = 0.09 and F-ratio = 86.07 for peck-head yield; R^2 = 0.07 and F-ratio = 66.28 for peck-brokens; and R^2 = 0.18 and F-ratio = 198.37 for peck-test weight. The critical F value is 3.92 (5 percent level of significance). There were 889 observations in the data set.

[b] All data pooled and coefficients estimated by ordinary least squares.

one-unit increase in peck damage could lower test weight to 44.3858 lb/bu. Such a decrease in test weight translates to indirect discounts across markets and years in rough rice price ranging from $0 to $0.0688 per percentage point of peck damage.[10]

Analysis of the relationship between head yield-peck, brokens-peck, and test weight-peck with the ARI data indicates similar coefficients and statistical significance levels. These results, presented in Table B.38, were used to verify the bid/acceptance market relationship.

Peck Related Field Losses

In addition to the implicit price discounting associated with peck damage, rice producers often suffer physical yield losses as a result of stink bug infestations. Stink bugs in the nymphal and adult stages feed on rice as the panicle develops (Bowling 1963). During the early milk stage of grain development, stink bug damage can prevent normal grain development, resulting in an empty glume or shriveled grain (i.e., yield loss). During the dough stage of grain development, stink bug damage weakens the grain structurally, resulting in breakage during milling and/or development of a black spot on the grain, both of which contribute to lower quality.

Bowling (1963) found that yields were decreased by 7.2 percent when stink bugs were maintained at four per square foot during grain forming, as compared to a no stink bug situation. Using Bowling's test data and regressing percent peck damage against yield expressed as a percent of control yield (no stink bug) indicate a loss of 17.1 percent in field yield for each percentage point of peck damage.[11] The equation estimated was:

$$\text{Yield (percent of control)} = 103.3 - \underset{(11.01)}{17.0981}\ \text{peck level}$$

$$R^2 = 0.98$$

where the figure in parenthesis is t-ratio.

Swanson and Newsom (1962) reported Louisiana yield losses associated with stink bug damage in 1960 and 1961 cage tests. Their results were similar to those found by Bowling (1963). No recent studies were found relating to field loss as a result of stink bugs.

Applying 1 percent peck damage to the estimated equation and assuming the Texas yield with no peck damage at 5,500 lb, indicates a 759-lb field loss as a result of peck (Table 10). During crop years 1982-83 and 1983-84, ARI

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[10] The effect of peck on test weight (0 to 0.6142) in Tables 8 and 9 multiplied by the premium for each unit of test weight ($0.0773 to $0.0064) in Tables 5 and 6 produces the indirect discount in rough rice price ($0 to $0.0688).

[11] A word of caution: Bowling's results recorded peck damage up to 0.59 percent with four bugs per square foot, about one-half of the mean damage found in the ARI and bid/acceptance market data analyzed in this study. Extrapolations beyond the test levels could be in error.

Table 10. Estimated field yields with selected levels of peck damage[a]

Percent peck damage				
0	0.5	1.0	1.5	2.0
		lb/A		
4,500	4,264	3,879	3,494	3,110
5,000	4,738	4,310	3,883	3,455
5,500	5,211	4,741	4,271	3,801
6,000	5,685	5,172	4,659	4,146

[a] Estimated from Bowling's (1963) data:

$$\text{Yield (percent of control)} = 103.3 - \underset{(11.01)}{17.0981}\ \text{peck level}$$

$R^2 = 0.98$ t-value = ( ).

reported a weight average peck damage in Texas rice of 1.41 percent (Table B.33). With an average yield of 45.48 hundredweight/acre (cwt/A) across both crop years, Bowling's data implies an average field yield loss due to stink bug damage of almost 12 cwt/A. With rough rice priced between $7 and $11/cwt, field losses as a result of stink bug damage represent a sizeable cost to the producer. This discussion is extrapolating from 1963 data. Additional research is needed to determine the impact of stink bug numbers on rice quality and field loss with current varieties.

Red Rice and Weed Related Field Losses

Weeds reduce rice yields by competing for growth requirements. The competitive effects vary by rice variety, weed type, the environment, and relative time of emergence of weeds and rice (Diarra et al. forthcoming). As weed density increases, crop yields decrease. Smith (1968) found that rice field yields were decreased by 4-10 percent for one weed per 8 square feet and 19-40 percent for one weed per square foot. Variability depended upon weed type. Diarra et al. (forthcoming) indicate five red rice plants per square meter reduce rice yields 21-23 percent.

No published research was found relating rice field loss to number of weed seed per 500-gram sample of rough rice or percent red rice in a sample of rough rice. Part of the problem of attempting to relate these factors is that red rice or weed seeds may shatter in the field before harvest, may be partially cleaned from the rough rice during combining, or may not be harvested during hand harvesting of research plots. Nevertheless, red rice and/or weed seeds in a sample of rough rice indicates their presence in the field and a previous rice field yield loss.

While no data are available to develop field loss estimates associated with either red rice or noxious weeds, it is important to recognize that the economic consequences of these quality factors are somewhat different, although related, to the losses associated with peck. It should be noted that the carryover effect of red rice and other weeds through germination, vegetative growth, and propagation in subsequent years extends their potential impact (i.e., detrimental effects) beyond a 1-year phenomenon as assumed with peck and stink bugs. The number of seed reproduced by each red rice or noxious weed plant suggests these phenomena are most likely geometric in nature through time, with some degree of mitigation occurring in association with normal cultural management practices such as tillage, herbicide treatments, rotations, etc. A proposed method of accounting for the net degree of economic loss associated with an observed level of red rice and for weed seeds in a rough rice sample is:

$$NL = [YL_1 \ (x) \cdot P_i] + \sum_{i=2}^{N} \frac{YL_i \ (g_i(y_i)) \cdot E(P_i)}{(1+r)^{i-1}}$$

$$\text{with } y_i = h_i(\bar{z})$$

where

NL = net present value of economic losses (dollars per acre);

$YL_1(x)$ = yield losses in current year associated with a sample level of x red rice or weed seed (pounds per acre);

P_i = current rough rice price (dollars per pound);

$h_i(Z)$ = function relating mitigation effects of tillage, herbicide treatment, rotations, etc. on level of red rice or weed seed infestation in year i;

$g_i(h_i(Z))$ = function relating geometric explosion of red rice or weed infestations in year i;

$YL_i(g_i(h_i(Z)))$ = function relating yield losses associated with red rice or weed infestations in year i;

$E(P_i)$ = expected rough rice price in year i (dollars per pound);

r = discount rate (i.e., opportunity cost of capital) (percent); and

N = length of planning horizon.

Substantial research is needed to clarify the mathematical properties of the respective yield loss and red rice/weed perpetuative function. One conclusion that can be reached at this point, however, is that rice producers must recognize the subsequent benefits of control treatments for red rice and/or weeds beyond the immediate year.

Marginal Implicit Prices

The estimated hedonic functions in Tables 4-6 and the indirect impacts of peck shown in Tables 7-9 describe the pricing structure for rough rice in bid/acceptance markets in Texas. These data can be used to derive estimates of the premium or discount (dollars per hundredweight of rough rice) associated with a one-unit change in the quality variable.[12] The discounts (per hundredweight and per acre) for peck, weed seed, red rice, chalk, heat damage, and smut are given in Tables 11-13.

The discounts for peck damage (both direct and indirect) ranged from

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[12] The direct discount per unit for peck at the Alvin market at 0.2897 is taken directly from Table 4. All direct peck, weed seed, red rice, chalk, heat damage, and smut coefficients per hundredweight in Table 11 are taken directly from Table 4. The indirect discount for peck (whole kernel, brokens, and test weight) is calculated as follows: for 1981-82, the effect of peck on head yield (1.1860) in Table 7 multiplied by the premium for each unit of head yield (0.1381 for Alvin) in Table 4 produces the indirect discount in rough rice price (0.1638) in Table 11. Other markets, years, and indirect effects are calculated similarly.

Table 11. Discounts per one unit change for selected quality attributes at specified Texas rice bid/acceptance markets, 1981-82

Quality attribute	Alvin	Ganado	Bay City	All markets
	Premium (+) or discount (-) per hundredweight ($)			
Peck				
direct	-0.2897*	-0.2897*	-0.2897*	-0.2858*
whole kernel	-0.1638*	-0.0857*	-0.1307*	-0.0622*
brokens	0.0235	0.0235	0.0235	0.0132
test weight	-0.0186	-0.0685*	-0.0156	-0.0211
total	-0.4486	-0.4204	-0.4125	-0.3559
Weed seed	-0.0071*	-0.0197*	-0.0197*	-0.0122*
Red rice	-0.1716*	-0.1716*	-0.1716*	-0.1831*
Chalk	-0.1448	-0.1448	-0.1448	0.0506
Heat damage	-0.0037*	0.0200	-0.1692	-0.0036
Smut	0.0099	0.0099	0.0099	0.0027
	Premium (+) or discount (-) per acre ($)[a]			
Peck				
direct	-13.62*	-13.62*	-13.62*	-13.43*
whole kernel	-7.70*	-4.03*	-6.14*	-2.93*
brokens	1.10	1.10	1.10	0.62
test weight	-0.87	-3.22*	-0.73	-0.99
total	-21.09	-19.76	-19.39	-16.73
Weed seed	-0.33*	-0.93*	-0.93*	-0.57*
Red rice	-8.07*	-8.07*	-8.07*	-8.61*
Chalk	-6.81	-6.81	-6.81	2.38
Heat damage	-0.17*	0.94	-7.95	-0.17*
Smut	0.47	0.47	0.47	0.13

[a] Weighted by state yield in 1981 (47 cwt) (USDA 1984).

