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An Empirical Analysis of the Effects of Quality Factors on the Price of Rough Rice in Louisiana.

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AN EMPIRICAL ANALYSIS OF THE EFFECTS OF QUALITY FACTORS ON THE PRICE OF ROUGH RICE IN LOUISIANA

A Dissertation

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ABSTRACT

This dissertation analyzes the effects of quality factors on prices paid producers for long and medium grain rough rice in Louisiana. Rough rice prices, and other information surrounding quality, were collected for the study for the 1986/87 and 1987/88 marketing years from the Louisiana Farm Bureau Marketing Association in Crowley, Louisiana.

The relationship between the price of rough rice, and its quality attributes or characteristics, was analyzed in a hedonic price framework. A conceptual model for the Louisiana rough rice market was constructed, and estimated premiums and discounts reported for a set of quality factors believed to influence producer prices.

Premiums and discounts were calculated for long and medium grain markets for the 1986/87 and 1987/88 marketing years and for marketing seasons within marketing years. The hedonic model was tested for structural differences across marketing years, marketing seasons, and classes of rough rice. Structural differences were found in all cases. A linear specification was chosen for the base model. However, the Box-Cox transformation indicated a semi-logarithmic specification for the 1987/88 marketing year.

In the set of quality factors studied head rice, red rice, and heat damage were the most important monetarily. The monetary value of the quality factors were calculated for

an average producer and compared to the cost of controlling quality where applicable.

Significant error problems were identified and rigorously analyzed in the hedonic models. In addition to least-squares point estimates, the hedonic model was estimated using an error-in-variables model (EVM). From this model a set of consistent hedonic prices were calculated. Prior information was used to re-specify and estimate the original hedonic rough rice model. The regressions were adjusted to account for the measurement error and statistics were calculated to measure the degree of error. The EVM model provided a likely range (upper and lower bound) for the premiums and discounts, and thus directly assessed the uncertainty about premiums and discounts relative to least squares estimates. The monetary value of premiums and discounts was reassessed based on these bounds.

AN EMPIRICAL ANALYSIS OF THE EFFECTS OF QUALITY FACTORS ON THE PRICE OF ROUGH RICE IN LOUISIANA

CHAPTER I

INTRODUCTION

The value of rough rice is influenced by several factors related to quality. Quality, as defined by Doll, Rhodes and West "is the sum of attributes of a product which influences its acceptability to many buyers and, hence, the price they are willing to pay for it."

Many of the quality factors affecting rice prices are related to production practices i.e., foreign seeds, insects, disease, etc. The discounts associated with those factors not only determine the net price of the product but also, to the extent they can be ascertained, determine which cultural practices are employed to control negative factors or enhance positive ones.

According to United States Department of Agriculture (USDA) inspection handbook for rice, the official quality of rice is determined by the following factors: 1) Grade level: the grade factors used to determine the grade level are weed seeds, damage, red rice, chalkiness, general appearance and "other". 2) Milling yield: "an estimate of the quantity of head rice and total milled rice (head and broken kernels combined) that will be produced in the processing of rough rice to a well milled degree." Head rice is rice that is 3/4 kernel or longer in length after milling. 3) Class: class is determined by the length, width and thickness of unprocessed kernels.[1]

Table 1 shows U.S.D.A standards for rough rice. These standards apply a "worst factor rule" (Martinez, et al.) ie. if a sample meets all the requirements for a specific grade except for one requirement, the sample will receive the lower grade under the worst factor rule. The standards given in

Table 1. USDA Standards for Rough Rice.

	Maximum Limits of						
	Seeds and Heat-Damaged Kernels			Chalky Kernels			
No. Grade	Total (Singly or Combined (No. in 500 Grams)	Heat-Damaged Kernels and Objectionable Seeds Combined (No. in 500 Grams)	Red Rice and Damaged Kernels (Singly or Combined)	In Long Grain Rice	In Medium or Short Grain Rice	Other[1/] Types	Colors
			----------- percent -----------				
US 1	4	3	0.5	1.0	2.0	1.0	Shall be white or creamy
US 2	7	5	1.5	2.0	4.0	2.0	May be slightly gray
US 3	10	8	2.5	4.0	6.0	3.0	May be gray slightly rosy
US 4	27	22	4.0	6.0	8.0	5.0	May be dark gray or rosy
US 5	37	32	6.0	10.0	10.0	10.0	May be dark gray or rosy
US 6	75	75	15.0	15.0	15.0	10.0	

US Sample grade shall be rough rice which: (a) does not meet the requirements for any of the grades from US 1 to US 6, inclusive; (b) contains more than 14.0 percent of moisture; (c) is musty, or sour, or heating; (d) has any commercially objectionable foreign odor; or (e) is otherwise of distinctly low quality.[2/]

Source: Rice Inspection Handbook USDA 1977.

1/ The predominant other types of damage found in rough rice are peck and smut.
2/ For the remainder of this research sample grade rice is given the numerical grade 7.

[1] For a more detailed explanation, see U.S.D.A. Inspection Handbook, p. 3.03.

Table 1 are applied to samples of rough rice which have been, in effect, milled by a standard but simulated process. Very few buyers strictly adhere to these standards or to the official processes used to measure them; however, the processes actually used by them are said to provide generally similar information.

Some of the differences in grading are believed to arise from differences in market forces across rice producing areas. For example, a larger percentage of Texas produced rice goes to the domestic market than does Louisiana produced rice which normally goes in greater proportions to the export market. The domestic market is believed to be more sensitive to certain quality factors than are some segments of the export market.

The Problem

In a market economy, the value of a commodity is determined in a system in which efficiency depends in part on the quantity and quality of information exchanged among participants (Ethridge and Neeper). Thus, in the U.S. market the price of rough rice is determined by those quality and non quality factors that characterize a sample of it, *ceteris paribus*. Currently, there is no widely accepted set of premiums or discounts reported for any of the quality factors believed to affect rice prices. Except for discounts applied to rice acquired under the government price support program, sellers largely rely on general experience and marketing operators for information on which to make production, pricing and other marketing decisions.