* Coefficients are significant at 5 percent level.

Table 12. Discounts per one unit change for selected quality attributes at specified Texas rice bid/acceptance markets, 1982-83

Quality attribute	Alvin	Danbury	El Campo	Ganado	Bay City	All markets
	Premium (+) or discount (-) per hundredweight ($)					
Peck						
direct	-0.3676	-0.0895	-0.2179	-0.0367	-0.1057*	-0.0815*
whole kernel	-0.1230	-0.1696	-0.1689	-0.1226*	-0.0682*	-0.1096*
brokens	0.0197	0.0217	0.0513	0.0501*	0.0105	0.0397*
test weight	0.1065	0.0429	-0.0039	-0.0168*	-0.0001	-0.0001
total	-0.3644	-0.1945	-0.3394	-0.1260	-0.1635	-0.1515
Weed seed	-0.0259	-0.0015	-0.0083	b	-0.0120*	-0.0083*
Red rice	-0.2267	-0.2267	-0.2267	-0.2267*	-0.2267*	-0.1010*
Chalk	0.1627	0.1627	0.1627	0.1627*	0.1627*	0.0187
Heat damage	0.0052	-0.0357	0.0068	0.0321	b	0.0012
Smut	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0023
	Premium (+) or discount (-) per acre ($)[a]					
Peck						
direct	-17.24*	-4.20	-10.22*	-1.72	-4.96*	-3.82*
whole kernel	-5.77	-7.95*	-7.92*	-5.75*	-3.20*	-5.14*
brokens	0.92	1.02	2.41	2.35*	0.49	1.86
test weight	4.99	2.01	-0.18	-0.79*	-0.00	-0.00
total	-17.09	-9.12	-15.55	-5.91	-7.67	-7.10
Weed seed	-1.19	-0.07	-0.38*	b	-0.55*	-0.39*
Red rice	-10.41*	-10.41*	-10.41*	-10.41*	-10.41*	-4.74
Chalk	7.47*	7.47*	7.47*	7.47*	7.47*	0.88
Heat damage	2.24	-1.64*	0.31	1.47	b	0.06
Smut	-0.01	-0.01	-0.01	-0.01	-0.01	-0.11

[a] Weighted by state yield in 1982 (46.9 cwt) (USDA 1984).

[b] Data not reported.

* Coefficients are significant at 5 percent level.

Table 13. Discounts per one unit change for selected quality attributes at specified Texas rice bid/acceptance markets, 1983-84

Quality attribute	Alvin	Danbury	El Campo	Ganado	Bay City	All markets
	Premium (+) or discount (-) per hundredweight ($)					
Peck						
direct	-0.6572	-0.0313	-0.2664*	-0.3845*	-0.1672*	-0.3521*
whole kernel	-0.3390	-0.2585*	-0.1432	-0.0414	-0.1483*	-0.2774*
brokens	0.3449	0.1590*	0.0377	-0.0460	0.0420	0.2086*
test weight	-0.0248	-0.0235	-0.0380	-0.0385	0.0000	0.0200
total	-0.6761	-0.1543	-0.4099	-0.5104	-0.2735	-0.4009
Weed seed	-0.0077	-0.0077*	-0.0077*	-0.0077*	-0.0077*	-0.0070*
Red rice	-0.1701	-0.1701*	-0.1701*	-0.1701*	-0.1701*	-0.2973*
Chalk	0.0641	0.0641	0.0641	0.0641	0.0641	0.2113*
Heat damage	-0.0033	b	b	-0.0366*	b	-0.0113*
Smut	-3.3430	-1.3706*	-0.1352	0.1620	-0.2286	-0.4757*
	Premium (+) or discount (-) per acre ($)[a]					
Peck						
direct	-28.52*	-1.36	-11.56*	-16.69*	-7.26*	-15.28*
whole kernel	-14.71*	-11.22*	-6.21	-1.80	-6.44*	-12.04*
brokens	14.97*	6.90*	1.64	-2.00	1.82	9.05*
test weight	-1.08	-1.02	-1.65	-1.67	0.00	0.87
total	-29.34	-6.70	-17.78	-22.16	-11.88	-17.40
Weed seed	-0.33*	-0.33*	-0.33*	-0.33*	-0.33*	-0.30*
Red rice	-7.38*	-7.38*	-7.38*	-7.38*	-7.38*	-12.90*
Chalk	2.78	2.78	2.78	2.78	2.78	9.17*
Heat damage	-0.14	b	b	-1.59*	b	-0.49*
Smut	145.09*	-59.48*	-5.87	7.03	-9.92	-20.65*

[a] Weighted by state yield in 1983 (43.4 cwt) (USDA 1984).

[b] Data not reported.

* Coefficients are significant at 5 percent level.

$0.4125 to $0.4486/cwt or $19.39 to $21.09/A in 1981-82 across markets.[13] This range across markets was slightly lower during 1982-83. Discounts for peck across markets during 1983-84 were larger and more variable than for the 2 previous years, ranging from $0.1543 to $0.6761/cwt or $6.70 to $29.34/A. The discounts for peck indicate a 1 percentage point reduction in peck damage could have raised the price received per hundredweight for rough rice by $0.1260 to $0.6761 across all markets and years ($5.91 to $29.34/A).

Applying the discount for peck to the average level of peck in each market per year indicates an average discount ranging from $0.12 to $1.40/cwt of rough rice or $5.63 to $60.76/A (Tables 14-16). Average peck damage across each market and year ranged from 0.9 to 2.6 percent. Individual lots in the bid/acceptance markets were reported, however, with up to 9.9 percent peck damage (i.e., $58 to $290/A). The data obtained from ARI indicate peck damage as high as 20.8 percent in 1982-83 (i.e., $123 to $355/A) (Table B.19). These levels of peck damage indicate sizeable discounts in the rough rice market. Discounts in the rough rice markets coupled with stink bug induced field losses point to sizeable losses in revenue where peck damage is a problem.

The discount for one weed seed per 500-gram sample across markets and years averaged from $0.00 to $0.0259/cwt ($0.00 to $1.19/A) (Tables 11-13). Combining the discounts per unit of weed seeds with the average level of weed seeds reported by market and year shows discounts ranging from $0.00 to $0.13/cwt ($0.00 to $6.11/A) (Tables 14-16). The average number of weed seeds across markets and years ranged from 1.9 to 12.8/500-gram sample, with most of the markets averaging below the number of seeds permitted for U.S. No. 2 rice (i.e., seven). Individual lots ranged, however, from 0 to 550 weed seeds per 500-gram sample. The lots with high weed seed numbers brought sizeable discounts in the markets and probably large reductions in rough rice field yields.

The discount for red rice was relatively stable across the bid/acceptance markets for all years, ranging from $0.1701 to $0.2267/cwt ($7.38 to $10.41/A) (Tables 11-13). Applying the discount per unit of red rice to the average level of red rice in each market and year indicates discounts ranging from $0.00 to $0.17/cwt ($0.00 to $7.97/A) (Tables 14-16). The average samples for the bid/acceptance markets in this study all fell within the red rice quality requirements for U.S. No. 2 or better. The general levels of red rice in some of the areas served by the bid/acceptance markets in this study were so low that the data were not recorded. The highest average levels of red rice were in the Alvin area, though these levels were lower than U.S. No. 2 rice. The ARI data (as indicated earlier) shows more red rice present in the eastern portion of the Texas Rice Belt. The averages during 1982-83 and 1983-84, even for these areas, however, were better than the requirements for U.S. No. 2 rice. As previously discussed, the presence of red rice in the sample indicates a lowering of rice field yields as a result of competition from red rice.

Discounts for smut ranged from $0.00 to $3.34/cwt ($0.00 to $145.09/A)

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[13] State average yield for each year was multiplied by the quality discount per hundredweight to derive discounts per acre. Texas rice yields average 4,700 lb, 4,790 lb, and 4,340 lb during 1981, 1982, and 1983, respectively (USDA 1984).

Table 14. Economic impacts at the means of selected quality attributes at specified Texas rice bid/acceptance markets, 1981-82

Quality attribute	Alvin	Ganado	Bay City	All markets
	Premium (+) or discount (-) per hundredweight ($)[a]			
Peck				
direct	-0.76*	-0.35*	-0.67*	-0.53*
whole kernel	-0.43*	-0.10*	-0.30*	-0.11*
brokens	0.06	0.03	0.05	0.02
test weight	-0.05	-0.07*	-0.13	-0.04
total	-1.18	-0.49	-1.05	-0.66
Weed seed	-0.09*	-0.04*	-0.13*	-0.07*
Red rice	-0.12*	0.00*	-0.01*	-0.04
Chalk	-0.31	0.00	-0.29	0.05
Heat damage	0.00*	0.00	-0.01	-0.01*
Smut	0.01	0.01	0.00	0.00
	Premium (+) or discount (-) per acre ($)[b]			
Peck				
direct	-35.72*	-16.45*	-31.49*	-24.91*
whole kernel	-20.21*	-4.70*	-14.10*	-5.17*
brokens	2.82	1.41	2.35	0.94
test weight	-2.35	-3.29*	-6.11	-1.88
total	-55.46	-23.03	-49.35	-31.02
Weed seed	-4.23*	-1.88*	-6.11*	-3.29*
Red rice	-5.64*	0.00*	-0.70*	-1.88*
Chalk	-14.57	0.00	-13.63	2.35
Heat damage	0.00*	0.00	0.47	-0.47*
Smut	0.47	0.47	0.00	0.00

[a] Discount per unit of quality variable (Table 11) multiplied by average level of that quality variable in the specified market (Tables B.1, B.8, and B.11).