The specific problem addressed in this dissertation is to provide information about the effects of quality factors on the price of rough rice received by Louisiana farmers. That is, what are the premiums and discounts associated with specific quality factors in the Louisiana rough rice market? Economically sound production and marketing decision making requires accurate and timely information on these factors.

In production planning the producer is faced with many important decisions. Economic theory suggests that a rational decision maker will employ the use of a resource up to the point where the expected marginal gain equates the expected marginal expenditure for that resource. The market structure for production inputs is efficient in that a producer can accurately, and on a timely basis, determine the cost of a unit of input e.g., the cost of insecticides to control stink bugs. However, information concerning price gains that are likely to be received in the rice market from employing given resources (e.g., stink bug control) to improve quality is not readily available. That is, a producer does not have a quantitative measure of the expected discount for a defined level of damage and other quality attributes. Hence, he is often unable to make a rational decision concerning the optimal usage of specific inputs. Given more reliable measurements of premiums and discounts associated with quality

factors, producers could function more efficiently in t
regard.

The lack of published information concerning quality values also affects the marketing of rough rice in other ways. Under the present system, for example, each potential buyer inspects and evaluates each sample of rice offered at auction sales and in much of the negotiated market. The physical handling of the samples by all buyers is time consuming, costly, and inefficient. Once the buyers evaluate the samples each may submit a bid to the seller. If one has generally bid too high, he will likely be buying more inventory than currently needed; if the bid is too low he may not obtain the needed inventory on a timely basis.

These problems appear to have been overcome in other grains and soybeans. For many years, soybeans, corn and wheat have been sold on the basis of standard grades and discounts for quality factors that do not measure up to those grades. Discounts announced by merchants are seldom changed within a marketing year and often not between years. Official grade standards are changed even less frequently. Given this situation, buyers can negotiate exactly the quantity needed and sellers know more precisely what the market is discounting for various quality factors. Appendix A Table 1, for example, shows the scale of discounts for test weight, moisture, damage, foreign matter (FM), shrunken and broken kernels and defects as reported by four major grain merchandising firms for wheat in 1989. Each of these merchants purchase from Louisiana producers.

Justification For Research

The rice industry is an important component of Louisiana's economy. In 1987, rice was the third largest, in terms of cash receipts, crop produced in the state. Cash receipts totaled approximately 169 and 111 million dollars in 1985 and 1986, respectively.

To the extent this research is successful, industry participants will benefit through increased efficiency. More accurate knowledge concerning prices and quality will be t nsferred to producers and agribusiness firms causing rice to be produced closer to what the market needs than is now the case. This information can be used to make more optimal decisions both about selling and the control of quality factors which affect the net prices received for various lots of rice.

Aggregated over producers, this information may also identify key areas for further research concerning the control of certain quality factors. The data base detailed for this study could also aid other researchers, for example in evaluating quality attributes in new varieties of rice that could be introduced. This information could also aid researchers in improving other cultural and processing practices.

An understanding of the variation in prices due to quality can also help producers choose among available marketing strategies. More knowledge of premiums and discounts in the market would be useful to producers and agribusiness operations; for example, in constructing basis charts for evaluating hedging opportunities, establishing electronic markets, and in evaluating basis and other types of forward contracts.

Objectives

General Objective

The general objective of this study is to measure the effect of quality factors on prices received by producers of rough rice in Southwest Louisiana.

Specific Objectives

The specific objectives are to:

1. Develop a data base of rough rice cash prices and associated quality and non-quality factors.

2. Identify quality and non-quality factors that affect prices received by farmers for both long and medium grain rough rice varieties.

3. Develop a hedonic price model that captures the price quality effects that exist in the Louisiana market for long and medium grain rough rice.

4. Determine if premiums and discounts associated with selected quality factors differ throughout the marketing season and across marketing years.

5. Estimate the monetary value of selected quality factors and compare these values to marginal costs of controlling them.

General Methodology

The relationships between the price of rough rice offered by buyers and the quality attributes or characteristics that are embodied in the commodity. The prices (premiums and discounts) associated with the quality attributes are termed hedonic or implicit prices. In this study, a hedonic price model is developed to approximate these relationships as estimated for the 1986/87 and 1987/88 marketing years for Louisiana. Proxies for quality factors specified in USDA grades, as well as other factors believed to affect the price of rough rice, were studied.

The Data

Rough rice prices and other information, including quality, surrounding individual sales transactions were collected for the 1986/87 and 1987/88 marketing years from the Louisiana Farm Bureau Marketing Association (LFBMA) in Crowley, Louisiana. This organization conducts a bid-acceptance auction, in which producers submit samples of their rice to the organization which in turn distributes portions of the sample to potential buyers, mostly mill operators. In the process, the LFBMA grades the rice for the information of its members. Each buyer also evaluates the quality of the samples for their needs and submits a bid on those lots in which they may be interested. The producer then either accepts or declines the bid.

In the grading process for rough rice, typically, a 500 gram sample is drawn by LFBMA and other commercial interests and processed to a well milled degree in a laboratory. Head and broken kernels are then separated, via screened shaker, and respectively weighed. Head and total milled rice, with the difference being broken kernels, are then calculated as a percentage of rough rice. For example rough rice, which when milled, may yield 55-70 i.e., 55 pounds of head rice and 70 pounds of total rice out of 100 pounds of rough rice. Post milling, the sample is inspected and levels of quality recorded in the form of a numerical grade (1-7).

The 500 gram sample often used in the trade is one of the main things different from the procedures used by the USDA Federal Grain Inspection Service (FGIS) which start with a 1000 gram sample. There are other minor differences in the procedures as well but one can approximate FGIS grades and actual yields from particular milling configurations from the procedures used in this study.

The data base includes information on individual producer lots submitted to LFBMA for sale between July 1986 and March 1988. It contains over 3000 observations of the highest offered price along with other information about the transactions. The information is essentially a pooled, time series, cross-sectional data set comprised of a cross-section of producers over two marketing seasons.

Quality information includes the overall estimated US grade, the milling yield, and a numerical grade for each of the set of quality factors used to estimate the US grade. Information on lot size (quantity of rice being offered for sale), sale date, producer location, class of rice (long or medium grain), and the variety of the rice were also obtained. The milling yield estimates the percentage of head and total rice that can be obtained from a given amount of rough rice. The difference between total rice and head rice is termed broken rice i.e., 3/4 or less of a kernel in length; head rice is 3/4 or more of a kernel in length.

The set of quality factors collected includes: (1) red rice, an undesirable wild rice; (2) quantity of foreign seeds; (3) heat damage, often but not exclusively caused by applying excess heat during the drying process, causing discoloration in the rice kernels; (4) chalk, a failure of the kernel to develop completely; (5) peck, caused mainly by stink bug damage; and (6) smut, caused by diseases.

Each of the quality factors, except for foreign seeds, was originally reported as a numerical grade (1-7) generally aligned with standards set for grades one through six and a sample grade by the USDA (Table 1). For purposes of this study, the grades were converted to an estimate of percent damage using the USDA grade standards reported in Table 1.

The midpoint of the range for each grade was used in this regard.

Organization of The Dissertation

This dissertation is organized into five chapters. Chapter II reviews relevant literature, both applied and theoretical. The literature review is followed by some theoretical considerations about hedonic pricing. The analytical framework and procedures are then proposed and discussed. Chapter III presents the data base for long and medium grain rough rice for the 1986/87 and 1987/88 marketing years. That chapter also goes into some detail about the Louisiana rice market and rice quality for the two marketing seasons studied. Chapter IV presents the main results from the development and estimation of the hedonic models. It also presents a variety of estimations relative to the markets and error properties of the hedonic models. Further, included in Chapter IV is a detailed analysis about the structure of the models across marketing seasons (harvest vs. post harvest), between marketing years, and between classes of rough rice (long vs. medium). The premiums and discounts for quality found in this study are also presented on a per acre basis and compared to the marginal cost for controlling them. Also, a consistent set of premiums and discounts are estimated using an error-in-variable model (EVM). Chapter V summarizes the research, draws some conclusions and discusses some implications for further research on this topic.

CHAPTER II

LITERATURE REVIEW, THEORETICAL CONSIDERATIONS, AND PROCEDURES

Literature Review

Most of the applications using hedonic pricing have dealt with industrialized products (Brorsen). That is, the empirical application of hedonic pricing in agricultural commodities has been limited but has increased in number during the eighties (at least five such studies have been published).

Hedonic Studies Applied to Agricultural Commodities

In 1982, Ethridge and Davis investigated prices associated with quality attributes of cotton lint. The quality attributes examined were: trash content, color, staple (length of cotton fiber), and micronaire (index of fiber fineness maturity). The data set used was a pooled time series cross-section for producer sales to nine cotton gins for two marketing years (1976/77 and 1977/78). They estimated hedonic prices using both OLS and Generalized Least Squares (GLS) estimation procedures. GLS procedures were used because they suspected autocorrelation, given the data showed seasonal price patterns (Ethridge). They included a time variable to capture tne time series effect. They developed models for each year and one for the two years combined. Correct signs and statistical significance were found for all quality factors examined. The OLS models exhibited significant first order autocorrelation.

Ethridge and Davis also believed that hedonic prices were not constant between marketing years so they performed a Chow test to see if there were any structural difference in the parameters between the years. The Chow test indicated there was a significant difference between marketing years and the researchers concluded that hedonic prices are not static.

For the marketing year 1981-82 Brorsen, Grant, and Rister estimated hedonic prices associated with rough rice in a bid/acceptance market in Texas. They addressed the problem of determining if U.S. grades capture all the quality factors that affect the value of rough rice. They estimated hedonic prices (discounts and premiums) associated with various quality factors. They also investigated factors that determine if a bid is accepted or not. A hedonic price model was estimated which included the following quality factors: head yield, mill yield, test weight, weed seeds, peck (stink bug damage), red rice, smut, green rice, chalk, and heat. The dependent variable of the hedonic model was the highest bid (or offer) price. The authors argued that this price represented demand for rough rice since it could have been declined by the producer. They included the Texas weekly mill price as an index variable to capture seasonal price patterns. The hedonic model was specified as linear for both the index variable and quality factors. They also estimated producer supply and determined the probability of accepting a bid.

The results of the study described above indicate that USDA grades do not adequately explain observed quality differentials. They also found that head rice and stink bug damage were the most important quality factors affecting the price of rough rice that producers could control. They estimated models that included (1) only USDA grades as explanatory variables, (2) only grade quality factors as explanatory variables, and (3) models that combined USDA grades and quality factors. They found the model which included only quality factors explained more of the variation in rough rice price than did the other models. No error problems associated with the estimated models were reported.

Brorsen, Grant, and Rister later updated their previous study to include additional years and markets. Geographically, the Texas rice market is large and they hypothesized that differences existed not only between years but between markets. Another major difference between the studies was the price that was used as the dependent variable i.e. the final transaction price rather than the highest offer price. The authors argued the final settlement price is more related to production than demand and this shows the reduced form effects of quality factors on equilibrium prices. They again selected a linear specification of the index variable and the quality factors. However, in this study they performed model specification tests for the correct functional form (Box-Cox procedure). Results indicated the linear specification was correct for all markets and years studied.

They analyzed the effect of quality on rough rice prices in three markets for the 1981/82 season and five markets for the 1982/83 and 1983/84 marketing years. Each of the markets was located on the west side of Houston - Alvin, Danbury, Bay City, El Campo, and Ganado, Texas. Their data set consisted of a cross section of producer lots pooled over the marketing year.

They used the same set of quality factors as in their previous study. However, they included dummy variables for the markets and used covariance analysis to test for differences in the slope and intercept terms across markets. They found significant differences across markets using the following function for each market in each year:

Price = f(mill price, head rice, broken rice, seed, red rice, peck, smut, chalk, heat, test, error term)

Results of the estimated hedonic price models found head rice and peck damage to be consistently the most important quality factors across markets and years. Sign and significance of the other variables were mixed across the various models proposed.

They also analyzed the effects of peck damage, caused by the stink bug, on other quality factors (head, brokens, and test weight) across years and markets. Peck damage has secondary effects on price since it appears to affect the amount of other quality factors, most importantly head rice.