[b] Weighted by state yield in 1981 (47 cwt) (USDA 1984).

* Coefficients are significant at the 5 percent level.

Table 15. Economic impacts at the means of selected quality attributes at specified Texas rice bid/acceptance markets, 1982-83

Quality attribute	Alvin	Danbury	El Campo	Ganado	Bay City	All markets
	Premium (+) or discount (-) per hundredweight ($)[a]					
Peck						
direct	-0.68*	-0.17	-0.29*	-0.03	-0.20*	-0.12*
whole kernel	-0.23*	-0.33*	-0.22*	-0.11*	-0.13*	-0.17*
brokens	0.04	0.04	0.07	0.04*	0.02	0.06*
test weight	0.20	-0.08	-0.01	-0.02*	0.00	0.00
total	-0.67	-0.54	-0.45	-0.12	-0.31	-0.23
Weed seed	-0.06	0.00	-0.05*	c	-0.02*	-0.02*
Red rice	-0.17*	-0.04*	0.00*	0.00*	0.00*	-0.01*
Chalk	0.36*	0.35*	0.00*	0.00*	0.02*	0.01
Heat damage	0.00	0.00*	0.00	0.01	0.00	0.00
Smut	0.00	0.00	0.00	0.00	0.00	0.00
	Premium (+) or discount (-) per acre ($)[b]					
Peck						
direct	-31.89*	-7.97	-13.60*	-1.41	-9.38*	-5.63*
whole kernel	-10.79*	-15.48*	-10.32*	-5.16*	-6.10*	-7.97*
brokens	1.88	1.88	3.28	1.88*	0.94	2.81*
test weight	9.38	-3.75	-0.47	-0.94*	0.00	0.00
total	-31.42	-25.32	-21.10	-5.63	-14.54	-10.79
Weed seed	-2.81	0.00	-2.34*	c	-0.94*	-0.94*
Red rice	-7.97*	-1.88*	0.00*	0.00*	0.00*	-0.47*
Chalk	16.88*	16.42*	0.00*	0.00*	0.94*	0.47
Heat damage	0.00	0.00*	0.00*	0.47	0.00	0.00
Smut	0.00	0.00	0.00*	0.00	0.00	0.00

[a] Discount per unit of quality variable (Table 12) multiplied by the average level of that quality variable in the specified market (Tables B.2, B.4, B.6, B.9, and B.12).

[b] Weighted by state yield in 1982 (46.9 cwt) (USDA 1984).

[c] Data not reported.

* Coefficients are significant at the 5 percent level.

Table 16. Economic impacts at the means of selected quality attributes at specified Texas rice bid/acceptance markets, 1983-84

Quality attribute	Alvin	Danbury	El Campo	Ganado	Bay City	All markets
	Premium (+) or discount (-) per hundredweight ($)[a]					
Peck						
direct	-1.36*	-0.04	-0.36*	-0.44*	-0.32*	-0.55*
whole kernel	-0.70*	-0.31*	-0.19	-0.05	-0.17*	-0.44*
brokens	0.71*	0.19*	0.05	0.05*	0.08	0.33*
test weight	-0.05	-0.03	-0.05	-0.04	0.00	0.03
total	-1.40	-0.19	-0.55	-0.48	-0.41	-0.63
Weed seed	-0.04*	-0.04*	-0.06*	-0.02*	-0.04*	-0.04*
Red rice	-0.03*	-0.05*	0.00*	0.01*	0.00*	-0.02*
Chalk	0.15	0.10	0.00	0.00	0.00	0.14*
Heat damage	0.00	c	c	0.00*	c	-0.02*
Smut	-0.84*	-0.28*	-0.01	0.03	-0.05	-0.09*
	Premium (+) or discount (-) per acre ($)[b]					
Peck						
direct	-59.02*	-1.74	-15.62*	-19.10*	-13.89*	-23.87*
whole kernel	-30.38*	-13.45*	-8.25	-2.17	-7.38*	-19.09*
brokens	30.81*	8.25*	2.17	2.17*	3.47	14.32*
test weight	-2.17	-1.30	-2.17	-1.74	0.00	1.30
total	-60.76	-8.25	-23.87	20.83	-17.79	-27.34
Weed seed	-1.74*	-1.74*	-2.60*	-0.87*	-1.81*	-1.74*
Red rice	-1.30*	-2.17*	0.00*	-0.43*	0.00*	-0.87*
Chalk	6.51	4.34	0.00	0.00	0.00	6.08*
Heat damage	0.00	c	c	0.00*	c	- 0.87*
Smut	-36.46*	-12.15*	-0.43	1.30	-2.17	-3.91*

[a] Discount per unit of quality variable (Table 13) multiplied by the average level of that quality variable in the specified market (Tables B.3, B.5, B.7, B.10, and B.13).

[b] Weighted by state yield in 1983 (43.4 cwt) (USDA 1984).

[c] Data not reported.

* Coefficients are significant at the 5 percent level.

(Tables 11-13), but were significant only in the Alvin and Danbury markets during 1983-84. Hurricane Alicia moved through these areas in August 1983, lowering quality of unharvested rice. Discounts per acre at the sample means were $12.15 (Danbury) and $36.46 (Alvin) (Tables 14-16). No quality problem with smut was detected in the other markets during the time period analyzed.

Discounts for chalk and heat damage are presented in Tables 11-13. These two quality factors had little effect on rough rice prices in the bid/acceptance markets studied, however, as further reflected in Tables 14-16.

ECONOMIC QUALITY CONTROL MEASURES

The range in magnitude of the per acre discounts presented in the previous section suggests the incidence and related cost of quality damage are not consistent across all markets analyzed during all years of the study. In several instances, the imputed discounts are at significant levels on a dollars per hundredweight and per acre basis, inferring concurrent control measures may be occurring at less than optimal levels, timing, and conditions. These results are highly supportive of a control program targeted at individual producers and locations rather than a broad all-encompassing effort. Regardless of the absolute magnitude of discounts across each market year, peck damage is relatively more costly per hundredweight and per acre than red rice and weed seeds, at least with respect to price discount.

Table B.27 summarizes recommended measures of insecticide control (Drees 1983). With respect to the control of rice stink bugs, the recommended practices range in cost from $3.70 to $7.78 per application. Texas Rice Belt producers are using from one to four applications of methyl parathion or from one to three applications of Sevin in their rice stink bug control program (Engbrock 1984); total control costs range from $3.70 to $14.80/A for methyl parathion to $7.78 to $23.34/A for Sevin.[14] This is what producers are doing; but, what level of control maximizes net returns to the producer? The information required to analyze that question is twofold: 1) What are the benefits of control on a per quality unit basis?, and 2) What are the costs of control on a per quality unit basis?

Tables 14-16 identify the average potential total dollar returns associated with complete control of the elements responsible for poor quality attributes in rough rice. Such absolute control is generally recognized as not economically feasible, i.e., diminishing production of additional control inputs commences at some point, resulting in marginal costs of additional control eventually exceeding the associated marginal returns. Tables 11-13 indicate the marginal discounts associated with a one-unit change in the respective quality attributes, i.e., marginal returns associated with controlling the responsible elements such that the attribute is reduced (peck, weed seeds, red rice, chalk, smut, and heat damage) or increased (whole kernel yield, total milling yield, and test weight) by one unit.

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[14] Field records during 1979-84 for Wharton County producers indicate 74 percent of the acreage received two or more applications of insecticides (Gerlow 1985). Methyl parathion was the major control measure used.

Economic decisions regarding control measures affecting the quality attributes discussed here should be evaluated on the basis of their cost per marginal unit of control relative to the associated marginal returns such as those identified in Tables 11-13. There is no information currently available regarding the cost of control on a per quality unit basis. Additional research in this area by Texas Agricultural Experiment Station and Texas Agricultural Extension Service scientists is underway in the Texas Rice Belt.

LIMITATIONS OF THE STUDY

Several important limitations of this study should be kept in mind. Discounts estimated in this analysis are only for the bid/acceptance markets indicated. Limited data were found measuring the impact of quality variables on field yield. Additionally, these data were taken during the early 1960s. Yield losses associated with the factors contributing to poor quality attributes in rough rice samples represent additional significant costs to producers. These losses should be considered when an attempt is made to identify economic control measures (Bowling 1963; Eastin 1983; Stansel 1983).

When the number of bidders is low and bidders have close contacts with each other, the markets may not be operating competitively. The number of bidders is generally lower on poorer quality rice; thus, discounts associated with lower quality rice may be partly a result of the thin market existing in the rice industry. Nevertheless, this does not bias the results reported here, since these discounts are real for the five bid/acceptance markets analyzed.

SUMMARY AND CONCLUSIONS

This paper reports results of analyses of 1981-82, 1982-83, and 1983-84 data from five rough rice bid/acceptance markets in the Texas Rice Belt. The objective was to determine the premium/discounts associated with various rough rice quality factors. These five markets are located on the western side of the Texas Rice Belt. To determine the extent of rice quality problems across the region, quality data were obtained on rice marketed by ARI for 1982-83 and 1983-84.

Quality factors, whole kernel yield, brokens, peck, red rice, weed seed, smut, chalk, heat damage, and test weight were analyzed to determine their impact on rough rice price. The premium per unit of whole kernel yield varied from $0.0723 at Ganado during 1981-82 to $0.2624 at Bay City during 1983-84. The premium per unit of brokens averaged $0.1795 in each market during 1983-84. Total discounts per unit of peck varied from $0.4125 to $0.4486 during 1981-82. The range across markets was slightly lower during 1982-83. Peck discounts during 1983-84 were larger and more variable, however, than during the 2 previous years. Discounts in the rough rice markets coupled with stink bug-induced field losses point to sizeable losses in revenue where peck damage is a problem.