They used the parameters of estimated hedonic price models to estimate premiums and discounts on a per acre basis for each year and each market.

It is worth noting that in neither of these two studies was the error properties of the hedonic price model indicated. Other studies (Ethridge) found significant autocorrelation. Given the data set used in the later two studies, that being a pooled, time series cross-sectional data base, error problems are expected i.e., errors which violate classical linear model assumptions. These problems have non-trivial implications concerning the validity of the estimated model.

In 1987, Ethridge and Neeper used a hedonic approach to estimate the premiums/discounts associated with two fiber properties currently excluded from the official USDA cotton grading system: strength and length uniformity. Producer prices were separated into two components, loan price and premium over loan, and these were estimated simultaneously using seemingly unrelated regression (SUR) procedures. Estimating the two equations gave insight into knowledge of the differences between loan and market prices and the context in which loan price factors explain market prices. The structure of the model was very similar to Ethridge's previous study.

In 1976, Martinez, Traylor, and Fielder conducted an analysis of the effect of quality and non-quality factors on prices of long and medium grain rice in Louisiana. Though not termed a hedonic study, the procedures used were consistent with the hedonic theory. The study covered the marketing years 1968/69 through 1973/74. They examined the following quality factors: (1) grade level and the following grade factors; weed seeds, red rice, chalk, general appearance, and "other". (2) milling yield and (3) class of rice. They compared two different grading systems. One grade, established by the Louisiana Grain Exchange, was considered to represent the buyer. The other grade was that of the USDA. They conducted a tabular and distributional analysis of the quality factors and associated grade levels for both medium and long grain rice. The two grades were compared and a conclusion reached that the government assigns better grades to the same lot of rice than does the buyer.

Statistical models were estimated for both grade and price. Results indicated that head rice, time trend, and red rice were significant in determining prices for both long and medium grain variety rice. Significant differences in quality factors between long and medium grain rice were observed. Also, variety of rice significantly affected the price of rice in their study. Linear and quadratic trend variables were included in all price models. Other variables examined were lot size, mill buyer, month of year, and location of rice.

Early Studies and Theoretical Foundations

The use of hedonic (as implicit) prices to measure or analyze the effects of quality on commodity prices is a relatively new approach used in economics and statistics. In 1961, Irma Adelman and Zi Griliches published a benchmark study for measuring quality effects on price which stimulated further applied and theoretical studies in this area.

The central problems which stimulated that study dealt with a systematic procedure for adjusting price indices e.g., CPI (Consumer Price Index) for quality change over time, due to technological change, and across new products as old products in the market basket become obsolete or not available. Adelman and Griliches discussed different means used at the time by the U.S. Bureau of Labor Statistics for adjusting the CPI for quality changes.

The central question posed in the article was "How much additional money would the average consumer have to pay in the base year in order to get a basket of goods identical with the one he purchased in the base year, except that the qualities available are those of the given year?" They addressed this question by first defining the concept of quality consisting of a composite of a number of different characteristics, each characteristic representing a different dimension of the commodity. They state that this specification of the notion quantifies quality into J objectively measured characteristics. The authors state that the number of quality specifications will differ for each commodity and will vary with time, implying the hedonic price function is not constant over time.

Adelman and Griliches give the following equation which assumes that the change in price of the ith commodity can be decomposed into two distinct additive components:

$$(2.1) \qquad dPi = dpi' + \sum_{j} \frac{\partial Pi}{\partial dij} d\alpha ij$$

where dpi' is the price movement which would have occurred in the absence of quality variations; $\frac{\partial Pi}{\partial dij}$ is the change in price from changing commodity i; and $d\alpha ij$ is the change in quality factor j. The above specification is the most popular specification used in current hedonic price studies.

The authors argue that for markets in which prices are free to fluctuate the marginal hedonic price ($\partial pi/\partial \alpha ij$) is equivalent to the increase in satisfaction generated from increasing the jth quality factor. They define the expression $\partial pi/\partial \alpha ij \; d\alpha ij$ as precisely the change one would observe in the price of the ith commodity if its jth quality index were increased by a small amount of $d\alpha ij$ (ceteris paribus). The study goes on to demonstrate that these partial derivatives that capture quality effects can be estimated by statistically estimating a regression equation that specifies the price of commodity i as a function of a set of j quality factors. The quality effects can then be obtained by taking the partial derivative of the estimated equation (partial regression coefficients). They offer two alternative regression equations: (a) a linear specification, and (b) a semi-logarithmic specification.

The study presents the results of an example of this technique applied to the automobile industry. After some experimentation, the authors used a semi-logarithmic model and justified its use by the degree of fit. The article then went on to demonstrate how these regression coefficients can be used to adjust indexes for changes in quality and justifying this procedure by showing that the marginal rate of substitution between quality characteristics is proportional to the ratio of their quality prices.

Some of the earlier theoretical recognitions of commodities as bundles of characteristics or attributes include Ironmonger, 1960; Lancaster, 1966; and Houthakker, 1951. Two studies by Robert E.B. Lucas (1975), and Sherwin Rosen (1974), use theoretical recognition of prices to show how hedonic price functions, how they are derived and what these implicit prices represent in a market economy. These two articles are the foundation for the next section of this dissertation (Theoretical Considerations of Hedonic Price Functions) and are presented in some detail at that point.

Lucas first introduces and defines a hedonic price function. He bases the hedonic function on Adelman and Griliches work and "Lancasterian Consumer Theory." The first section of that paper discusses hedonic price functions and consumer choice. He uses the Lancasterian consumer theory to show how an individual chooses levels of product characteristics to be consumed and how the solution to this problem gives rise to a hedonic price function. He then discusses hedonic price indices and how these indices relate to consumer theory. The last two sections of the paper discuss hedonic price functions, production cost, supply and demand, and the hedonic price function. Lucas uses a symmetric theoretical framework as established by consumer theory to producer theory by letting cost, instead of utility, be a function of characteristic to determine the optimal quantities of characteristics a producer will supply. He then discusses how one could specify supply and demand functions as a function of price.