Discounts per unit of red rice were relatively stable across the bid/acceptance markets for all years, ranging from $0.1701 to $0.2267. The

occurrence of red rice was low, however, in the bid/acceptance markets. ARI data show more red rice being present in samples of red rice grown in the eastern portion of the Texas Rice Belt. Presence of red rice in a sample also indicates a lowering of rice field yields as a result of competition from red rice.

The discount per weed seed in a 500-gram sample varied from $0.0071 to $0.0197. The average number of weed seeds per sample across markets and years ranged from 1.9 to 12.8/500-gram sample, with most of the markets averaging below the number of seeds permitted for U.S. No. 2 rice. Lots with high weed seed numbers brought sizeable discounts in the markets and also large reductions in rough rice field yields.

Discounts for smut were only significant in the Alvin and Danbury markets during 1983-84. Hurricane Alicia moved through these areas in August 1983. Discounts for chalk and heat damage had little effect on rough rice prices in the bid/acceptance markets studied.

Depending on the costs associated with controlling the respective quality characteristics, rice producers may be experiencing significant economic losses as a result of the price discounts associated with peck, red rice, weed seed, chalk, heat damage, and smut, among other quality attributes. Additional research is required to identify the aggregate impact of yield losses associated with several factors contributing to poor rough rice quality and identify the appropriate economic levels of control which affect the specific quality attributes of rough rice. This will require research by entomologists and economists on efficient use of various stink bug control tactics and impact of stink bug level on field yields, peck damage, and milling characteristics of damaged rice.

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APPENDIX A

HEDONIC PRICING

Hedonic price functions are regressions of the form (Lucas 1975):

$$(1) \quad P_i = P(V_{i1},\ldots,V_{ij};u_i)$$

where P_i is the observed price of commodity i, V_{ij} measures the amount of some "intrinsic quality" j per unit of commodity i, and u_i is a disturbance term. This type of model can be derived from a non-linear programming model (Lancaster 1971; Lucas 1975; Ladd and Martin 1976). This type of interpretation implies a linear model (1). Most researchers, however, have used a semi-logarithmic relationship between prices and characteristics (Griliches 1971). The analysis discussed here is performed using a linear specification of (1).

Typically, estimated hedonic price functions identify neither demand nor supply functions (Rosen 1974). Both observed prices and implicit prices of embodied attributes may be affected by aggregate demand/supply conditions. The implied values of an embodied quality attribute may not be the same across marketing years and may also vary with the specific market (location) being analyzed.

The previous discussion is appropriate for the analysis of cross-section data. The data sets used in this study, however, are pooled time-series/cross-section data. The hedonic estimation technique must, therefore, be adjusted for differences in market forces over time. Ethridge and Davis (1982) and Martinez et al. (1976) accounted for temporal price changes by including some combination of linear and quadratic time trends and dummy variables for month or year in the model. Deaton and Muellbauer (1980) suggest using some type of an index variable and propose the following semi-logarithmic model:

$$(2) \quad \ln(P_{it}) = \ln(I_t) + f(V_{i1},\ldots,V_{ij};\ u_i)$$

where I_t is the price of some reference commodity that can serve as a measure of the general price level. Since no weekly farm price is available for rice in the study area, the Texas weekly mill price is used in this analysis as the index variable (USDA). Farm and mill prices move very closely together (Brorsen 1983). No *a priori* information is available regarding whether the farm/mill margin is an absolute markup, a constant percentage, or some combination of both. For this study, equation (2) implies the margin between farm and mill prices is a constant percentage.

In this study a linear specification is used and the mill price is included as one of the regressors.[15] The quality factors, thus, can be interpreted as discounts or premiums from the base price. The question still remains as to how data should be analyzed under a bid/acceptance system as exists in rough rice markets. Martinez et al. (1976) discarded the observations where the bid was not accepted; i.e., they assumed such observations were not reflective of an effective market. The bid price, however, can be viewed as representing existing demands. A considerable amount of information is eliminated if the observations are discarded where the bid was rejected. The bid price represents the highest price any participating bidder is willing to pay for a given lot of rice on a given day within the constraints of the bid/acceptance market. In Brorsen et al. 1984 demand was estimated by including the highest bid price, regardless of whether the bid was accepted, as the dependent variable. However, in this analysis, the final settlement price for each lot of rice was obtained and used as the dependent variable. Only settlement prices are used, since some high bid prices are not serious bids. The discounts associated with quality are still expected to vary from year to year depending on aggregate supply and demand.

The data consisted of a cross section of observations for a given sale. However, the number of cross-sectional observations was not equal across markets or time periods. Separate coefficients could have been estimated for each sale and market, but the larger number of coefficients estimated would make the interpretation of the results difficult. Additionally, the limited number of individual lots sold during some of the sales would restrict the quality variables analyzed. As an alternative, the cross-sectional data for each sale were pooled for the crop years, resulting in the estimated hedonic price function for each crop year. Hypotheses that the intercept and slope coefficients were the same across markets were tested using the pooled crop year data.[16] Analysis of covariance was used to test these hypotheses (Freund and Littell 1981). Thus, the resulting model is:

$$(3)\quad P_{imtk} = a_{1k} + \sum_{n=2}^{N_k} a_{nk} D_n + b_{mk} P_{tk}^{mill} + \sum_{j=1}^{J} c_{jmk} V_{jimtk} + u_{imtk}$$

$$\text{with } i = 1,\ldots,I_{mtk};$$

$$m = 1,\ldots,N_k;$$

$$t = 1,\ldots,52; \text{ and}$$

$$k = 1, 2, \text{ and } 3,$$

where P_{imtk} is the settlement price for lot number i in market m during week t of year k, D_n is a dummy variable for market, P_{tk}^{mill} is the milled rice price in

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[15] The results in this study are similar regardless of whether a linear or semi-logarithmic specification is used. The linear model was selected partly because of its theoretical interpretation and ease of explanation to members of the rice industry. Tests using the Box-Cox transformation also showed the linear specification to be more appropriate.

[16] The functional form of the model for each market and year were tested using the Box-Cox transformation. Results indicate a linear model was appropriate in all cases (Table B.26).

week t of year k, V is quality factor j for lot number i in market m during week t of year k, the a's, b's and c's are parameters to be estimated, I_{mtk} is the number of lots sold in market m during week t of year k, and N_k is the number of markets for which data was analyzed from year k. Three markets are included for 1981-82 ($N_1 = 3$) and five markets are included for 1982-83 and 1983-84 ($N_2 = 5$ and $N_3 = 5$). The model provides a framework for testing whether the slopes of the quality variables and the intercept term are the same across markets.

APPENDIX B

Table B.1. Weighted means, standard deviations, and ranges of selected variables at Alvin, 1981-82

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	170			
Head yield	%	57.3345	6.2124	19.00	66.00
Mill yield	%	69.7046	1.6669	62.00	72.00
Grade	no.	2.9444	1.2865	2.00	7.00
Seed	no.	12.8459	28.9848	0.00	245.00
Peck	%	2.6138	1.4023	0.80	8.60
Red rice	%	0.7146	2.3135	0.00	25.00
Smut	%	0.6945	1.0315	0.00	5.00
Chalk	%	2.1513	0.3632	2.00	4.00
Stack	%	0.8325	4.6525	0.00	33.00
Test weight	lb/bu	44.8128	1.1001	41.00	47.00
Settlement price	$/cwt	10.8078	1.8327	5.25	13.63
Mill price at sale	$/cwt	24.0559	2.1041	20.00	26.00

Table B.2. Weighted means, standard deviations, and ranges of selected variables at Alvin, 1982-83

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	58			
Head yield	%	59.4730	2.1488	55.00	62.00
Mill yield	%	70.2668	1.2413	7.00	72.00
Grade	no.	2.5948	0.7952	2.00	7.00
Seed	no.	2.2347	4.2017	0.00	30.00
Peck	%	1.8613	0.5392	0.80	3.70
Red rice	%	0.7713	1.2229	0.00	7.70
Smut	%	0.5968	0.4513	0.00	3.70
Chalk	%	2.2121	0.4449	2.00	5.00
Stack	%	0.2848	0.4881	0.00	5.00
Test weight	lb/bu	44.7471	0.6488	41.50	46.00
Settlement price	$/cwt	9.3789	0.3973	6.80	10.13
Mill price at sale	$/cwt	18.5690	0.5537	17.75	20.00

Table B.3. Weighted means, standard deviations, and ranges of selected variables at Alvin, 1983-84

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	159			
Head yield	%	54.6627	6.2365	25.00	63.00
Mill yield	%	69.3692	1.4742	60.00	72.00
Grade	no.	2.9564	0.9713	1.00	7.00
Seed	no.	4.7794	14.0184	0.00	185.00
Peck	%	2.0716	0.9186	0.60	8.00
Red rice	%	0.1964	0.8107	0.00	11.00
Smut	%	0.2510	0.2376	0.00	1.10
Chalk	%	2.4050	0.5714	2.00	4.00
Stack	%	0.1836	0.8561	0.00	5.50
Test weight	lb/bu	44.3857	0.8234	40.00	45.50
Settlement price	$/cwt	11.2785	2.3257	6.55	17.16
Mill price at sale	$/cwt	19.7051	0.4367	19.00	20.25

Table B.4. Weighted means, standard deviations, and ranges of selected variables at Danbury, 1982-83