Rosen ties the development of hedonic prices to implicit markets for the characteristic which hedonic prices represent. He introduces a class of differentiated products (versus the standard assumption of homogenous products used in the markets of pure competition) that can be described completely by a vector of characteristics capable of objective measurement.

He proceeds to show that observed product prices and quantifiable characteristic levels associated with a commodity define a set of implicit or "hedonic" prices.

Rosen formulates hedonic theory in terms of a spatial equilibrium between buyers and sellers and argues that the hedonic price function guides producers and consumers to locational decisions in characteristic space i.e., quantities of characteristic j to be produced and consumed. He, like Lucas, presents a method of determining how much of a characteristic is consumed by using a utility function. His procedures differ from Lancaster in that he used optimization techniques i.e., partial differentiation versus mathematical programming. He also develops hedonic prices from the producer side via a symmetric framework to his consumer analysis.

Rosen then discusses the meaning of hedonic prices and combines his production and consumption theories to derive a market equilibrium in characteristic space. He also discusses the identification problem of hedonic prices i.e., the supply and demand question and concludes that the hedonic price function reveals little about underlying commodity supply and demand functions but do provide information about the structure of the underlying functions.

He establishes a two stage procedure for estimating supply and demand equations using hedonic prices. First, he suggests estimating an hedonic price function by regressing observed commodity prices at characteristic levels. Then, using the estimated hedonic equation, he generates commodity prices (P_i) and use these prices, which are invariant to quality variations, as the endogenous variable to estimate either a supply or demand function. He concludes his article by using his model to analyze the welfare consequences of quality standards legislation.

Cowling and Rayner used a procedure similar to that used by Rosen to estimate demand functions using hedonic prices. The basic motivation for the study was the lack of techniques to estimate the demand for specific brands of a commodity. Most demand studies disregard the differentiation of commodities by brand.

Cowling and Rayner argue that a major component of the observed differences in prices (demand) for different brands is due (but not exclusively) to quality differences. In their article they offer a procedure that utilizes a hedonic price function to estimate demand. The first step is to estimate a hedonic price function using common regression procedures. They then use the vector of regression errors as an independent variable in the demand equation that includes common demand theory variables. The argument for using the error is that it represents deviations about price excluding quality effects. They conclude by using these procedures in a case study of the tractor market in the United States.[2]

"Hedonic Pricing" Some Theoretical Considerations[3]

The central theory behind "Hedonic Pricing" is that goods are valued for their utility bearing characteristics or attributes. Hedonic prices are defined as the implicit prices of characteristics that are revealed to economic agents from observed commodity prices and specific amounts of characteristics associated with them (Rosen). This theory gives rise to the hedonic price function.

Hedonic price functions are regression equations of the general class (Lucas):

$$\dot{P}_i = P(V_{i1}, \ldots, V_{ij}; e_i) \tag{2.2}$$

where $\dot{P}_i$ = observed price of commodity i;
V_{ij} = amount of some intrinsic quality (characteristic) j per unit of commodity i;
e_i = a disturbance term.

The above function establishes a relationship between observed commodity prices (producer level rough rice prices) and levels

[2] An earlier study that examined the effects of quality change on tractor prices was Fetting in 1967 published in the Journal of Farm Economics.

[3] The majority of this section is extracted from the theories of "Hedonic Pricing" as reviewed, established, and discussed in Rosen and Lucas.

of characteristics per unit of commodity. This relationship decomposes the commodity price into a set of implicit (hedonic) prices for each of the j quality factors.

In this context the market for a commodity, or in a general context, a class of commodities can be described by a vector of characteristics denoted as $Z = (Z_1, Z_2, \ldots Z_j)$ (Rosen). The components of Z are levels of characteristics.[4] In the market a price is quoted (market price) that is associated with a level of Z, hence, the product market implicitly reveals a hedonic price (Rosen) as given in equation (2.2). Rosen notes this function as the buyer's (and seller's) equivalent of a hedonic price regression, obtained from shopping around and comparing prices of brands with different characteristics.

Buyers will choose a lot with a desired level of quality for the minimum price available in the market. Sellers realize the demand for Z and can only change the level of Z by employing additional resources into the production of the commodity. Hence, the function $P(Z) = P(Z_1, \ldots, Z_j)$ guides buyers and sellers in the decision process concerning the consumption and production of the quality factors. This

[4] Rosen makes the assumption that a sufficiently large number of differentiated products exist so the choice among various combinations of Z is continuous. While on the surface most consider rough rice to be a homogenous product, in terms of characteristic combinations, the commodity is highly differentiated.

implies that there exists a demand and supply function for each quality factor.

The literature states that buyers place a positive value on all the arguments of Z. That is, they can only receive higher levels of Z_i by paying a price equal to the marginal cost of producing an additional unit of Z_i. In the rice market, many of the quality factors are undesirable to buyers e.g., red rice. This does not affect the analysis. It simply means that the direction of the function P(Z) with respect to the undesirable Z_i is reversed.

The above has introduced the hedonic price function as given by both Lucas and Rosen and summarized its theoretical foundation. It has not, however, explicitly revealed how the hedonic price function is determined. As previously mentioned the hedonic price function is augmented on both the demand (consumption) side and the production side. Therefore, it can be derived from either the consumption decision or the production decision. The next section presents two alternative but similar views of how a hedonic price function can be developed from both the consumer and producer decision.

Hedonic Prices and the Consumption Decision[5]

A. A Lancasterian Approach

Lancaster writes the individual utility function as,

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[5] The first presentation follows the Lancasterian consumer theory as presented by Lucas while the second is taken from Rosen.

(1.A) $U = U(Z_1, \ldots Z_J)$

where Z_j is the total amount of characteristic j consumed by an individual. An individual can obtain Z_j from different commodities e.g., a rice mill can obtain head rice from either long or medium grain rice.

A linear consumption technology is assumed to relate the vector of characteristics to the quantities of commodities consumed in the form given by equation (2.A).

(2.A) $$Z_j = \sum_i V_{ij} \, q_i \qquad j = 1,J$$

where q_i = the quantity of commodity i consumed.

Lancaster assumes that consumers choose a mix of continuously variable commodities such as to maximize utility subject to the consumption technology and the budget constraint. This maximization problem can be summarized in the following using Lucas's notations.

(3.A)
$$\begin{aligned} & \text{Max } U(Z) \\ \text{S.T. } & Z = Vq \\ & Y \geq pq \\ & Z,q \geq 0 \end{aligned}$$

where
- Z is the vector $[Z_j]$ $j = 1, J$
- V is the Matrix $[V_{ij}]$ $i = 1,I$ $j = 1,J$
- Y is the consumers income
- P is a vector of commodity prices $[P_i]$ $i = 1,I$
- q is the vector $[q_i]$ $i = 1,I$

The non-linear program has a solution for the optimal bundle of characteristics, which Lucas denotes as Z.

Lancaster notes the most efficient means of obtaining this optimal bundle of characteristics (Z^*) is given by the solution to the program,

$$(4.A) \quad \text{Minimize } Pq \quad \text{S.T. } Vq \geq Z^* \quad q \geq 0$$

The dual of this program is written,

$$(5.A) \quad \text{Maximize } pZ^* \quad \text{S.T. } p\,V \leq p$$

where p are the shadow prices of the characteristic.

Lucas then gives for those constraints which are binding in the solution of (5.A),

$$(6.A) \quad P^a = pV^a$$

where P^a is the solution sub-vector of P_i
V^a is the solution sub-matrix of V.

Lucas notes that this result is a linear specification of the class of functions given by (2.2), the hedonic price function.

Lucas then goes into detail of how (6.A) relates to the "estimated" hedonic price function. He surmises that the conceptual experiment of consumers efficiently selecting commodities with parametric price characteristics gives rise to a function which he denotes as:

(7.A) $P_i^* = P^*((V_{i1},....,V_{iJ})$

where P_i^* is the demand reservation price from commodity i.

B. Rosen's Version of the Consumption Decision:

Rosen defines the consumer's utility function for a commodity as $U = U(x, Z_1,...,Z_J)$ where x is all other goods consumed. He assumes that U is strictly concave, as well as the other usual assumptions. Rosen sets the price of x equal to unity, and measures income, y, in terms of units of x: $y = x + P(Z)$. Rosen notes that maximization of U subject to a nonlinear budget constraint is obtained from selecting a mix of Z_i and x such that the budget constraint and first-order conditions, $\partial P/\partial Z_i = P_i = U_{Zi}/U_x$, $i = 1,..,J$, are satisfied.

Given this optional mix of characteristics the consumer can determine how much he is willing to pay (e.g., his reservation demand price for an additional unit of Z_i). Rosen goes about determining this by first defining a value on bid functions $\theta = \theta(Z_1,...,Z_J; u,y)$ according to

(1b) $u = u(y - \theta, Z_1,...,Z_J)$

This function reveals the expenditure a consumer is willing to pay for Z_i given a utility index and income represented by $\theta(Z;u,y)$. It defines a family of indifference surfaces relating Z_i with money (i.e., with x foregone) (Rosen). Rosen twice differentiates (1b) which yields (2b) and (3b).

(2b) $$\theta_{Z_i} = U_{Z_i}/U_x)\ 0, \quad \theta_u = {}^{-1}/u_x < 0 \text{ and } \theta_y = 1,$$

(3b) $$\theta_{Z_iZ_i} = \frac{(U^2_x \quad U_{Z_iZ_i} - 2U_x\, U_{Z_i}\, U_{xZ_i} + U_{Z_i}{}^2\, U_{xx}) \quad < 0}{U^3_x}$$

Rosen notes that θ_{Z_i} can alternatively be interpreted as the marginal rate of substitution between Z_i and money, or the implicit marginal valuation the consumer places on Z_i at a given utility index and income.

This provides the setting to determine exactly where utility is maximized. $\theta(Z_iUy)$ indicates the amount the consumer is willing to pay for Z at the fixed utility and income levels. P(Z), the hedonic price function, is the minimum price he must pay, which is given by the market. Here utility is maximized when $\theta_{Z_i}(Z^*;U^1,Y) = P_i(Z^*)$, $i = 1,..,J$, where U^* and Z^* are optimum quantities.[6] This consumer

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[6] One consequence as noted by Lucas is the question of how the q_i (quantity of commodity i) drops out of the solution.

equilibrium point is graphically depicted in Figure 1 at the point A. Both functions are upward sloping in this case because we have assumed that both the marginal cost of supplying and the marginal benefit of consuming an additional unit of Z_1 is positive. For an undesirable characteristic,