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	66			
Head yield	%	58.9414	3.4503	46.00	64.00
Mill yield	%	69.7316	1.2713	66.00	71.00
Grade	no.	2.7713	1.1860	2.00	7.00
Seed	no.	3.3188	9.9695	0.00	77.00
Peck	%	1.9281	0.8155	0.80	3.80
Other damage	%	0.0051	0.0315	0.00	0.20
Color	grade	2.7954	7.1352	0.00	46.00
Red rice	%	0.1836	0.3240	0.00	2.20
Smut	%	0.9718	1.8432	0.00	12.00
Green	%	0.1760	0.8123	0.00	5.00
Chalk	%	2.1772	0.6689	0.00	4.00
Stack	%	0.0714	0.4030	0.00	4.40
Test weight	lb/bu	45.9486	0.7383	43.00	47.00
Moisture	%	12.2664	0.5410	11.10	14.40
Settlement price	$/cwt	9.3332	0.6827	5.85	10.50
Mill price at sale	$/cwt	18.8788	0.3289	18.00	19.00

Table B.5. Weighted means, standard deviations, and ranges of selected variables at Danbury, 1983-84

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	72			
Head yield	%	59.3919	3.7584	30.00	64.00
Mill yield	%	70.2858	1.2063	59.00	72.00
Grade	no.	3.1736	1.6355	2.00	7.00
Seed	no.	4.7689	16.2219	0.00	250.00
Peck	%	1.2002	1.3844	0.00	9.00
Color	grade	0.1952	0.3963	0.00	1.00
Red rice	%	0.2997	0.6614	0.00	3.70
Smut	%	0.2049	0.3250	0.00	1.10
Chalk	%	1.5646	0.9721	0.00	4.00
Moisture	%	12.1763	0.5200	10.40	14.20
Test weight	lb/bu	45.9332	1.0312	41.00	48.00
Odor	%	0.1258	0.3317	0.00	1.00
Bugs	%	0.1758	0.3806	0.00	1.00
Grass	%	0.0291	0.1682	0.00	1.00
Mud	%	0.1305	0.3368	0.00	1.00
Shelled	%	4.8235	15.2636	0.00	60.00
Sprout	%	0.0712	0.2571	0.00	1.00
Green	%	0.1375	0.3444	0.00	1.00
Settlement price	$/cwt	10.4290	0.9813	6.83	11.56
Mill price at sale	$/cwt	20.0069	0.2845	19.00	20.25

Table B.6. Weighted means, standard deviations, and ranges of selected variables at El Campo, 1982-83

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	224			
Head yield	%	57.2611	4.3038	34.00	66.00
Mill yield	%	69.0092	1.2317	61.00	72.00
Grade	no.	1.8237	1.3561	1.00	7.00
Peck	%	1.3165	0.9185	0.10	4.50
Other damage	%	0.8902	1.4054	0.00	9.50
Red rice	%	0.0189	0.0947	0.00	0.80
Total damage	%	2.2010	2.1040	0.10	9.80
Smut	%	0.3782	0.8164	0.00	5.00
Moisture	%	11.2191	0.8589	8.90	16.60
Test weight	lb/bu	45.3586	1.2578	40.00	48.00
Seed	no.	5.6891	27.6967	0.00	350.00
Stack	%	0.0099	0.2992	0.00	9.00
Settlement price	$/cwt	9.2830	0.7253	6.05	10.87
Mill price at sale	$/cwt	18.5507	0.5651	17.75	20.00

Table B.7. Weighted means, standard deviations, and ranges of selected variables at El Campo, 1983-84

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	311			
Head yield	%	58.7606	3.6687	36.00	66.00
Mill yield	%	69.0965	1.1649	61.00	71.00
Grade	no.	1.9859	1.4146	1.00	7.00
Peck	%	1.3361	0.8253	0.00	5.50
Other damage	%	1.1771	1.5467	0.00	9.00
Total damage	%	2.6114	2.2234	0.20	12.00
Smut	%	0.0870	0.3097	0.00	3.30
Test weight	lb/bu	45.6593	0.9860	41.00	48.00
Moisture	%	11.5665	0.6560	10.00	12.60
Seed	no.	8.0111	33.3190	0.00	550.00
Settlement price	$/cwt	10.7196	0.7369	7.00	11.45
Mill price at sale	$/cwt	19.8245	0.4126	19.00	20.25

Table B.8. Weighted means, standard deviations, and ranges of selected variables at Ganado, 1981-82

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	208			
Head yield	%	54.8739	4.9422	40.00	66.00
Mill yield	%	68.7099	1.6045	62.00	72.00
Grade	no.	1.6418	0.9974	1.00	7.00
Seed	no.	1.8613	8.8343	0.00	205.00
Peck	%	1.2191	0.8593	0.00	4.00
Red rice	%	0.0063	0.0568	0.00	0.80
Smut	%	0.5882	0.9706	0.00	7.20
Stack	%	0.1690	0.4733	0.00	4.60
Test weight	lb/bu	45.5452	1.2238	40.50	47.50
Moisture	%	11.2585	0.6499	9.10	13.60
Other damage	%	1.0002	1.3147	0.00	6.50
Settlement price	$/cwt	10.2071	1.4226	4.95	13.80
Mill price at sale	$/cwt	21.9219	2.3267	19.00	27.00

Table B.9. Weighted means, standard deviations, and ranges of selected variables at Ganado, 1982-83

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	190			
Head yield	%	55.8612	4.3728	36.00	65.00
Mill yield	%	68.2213	1.6490	52.00	71.00
Grade	no.	1.5324	0.9843	1.00	7.00
Seed	no.	0.0000	0.0000	0.00	0.00
Peck	%	0.8965	1.1544	0.00	7.00
Red rice	%	0.0111	0.0723	0.00	0.60
Smut	%	0.1136	0.2655	0.00	1.50
Stack	%	0.0364	0.4665	0.00	6.00
Test weight	lb/bu	45.5598	0.9801	40.00	47.50
Moisture	%	11.5932	0.3610	10.50	13.00
Other damage	%	0.3277	0.9347	0.00	6.20
Settlement price	$/cwt	8.9743	0.5770	3.50	10.50
Mill price at sale	$/cwt	18.4895	0.5574	17.75	19.00

Table B.10. Weighted means, standard deviations, and ranges of selected variables at Ganado, 1983-84

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	153			
Head yield	%	57.2987	4.0740	45.00	66.00
Mill yield	%	68.6385	1.4521	63.00	71.00
Grade	no.	1.8244	1.0247	1.00	6.00
Peck	%	1.1344	0.7418	0.00	4.50
Other damage	%	0.9948	1.5175	0.00	7.50
Red rice	%	0.0705	0.3080	0.00	4.20
Smut	%	0.1763	0.3540	0.00	1.50
Test weight	lb/bu	45.8120	0.8588	42.00	47.00
Seed	no.	2.5863	8.7358	0.00	75.00
Stack	%	0.0937	0.6365	0.00	6.50
Settlement price	$/cwt	10.7184	0.8057	7.50	11.60
Mill price at sale	$/cwt	19.8650	0.3849	19.00	20.25

Table B.11. Weighted means, standard deviations, and ranges of selected variables at Bay City, 1981-82

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	92			
Head yield	%	55.2580	4.7629	25.00	62.00
Mill yield	%	68.6880	1.1022	58.00	70.00
Grade	no.	2.1546	0.6713	1.00	6.00
Seed	no.	6.7961	19.4508	0.00	275.00
Peck	%	2.2960	1.1206	0.80	6.50
Other damage	%	0.0000	0.0000	0.00	0.00
Color	grade	0.0000	0.0000	0.00	0.00
Red rice	%	0.0866	0.3033	0.00	4.00
Smut	%	0.3749	0.4907	0.00	4.00
Green	%	2.6378	1.0627	0.00	8.00
Chalk	%	2.0194	0.1628	0.00	3.00
Stack	%	0.0600	0.4989	0.00	10.00
Test weight	lb/bu	45.4950	0.9435	40.00	47.00
Settlement price	$/cwt	9.9216	1.7504	4.70	13.45
Mill price at sale	$/cwt	21.8262	2.5272	19.00	26.00

Table B.12. Weighted means, standard deviations, and ranges of selected variables at Bay City, 1982-83

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	174			
Head yield	%	55.5491	2.7001	34.00	63.00
Mill yield	%	68.4144	0.9205	64.00	71.00
Grade	no.	1.9853	0.6122	1.00	6.00
Seed	no.	2.0333	10.2881	0.00	135.00
Peck	%	1.9324	1.4820	0.00	9.90
Color	grade	0.0000	0.0000	0.00	0.00
Red rice	%	0.0000	0.0026	0.00	0.10
Smut	%	0.0791	0.2431	0.00	2.00
Green	%	0.1757	0.7871	0.00	7.00
Chalk	%	0.1047	0.4454	0.00	2.00
Stack	%	0.0014	0.0538	0.00	2.00
Test weight	lb/bu	45.4693	0.1694	43.00	51.00
Other damage	%	0.0000	0.0000	0.00	0.00
Settlement price	$/cwt	9.1122	0.5739	7.10	11.00
Mill price at sale	$/cwt	18.5833	0.6043	17.75	20.00

Table B.13. Weighted means, standard deviations, and ranges of selected variables at Bay City, 1983-84

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	188			
Head yield	%	56.7743	3.3354	40.00	65.00
Mill yield	%	68.5781	1.1640	63.00	71.00
Grade	no.	2.3343	0.8454	1.00	6.00
Peck	%	1.8913	1.1475	0.00	7.00
Smut	%	0.2237	0.6227	0.00	6.00
Seed	no.	5.4217	23.4813	0.00	550.00
Settlement price	$/cwt	10.4611	0.8050	6.32	11.48
Mill price at sale	$/cwt	19.5788	0.3825	19.00	20.25

Table B.14. Federal grades at Alvin for the market years 1981-82, 1982-83, and 1983-84

Variable	Unit	1981-82	1982-83	1983-84
Observation	no.	170	58	159
Grade 1	%	0.00	0.00	2.54
Grade 2	%	51.85	53.50	27.88
Grade 3	%	25.62	37.79	48.81
Grade 4	%	9.60	6.25	16.98
Grade 5	%	4.98	1.16	1.71
Grade 6	%	6.02	0.78	0.08
Sample Grade	%	1.93	0.52	2.00

Table B.15. Federal grades at Danbury for the market years 1982-83 and 1983-84

Variable	Unit	1982-83	1983-84
Observation	no.	66	72
Grade 1	%	0.00	0.00
Grade 2	%	55.27	52.60
Grade 3	%	30.02	18.86
Grade 4	%	3.03	10.38
Grade 5	%	5.98	4.14
Grade 6	%	3.47	4.75
Sample Grade	%	2.23	9.27

Table B.16. Federal grades at El Campo for the market years 1982-83 and 1983-84

Variable	Unit	1982-83	1983-84
Observation	no.	224	311
Grade 1	%	60.99	45.21
Grade 2	%	18.73	37.23
Grade 3	%	8.28	7.66
Grade 4	%	6.41	3.02
Grade 5	%	1.76	0.49
Grade 6	%	2.16	3.18
Sample Grade	%	1.67	3.20

Table B.17. Federal grades at Ganado for the market years 1981-82, 1982-83, and 1983-84

Variable	Unit	1981-82	1982-83	1983-84
Observation	no.	208	190	153
Grade 1	%	60.92	66.62	45.63
Grade 2	%	22.61	22.90	39.19
Grade 3	%	11.47	5.39	9.14
Grade 4	%	2.16	2.57	2.87
Grade 5	%	2.15	1.39	1.35
Grade 6	%	0.58	0.48	1.82
Sample Grade	%	0.10	0.65	0.00

Table B.18. Federal grades at Bay City for the market years 1981-82, 1982-83, and 1983-84

Variable	Unit	1981-82	1982-83	1983-84
Observation	no.	92	172	188
Grade 1	%	1.74	11.50	0.64
Grade 2	%	90.13	83.32	80.39
Grade 3	%	3.75	3.13	10.65
Grade 4	%	0.00	0.28	3.79
Grade 5	%	3.98	0.82	2.36
Grade 6	%	0.40	0.94	2.18
Sample Grade	%	0.00	0.00	0.00

Table B.19. Weighted means, standard deviations, and ranges of selected variables at American Rice, Incorporated east Texas warehouses, 1982-83

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	517			
Head yield	%	59.2231	4.4191	26.00	66.00
Mill yield	%	69.8852	1.3842	56.00	72.00
Grade	no.	1.9255	1.4271	1.00	7.00
Loan value	$	8.6128	2.1958	0.00	10.12
Peck	%	1.3036	1.1229	0.00	20.80
Total damage	%	2.3301	2.0578	0.00	28.80
Smut	%	0.3317	0.4929	0.00	4.40
Red rice	%	0.4095	1.1813	0.00	59.00
Other damage	%	0.7274	0.8815	0.10	21.50
Chalk	%	0.2142	0.0616	0.10	0.90
Stack light	no.	3.2624	27.4063	0.00	626.00
Stack dark	no.	0.0507	0.8744	0.00	26.00
Mix long grain	%	0.0000	0.0000	0.00	0.00
Mix medium grain	%	0.0881	0.3510	0.00	4.90
Test weight	lb/bu	45.1155	0.9900	40.10	49.10
Seed	no.	7.2128	47.2685	0.00	1509.00
Settlement price	$/cwt	8.7422	0.6557	3.78	9.62

Table B.20. Weighted means, standard deviations, and ranges of selected variables at American Rice, Incorporated northwest Texas warehouses, 1982-83

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	827			
Head yield	%	57.7165	4.6575	29.00	66.00
Mill yield	%	69.2640	1.4672	62.00	72.00
Grade	no.	1.5500	1.1208	1.00	7.00
Loan value	$	8.8580	1.5183	0.00	10.07
Peck	%	1.4782	0.9157	0.00	8.40
Total damage	%	2.4347	1.8936	0.00	12.80
Smut	%	0.4514	0.7225	0.00	6.70
Red rice	%	0.0445	0.1949	0.00	4.80
Other damage	%	0.4635	0.4282	0.10	4.90
Chalk	%	0.2422	0.0757	0.10	0.70
Stack light	no.	0.7627	12.2389	0.00	440.00
Stack dark	no.	0.0026	0.1021	0.00	4.00
Mix long grain	%	0.0000	0.0000	0.00	0.00
Mix medium grain	%	0.0135	0.0781	0.00	0.90
Test weight	lb/bu	45.3862	1.1534	39.70	49.30
Seed	%	5.5945	59.1900	0.00	1788.00
Settlement price	$/cwt	8.7644	0.4804	4.90	9.62

Table B.21. Weighted means, standard deviations, and ranges of selected variables at American Rice, Incorporated south Texas warehouses, 1982-83

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	1028			
Head yield	%	57.8099	3.8982	29.00	66.00
Mill yield	%	68.8219	1.5580	61.00	72.00
Grade	no.	1.5800	1.2446	1.00	7.00
Loan value	$	8.7485	1.7927	0.00	10.07
Peck	%	1.1828	0.9523	0.10	9.30
Total damage	%	2.2098	2.0694	0.30	17.50
Smut	%	0.3379	0.5689	0.00	6.10
Red rice	%	0.0697	0.4138	0.00	24.70
Other damage	%	0.4141	0.4690	0.10	7.30
Chalk	%	0.2247	0.0718	0.10	0.50
Stack light	no.	0.5212	11.8226	0.00	1043.00
Stack dark	no.	0.0000	0.0000	0.00	0.00
Mix long grain	%	0.0000	0.0000	0.00	0.00
Mix medium grain	%	0.0189	0.2228	0.00	22.40
Test weight	lb/bu	45.5644	1.0748	39.80	48.40
Seed	no.	4.6419	27.9132	0.00	961.00
Settlement price	$/cwt	8.7436	0.4558	5.23	9.62

Table B.22. Weighted means, standard deviations, and ranges of selected variables at American Rice, Incorporated east Texas warehouses, 1983-84

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	593			
Head yield	%	57.1328	5.1691	24.00	66.00
Mill yield	%	69.5399	1.2584	59.00	71.00
Grade	no.	2.0861	1.3603	1.00	7.00
Loan value	$	8.6932	1.9958	0.00	10.12
Peck	%	1.9204	1.5346	0.00	14.80
Total damage	%	2.7533	2.2252	0.00	17.20
Smut	%	0.3493	0.6084	0.00	4.40
Red rice	%	0.5137	2.0797	0.00	76.20
Other damage	%	1.0274	1.6776	0.10	46.20
Chalk	%	0.2749	0.1800	0.10	1.70
Stack light	no.	24.5000	253.5276	0.00	9999.00
Stack dark	no.	0.3426	15.6423	0.00	736.00
Mix long grain	%	0.0059	0.2487	0.00	14.20
Mix medium grain	%	0.1229	0.5370	0.00	10.40
Test weight	lb/bu	44.8965	1.1121	35.50	48.40
Seed	no.	5.0663	25.0444	0.00	372.00
Settlement price	$/cwt	10.0733	1.0561	4.88	12.00

Table B.23. Weighted means, standard deviations, and ranges of selected variables at American Rice, Incorporated central Texas warehouses, 1983-84

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	13			
Head yield	%	59.1482	4.1693	49.00	64.00
Mill yield	%	70.0195	1.0163	68.00	71.00
Grade	no.	1.9777	1.2501	1.00	6.00
Loan value	$	8.8207	2.4046	0.00	9.95
Peck	%	1.9576	0.9088	0.60	3.60
Total damage	%	3.5018	1.4557	1.20	5.80
Smut	%	0.1634	0.2109	0.00	0.80
Red rice	%	0.1546	0.1824	0.00	0.50
Other damage	%	0.7714	0.5061	0.20	1.90
Chalk	%	0.2226	0.0798	0.10	0.40
Stack light	no.	0.0000	0.0000	0.00	0.00
Stack dark	no.	0.0000	0.0000	0.00	0.00
Mix long grain	%	0.0000	0.0000	0.00	0.00
Mix medium grain	%	0.0623	0.1074	0.00	0.30
Test weight	lb/bu	44.3872	1.0206	42.40	45.70
Seed	no.	6.1097	16.7317	0.00	68.00
Settlement price	$/cwt	10.2402	0.8391	8.54	11.80

Table B.24. Weighted means, standard deviations, and ranges of selected variables at American Rice, Incorporated northwest Texas warehouses, 1983-84