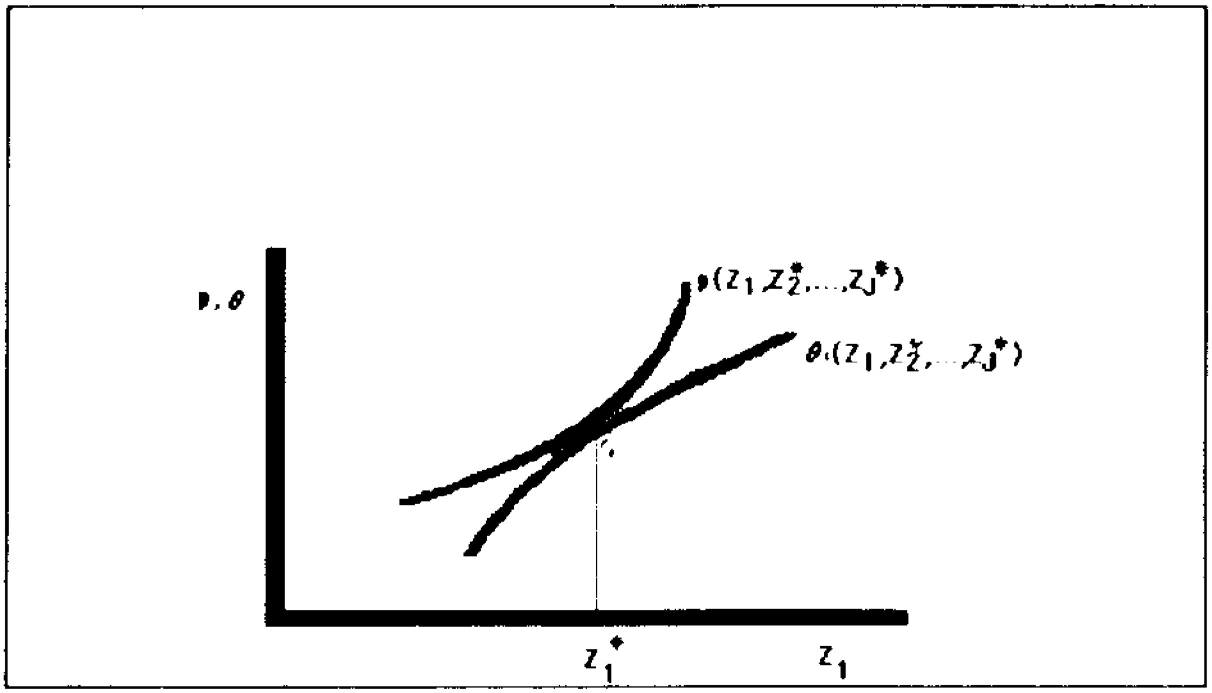

Figure 1. Consumer Equilibrium For a Desirable Characteristic.

such as red rice the situation depicted in Figure 2 would be appropriate. The slope of these functions indicate that small levels of Z_2 are more costly because additional resources must be utilized to reduce its level.$_2$ The downward sloping bid function indicates the undesirableness of the quality factor.

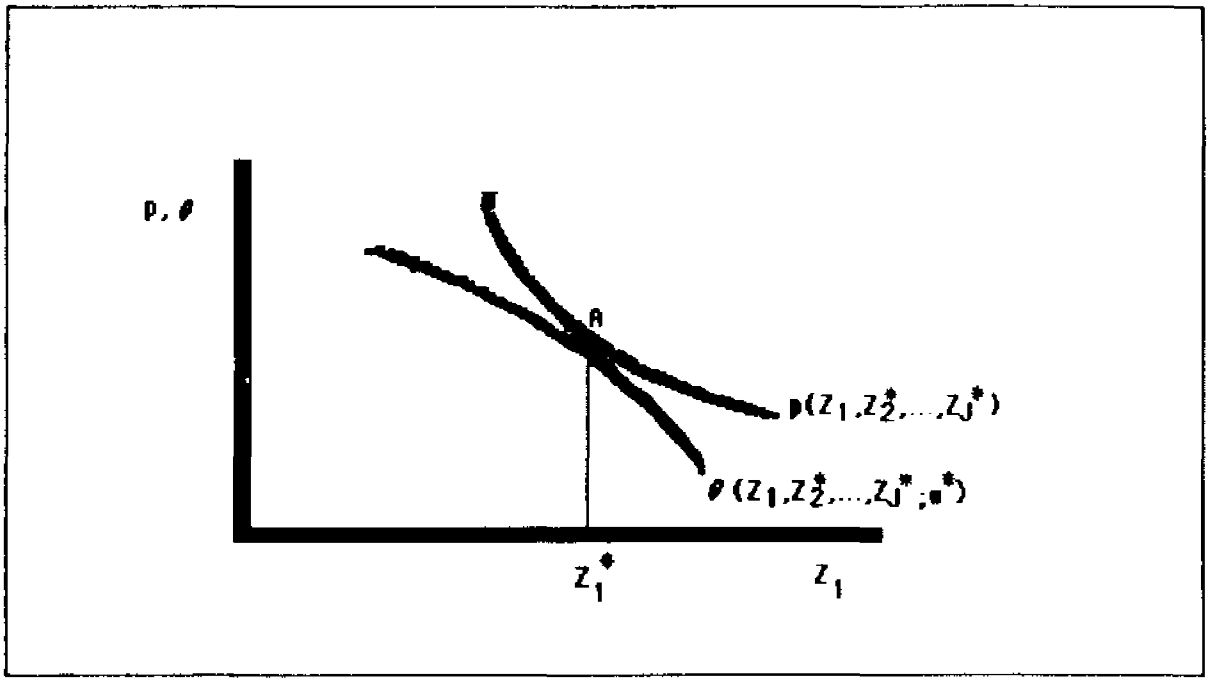

Figure 2. Consumer Equilibrium for a Undesirable Characteristic.

Hedonic Prices and the Production Decision

The first approach is taken from Lucas which follows very closely the Lancasterian utility theory. The second part is taken from Rosen.

I. Lucas' Version of the Production Decision:

Lucas begins the analysis by assuming that production costs are a function of characteristic levels (Z) and factor prices. He gives the cost function as:

$$(1.I) \qquad C = C(Z_i r)$$

where Z = Vq and Z, V, and q are defined in previous section following the Lancasterian utility theory. Lucas states that any efficient firm faced with a set of factor prices will minimize cost subject to receiving a given level of income. Lucas writes this problem as,

$$(2.I) \qquad \begin{aligned} &\text{Minimize } C(Z_i r) \\ &\text{ST} \quad Z = Vq \\ &\qquad pq \geq R^* \\ &\qquad Z_1 q \geq 0 \end{aligned}$$

where R is the revenue constraint. This problem closely resembles the earlier model from consumer theory taken from Lucas and its solution yields an efficiency price locus for a case of heterogeneous firms which is given by the function:

$$(3.I) \qquad P_i^{**} = P^{**}(V_{i1}, \ldots, V_{iJ})$$

where P_i^{**} is the supply reservation price of commodity i (Lucas). Lucas notes that the estimated hedonic price function can be interpreted such that its partial derivatives are proportional to the marginal cost of characteristics (Lucas).

II. Rosen's Version of the Production Decision:

Rosen begins his analysis as Lucas did by defining a cost function which is a function of a set of Z characteristics. Specifically, Rosen defines cost: $C = C(m, Z; \beta)$, where m is the number of units produced and β is a shift parameter reflecting underlying factors of the cost minimization problem. The cost function is derived by minimizing cost subject to a production function. Rosen makes the usual assumptions relative to a standard cost function minimization problem. Rosen assumes that firms maximize profits $\pi = Mp(Z) - C(M, Z_1, \ldots, Z_J)$ by choosing optimal levels of M and Z. The revenue function is given by the implicit price function P(Z).