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	718			
Head yield	%	56.1501	5.2789	18.0	65.00
Mill yield	%	69.3780	1.4926	52.0	72.00
Grade	no.	1.7131	1.2100	1.0	7.00
Loan value	$	8.8197	1.7201	0.0	10.09
Peck	%	1.5270	1.1090	0.2	11.20
Total damage	%	2.4639	2.0309	0.4	25.80
Smut	%	0.3824	0.6278	0.0	6.60
Red rice	%	0.0333	0.3843	0.0	19.20
Other damage	%	0.5818	0.7022	0.1	9.00
Chalk	%	0.3880	0.3046	0.1	1.60
Stack light	%	12.4936	84.1703	0.0	894.00
Stack dark	%	0.0450	1.0171	0.0	23.00
Mix long grain	%	0.0000	0.0000	0.0	0.00
Mix medium grain	%	0.0068	0.0607	0.0	1.40
Test weight	lb/bu	45.2385	0.9959	39.1	47.10
Seed	no.	4.5076	45.5096	0.0	1796.00
Settlement price	$/cwt	10.4587	0.9660	6.2	12.02

Table B.25. Weighted means, standard deviations, and ranges of selected variables at American Rice, Incorporated southern Texas warehouses, 1983-84

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Observation	no.	687			
Head yield	%	57.3550	3.6951	30.00	65.00
Mill yield	%	69.4021	1.2256	62.00	71.00
Grade	no.	1.5689	1.2222	1.00	7.00
Loan value	$	8.9445	1.7337	0.00	10.04
Peck	%	1.1499	0.9818	0.20	7.60
Total damage	%	2.2555	2.6200	0.30	19.80
Smut	%	0.0912	0.2051	0.00	2.50
Red rice	%	0.0283	0.2455	0.00	5.40
Other damage	%	0.4724	0.6620	0.10	6.40
Chalk	%	0.3439	0.2722	0.10	1.60
Stack light	no.	4.5754	42.9654	0.00	850.00
Stack dark	no.	0.0056	0.1059	0.00	2.00
Mix long grain	%	0.0000	0.0000	0.00	0.00
Mix medium grain	%	0.0086	0.0603	0.00	1.00
Test weight	lb/bu	45.4207	1.0756	37.50	47.90
Seed	no.	4.1405	22.7781	0.00	387.00
Settlement price	$/cwt	10.8109	0.9414	7.10	11.91

Table B.26. Maximum likelihood estimates of the Box-Cox Model at the Alvin, Danbury, El Campo, Ganado, and Bay City markets for the years 1981-82, 1982-83, and 1983-84

Market	1981-82	1982-83	1983-84	Combined years
Alvin	1.00	1.02	1.01	1.10
Danbury	--	1.01	1.02	1.01
El Campo	--	0.81	1.00	0.80
Ganado	0.85	1.00	0.11	0.93
Bay City	0.84	1.00	1.01	1.00

Note: A value of 1.00 means a linear model is selected while a value of 0 means a log-linear model is preferred.

Table B.27. Summary of 1985 rice stink bug control costs[a]

Insecticide[b]	Formulation (unit) rate/A	Active ingredients (lb) rate/A	Cost of insecticide $/unit	Cost of insecticide $/A	Spray volume gal/A	Flying cost $/A	Total cost $/A
Methyl parathion 4 EC	3/4 pt	0.25	1.34/pt	1.00	1-5	2.70	3.70
Sevin XLR-4lb/gal	1 qt	1.00	18.70/gal	4.68	2-3	3.10	7.78

[a] The reported costs are based on a survey of several companies located on both the west and east sides of the Texas Rice Belt. Thus, quoted costs should be fairly representative of the range of costs for the entire rice growing area.

[b] Methyl parathion is the least expensive and Sevin XLR is the most expensive treatment recommended for rice stink bug control; thus, these insecticides represent the largest range in stink bug control costs.

Source: Drees 1983.

Table B.28. Percent peck damage by county, American Rice, Incorporated data, 1982-83 and 1983-84

	Range of peck damage (%)						
County	0	.01-.50	.51-1.00	1.01-1.50	1.51-2.00	2.00-3.00	>3.00
	percent						
Brazoria	0.0	11.9	19.1	21.8	20.5	18.9	7.8
Harris	3.3	22.7	21.7	19.8	19.9	7.3	5.3
Matagorda	0.0	10.7	31.0	19.6	13.0	15.8	9.9
Calhoun	0.0	16.7	29.1	10.2	21.1	8.3	14.6
Jackson	0.0	24.4	37.4	15.2	10.5	7.3	5.2
Victoria	0.0	77.6	0.0	0.0	0.0	7.9	14.5
Wharton	0.0	30.4	33.7	18.7	8.3	6.5	2.4
Colorado	0.1	23.7	37.9	18.8	12.0	5.9	1.6
Fort Bend	0.0	3.0	15.5	21.8	18.1	31.5	10.1
Waller	0.0	1.1	16.2	27.7	17.9	25.1	12.0
Madison	5.2	3.2	36.7	15.2	27.0	7.3	5.4
Austin	0.0	0.0	17.2	0.0	58.5	0.0	24.3
Hardin	87.3	0.0	0.0	4.5	0.0	0.0	8.2
Orange	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Jefferson	4.7	4.2	16.8	19.4	18.7	20.4	15.8
Liberty	8.4	9.6	24.6	21.5	16.7	12.3	6.9
Chambers	11.6	6.1	11.6	9.2	16.7	24.8	20.0
Texas	2.8	14.1	27.1	19.4	15.0	13.9	7.7

Table B.29. Percent red rice by county, American Rice, Incorporated data, 1982-83 and 1983-84

County	Range of red rice (%)						
	0	.01-.50	.51-1.00	1.01-1.50	1.51-2.00	2.00-3.00	>3.00
	percent						
Brazoria	93.3	6.7	0.0	0.0	0.0	0.0	0.0
Harris	61.1	26.7	8.3	0.3	2.8	0.0	0.9
Matagorda	93.7	4.4	0.8	0.1	0.0	0.0	1.0
Calhoun	98.3	1.7	0.0	0.0	0.0	0.0	0.0
Jackson	87.9	9.2	2.0	0.4	0.3	0.2	0.0
Victoria	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Wharton	86.4	11.3	1.3	0.7	0.1	0.0	0.2
Colorado	92.3	6.8	0.4	0.2	0.2	0.1	0.0
Fort Bend	86.9	8.5	3.2	0.3	0.7	0.2	0.2
Waller	91.4	8.1	0.5	0.0	0.0	0.0	0.0
Madison	76.5	19.6	3.9	0.0	0.0	0.0	0.0
Austin	82.8	17.2	0.0	0.0	0.0	0.0	0.0
Hardin	41.8	48.8	9.4	0.0	0.0	0.0	0.0
Orange	33.7	35.6	15.8	5.0	3.0	0.0	6.9
Jefferson	38.8	41.0	8.3	3.9	2.2	1.8	4.0
Liberty	54.8	32.1	5.6	1.8	1.0	1.7	3.0
Chambers	44.2	30.2	11.4	3.2	2.6	3.4	5.0
Texas	78.4	15.5	2.9	1.0	0.6	0.5	1.1

Table B.30. Percent smut damage by county, American Rice, Incorporated data, 1982-83 and 1983-84

	Range of smut damage (%)						
County	0	.01-.50	.51-1.00	1.01-1.50	1.51-2.00	2.00-3.00	>3.00
	percent						
Brazoria	62.0	38.0	0.0	0.0	0.0	0.0	0.0
Harris	32.2	42.9	5.8	12.1	4.2	2.8	0.0
Matagorda	41.1	52.0	5.0	0.8	0.4	0.7	0.0
Calhoun	33.4	50.6	12.7	0.0	3.3	0.0	0.0
Jackson	47.3	36.5	6.6	4.9	1.8	2.7	0.2
Victoria	53.5	46.5	0.0	0.0	0.0	0.0	0.0
Wharton	45.0	41.9	7.8	3.0	0.8	1.3	0.2
Colorado	33.5	50.5	10.1	2.5	2.1	0.4	0.9
Fort Bend	30.3	39.6	17.9	5.1	3.4	1.6	2.1
Waller	23.3	39.5	15.0	8.4	7.7	4.0	2.1
Madison	34.6	40.4	9.8	10.4	2.8	2.0	0.0
Austin	17.2	29.3	53.5	0.0	0.0	0.0	0.0
Hardin	80.6	19.4	0.0	0.0	0.0	0.0	0.0
Orange	32.2	54.2	9.8	3.8	0.0	0.0	0.0
Jefferson	27.0	42.6	16.9	6.4	1.0	3.4	2.7
Liberty	27.6	55.4	10.5	3.1	1.0	2.1	0.3
Chambers	45.0	43.5	5.5	4.3	1.7	0.0	0.0
Texas	34.4	47.1	10.2	3.8	2.0	1.8	0.7

Table B.31. Percent chalk by county, American Rice, Incorporated data, 1982-1983 and 1983-84

County	Range of chalk (%)						
	0	.01-.50	.51-1.00	1.01-1.50	1.51-2.00	2.00-3.00	>3.00
	percent						
Brazoria	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Harris	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Matagorda	0.0	98.8	1.2	0.0	0.0	0.0	0.0
Calhoun	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Jackson	0.0	92.8	5.2	1.3	0.7	0.0	0.0
Victoria	0.0	74.3	25.7	0.0	0.0	0.0	0.0
Wharton	0.0	91.7	6.9	11.4	0.0	0.0	0.0
Colorado	0.0	84.7	11.8	3.3	0.2	0.0	0.0
Fort Bend	0.0	95.1	2.9	2.0	0.0	0.0	0.0
Waller	0.0	94.3	4.8	0.9	0.0	0.0	0.0
Madison	0.0	96.8	3.2	0.0	0.0	0.0	0.0
Austin	0.0	82.8	17.2	0.0	0.0	0.0	0.0
Hardin	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Orange	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Jefferson	0.0	98.4	1.6	0.0	0.0	0.0	0.0
Liberty	0.0	96.4	3.2	0.4	0.0	0.0	0.0
Chambers	0.0	96.5	2.4	1.0	0.1	0.0	0.0
Texas	0.0	93.8	5.0	1.1	0.1	0.0	0.0

Table B.32. Number of seed by county, American Rice, Incorporated data, 1982-83 and 1983-84

County	Range of seed (no.)						
	0	.01-2.50	2.51-5.00	5.01-7.50	7.51-10.00	10.01-15.00	>15.00
	percent						
Brazoria	90.3	0.0	9.7	0.0	0.0	0.0	0.0
Harris	46.7	0.0	47.0	0.0	0.0	0.0	6.3
Matagorda	77.0	0.0	12.7	0.4	1.5	1.9	6.5
Calhoun	96.2	0.0	0.8	1.1	0.0	1.4	0.5
Jackson	86.8	1.0	5.9	0.1	0.7	0.5	5.0
Victoria	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Wharton	78.4	0.4	9.3	1.4	1.3	1.4	7.8
Colorado	82.8	0.4	7.6	0.3	0.8	1.0	7.1
Fort Bend	81.0	0.0	11.8	1.0	0.4	0.6	5.2
Waller	84.1	2.2	10.0	0.2	0.6	0.3	2.6
Madison	89.4	0.0	2.8	4.4	0.0	0.0	3.4
Austin	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Hardin	80.5	0.0	19.5	0.0	0.0	0.0	0.0
Orange	83.9	0.0	7.1	0.0	0.0	0.0	9.0
Jefferson	84.2	0.0	8.2	0.2	1.8	0.5	5.1
Liberty	75.6	0.4	13.6	1.5	0.3	1.4	7.2
Chambers	80.2	0.4	10.6	11.2	0.2	0.2	7.2
Texas	80.8	0.5	9.4	1.0	0.9	1.0	6.4

Table B.33. Mean and standard deviation for rice quality factors, American Rice, Incorporated data, 1982-83 and 1983-84

County	Peck		Red Rice		Smut		Chalk		Seed	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
	percent								number	
Brazoria	1.63	1.22	0.02	0.09	0.06	0.08	0.20	0.09	0.37	1.16
Harris	1.29	1.19	0.20	0.56	0.45	0.65	0.20	0.05	7.53	24.78
Matagorda	1.57	1.12	0.07	0.65	0.19	0.31	0.22	0.10	3.23	11.33
Calhoun	1.76	1.73	0.01	0.05	0.30	0.38	0.19	0.08	0.38	2.22
Jackson	1.15	0.90	0.05	0.22	0.30	0.58	0.28	0.21	3.51	33.37
Victoria	0.98	1.34	0.00	0.00	0.05	0.06	0.47	0.20	0.00	0.00
Wharton	1.01	0.78	0.05	0.27	0.24	0.47	0.28	0.19	5.67	24.93
Colorado	1.05	0.74	0.02	0.15	0.30	0.55	0.34	0.26	4.84	21.65
Fort Bend	1.95	1.00	0.08	0.53	0.51	0.87	0.27	0.17	11.51	110.83
Waller	1.91	1.02	0.02	0.07	0.61	0.76	0.29	0.16	1.75	9.57
Madison	1.33	0.77	0.06	0.14	0.41	0.54	0.26	0.17	1.48	5.85
Austin	2.29	1.21	0.02	0.04	0.53	0.31	0.22	0.18	0.00	0.00
Hardin	0.40	1.14	0.23	0.27	0.02	0.04	0.24	0.05	0.63	1.32
Orange	0.00	0.00	0.71	2.09	0.24	0.28	0.22	0.07	5.53	22.89
Jefferson	1.91	1.41	0.48	1.06	0.51	0.76	0.21	0.10	4.14	22.30
Liberty	1.42	1.23	0.41	1.82	0.32	0.49	0.25	0.13	7.37	46.31
Chambers	2.04	1.63	0.63	1.54	0.22	0.38	0.25	0.16	4.69	18.32
Texas	1.41	1.06	0.07	0.43	0.34	0.58	0.28	0.19	5.06	39.11

Table B.34. Tests of hypothesis of consistency in quality effects across Texas bid/acceptance markets (F-ratio)[a]

Quality factor	Market year[b] 1981-82	1982-83	1983-84
Market	1.97	11.06*	12.40*
Mill price	2.57**	13.16*	7.07*
Head yield	8.92*	1.88	4.68*
Brokens	1.74	2.20**	2.21*
Weed seed	5.93*	2.76*	0.98
Red rice	0.89	2.06	1.87
Peck	2.12	3.49*	12.97*
Smut	1.16	0.64	24.48*
Chalk	0.46	1.26	1.14
Heat damage	3.04*	2.39*	6.30*
Test weight	4.10*	2.41*	0.71

* Indicates rejection of the null hypothesis (i.e., quality effects are equal across markets) at the 5 percent level of significance.

**Indicates rejection of the null hypothesis at the 10 percent level of significance.

[a] Bid/acceptance markets were located at Alvin, Danbury, Bay City, El Campo, and Ganado.

[b] Rejection of the null hypothesis indicates that premiums/discounts for that quality factor are different across markets within a given year.

Table B.35. Correlation between quality factors

Market year and quality factor	Quality factor								
	Mill price	Head yield	Brokens	Seed	Red rice	Peck	Smut	Chalk	Heat damage
1981-82:									
Head yield	0.10								
Brokens	-0.03	-0.96							
Seed	-0.12	-0.06	0.01						
Red rice	0.16	-0.00	0.02	0.13					
Peck	-0.05	-0.10	0.03	0.50	0.17				
Smut	0.10	-0.15	0.13	-0.17	-0.05	-0.12			
Chalk	0.24	0.07	-0.04	0.34	0.28	0.59	-0.06		
Heat damage	-0.08	-0.01	0.01	0.01	-0.01	0.04	-0.03	0.07	
Test weight	0.05	0.31	-0.17	-0.38	-0.10	-0.54	-0.12	-0.31	-0.11
1982-83:									
Head yield	-0.01								
Brokens	-0.01	-0.94							
Seed	-0.09	-0.05	0.03						
Red rice	0.06	0.05	-0.02	0.02					
Peck	0.07	-0.28	0.21	0.09	0.10				
Smut	0.07	0.14	-0.13	-0.06	0.06	0.05			
Chalk	0.14	0.21	-0.14	-0.03	0.45	0.20	0.24		
Heat damage	0.03	0.01	0.01	0.01	0.02	0.04	0.13	0.14	
Test weight	-0.11	0.25	-0.16	-0.05	-0.10	-0.23	-0.04	-0.01	-0.09
1983-84:									
Head yield	0.06								
Brokens	-0.08	-0.96							
Seed	0.14	-0.03	-0.01						
Red rice	0.00	-0.10	0.09	-0.03					
Peck	0.09	-0.33	0.29	0.12	0.05				
Smut	-0.05	-0.07	0.07	-0.08	0.08	0.11			
Chalk	-0.05	-0.36	0.48	-0.07	0.21	0.18	0.12		
Heat damage	0.02	0.04	-0.02	-0.02	0.00	0.04	0.01	0.12	
Test weight	-0.02	0.47	-0.45	-0.03	-0.14	-0.36	-0.09	-0.47	-0.09

Table B.36. Tests of significance of classification variables (Texas bid/acceptance markets) on selected quality variables (F-ratio)

Classification variable	Selected variables	Market year[a]		
		1981-82	1982-83	1983-84
Market	Head yield	21.02*	39.49*	18.65*
	Brokens	9.54*	14.39*	32.72*
	Test weight	7.32*	24.43*	38.72*

* Indicates rejection of the null hypothesis at the 5 percent level of significance.

[a] Rejection of the null hypothesis indicates that the market intercept term is not equal across markets for that year.

Table B.37. Tests of hypothesis of constancy in peck coefficients on selected variables across Texas bid/acceptance markets (F-ratio)[a]

Quality factor affected by peck	Market year[b] 1981-82	1982-83	1983-84
Head yield	0.46	3.97*	6.33*
Brokens	0.88	3.98*	8.40*
Test weight	4.51*	17.13*	13.97*

* Indicated rejection of the null hypothesis at the 5 percent level of significance.

[a] Bid/acceptance markets were located at Alvin, Danbury, Bay City, El Campo, and Ganado.

[b] Rejection of the null hypothesis indicates that the effect of peck on head yield, brokens, or test weight was different across markets within a given year.

Table B.38. Impact of peck on selected quality variables, American Rice, Incorporated (t-ratios in parentheses)

Item	1982-83	1983-84	1982-83/1983-84
Head yield:			
Intercept	59.6259 (471.79)*	57.7725 (369.79)*	58.9856 (596.50)*
Peck	-0.9588 (-13.39)*	-0.6146 (-7.79)*	-0.8409 (-15.68)*
F-ratio	179.24*	60.63*	245.77*
R^2	0.052	0.026	0.042
Brokens:			
Intercept	10.3730 (94.05)*	12.1042 (88.62)*	10.9455 (125.92)*
Peck	0.4640 (7.42)*	0.3393 (4.92)*	0.4451 (9.44)*
F-ratio	55.12*	24.18*	89.13*
R^2	0.016	0.011	0.016
Test weight:			
Intercept	45.9359 (1591.32)*	45.4722 (1293.59)*	45.7586 (2041.17)*
Peck	-0.4225 (-25.83)*	-0.2049 (-11.54)*	-0.3320 (-27.30)*
F-ratio	667.00*	133.13*	745.53*
R^2	0.168	0.055	0.118

* Indicates rejection of the null hypothesis at the 5 percent level of significance.

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