Optimal choice of M and Z implies that marginal revenue from additional characteristics equals their respective marginal cost of production per unit sold which implies that quantities of a commodity are produced up to the point where unit revenue P(Z) equals the marginal cost of production, determined at the optimal (cost minimizing) levels of characteristics (Rosen). This is given by equation (1.II).

$$(1.II) \qquad P(Z) = C^{n}(M_1 Z_1, \ldots, Z_J)$$

Recall from the consumption problem a value function was defined; here Rosen defines an "offer" function $\phi(Z_1,...,Z_J;\pi,\beta)$ indicating per unit prices the firm is willing to accept at a constant profit given that optimum levels of characteristics are produced. ϕ can be interpreted as a family of production indifference surfaces. Rosen then finds $\phi(Z_1,...,Z_J;\pi,\beta)$ by eliminating M from the profit equation.

(2.II) $\pi = M\phi - C(M,Z_1,...,Z_J)$

and

(3.II) $C_m(M,Z_1,....,Z_J) = \phi,$

and solving ϕ in terms of Z, π, and β. Rosen differentiates (2.II) and (3.II) to obtain $\phi_{Z_i} = C\ Z_i/N > 0$ and $\phi_\pi = 1/M > 0$.

Rosen defines ϕ_{Z_i} as the marginal reservation supply price for characteristic i at constant profit. Now Rosen has established that ϕ is the offeı price the seller is willing to accept given his optimal combination of characteristics at profit level π, and P(Z) is the maximum obtainable price for that model established by the market, profit is maximized by an equivalent maximization of the offer price subject to the constraint $P = \phi$. Thus, this satisfies $Pi(Z^*) = \phi{*}Z_1^*,...Z_J;\pi^*,\beta)$ (Rosen).

As in the consumer problem, this equilibrium situation can be graphically presented. Figure 3 presents an equilibrium situation for Z_1 given optimal levels of $Z_2^*,...***Z_J^*$. Point A is an equilibrium situation for a firm with the ϕ offer function. Theta can shift around for different firms as the technology of the firm differs relative to different characteristics.

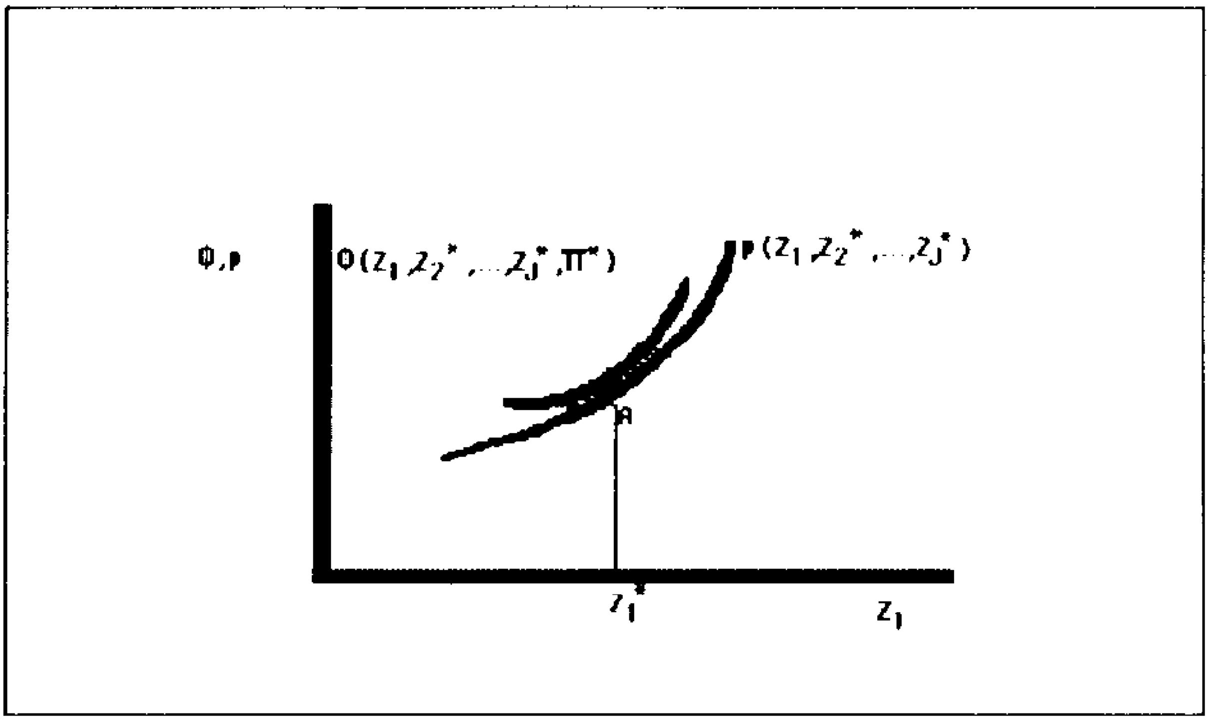

Figure 3. Producer Equilibrium For a Characteristic.

Hedonic Prices - Supply and Demand

The hedonic price function introduced in the beginning of this chapter has been shown to be generated from the supply and demand side. We know that in a market economy price is determined by the intersection of supply and demand. The question, which is quite obvious here, is what do the hedonic prices represent? Is the hedonic price function a supply or demand equation?

Rosen uses the offer and value functions previously presented to address this problem. If we were to superimpose Figure 1 onto Figure 3 one would see that there is a tangency point where the two functions are tangent. Figure 4 depicts this equilibrium situation between buyers and sellers.

At point A buyers and sellers are perfectly matched with respect to their value and offer functions. This point is given by the gradient of the market clearing implicit price function P(Z). Rosen states that observations of P(Z) represent a joint envelope of a family of value functions and another family of offer functions and that an envelope function by itself reveals nothing about the underlying members that generate it; and they in turn constitute the generating structure of the observations (Rosen).

What Rosen is suggesting is that the estimated hedonic prices do not by themselves identify a supply or demand function but are more related to the structure of supply and demand. More simply, the bundle of characteristics offered by the firm, and the prices they are being offered, are derived from supply and demand factors (Crowling and Rayner).

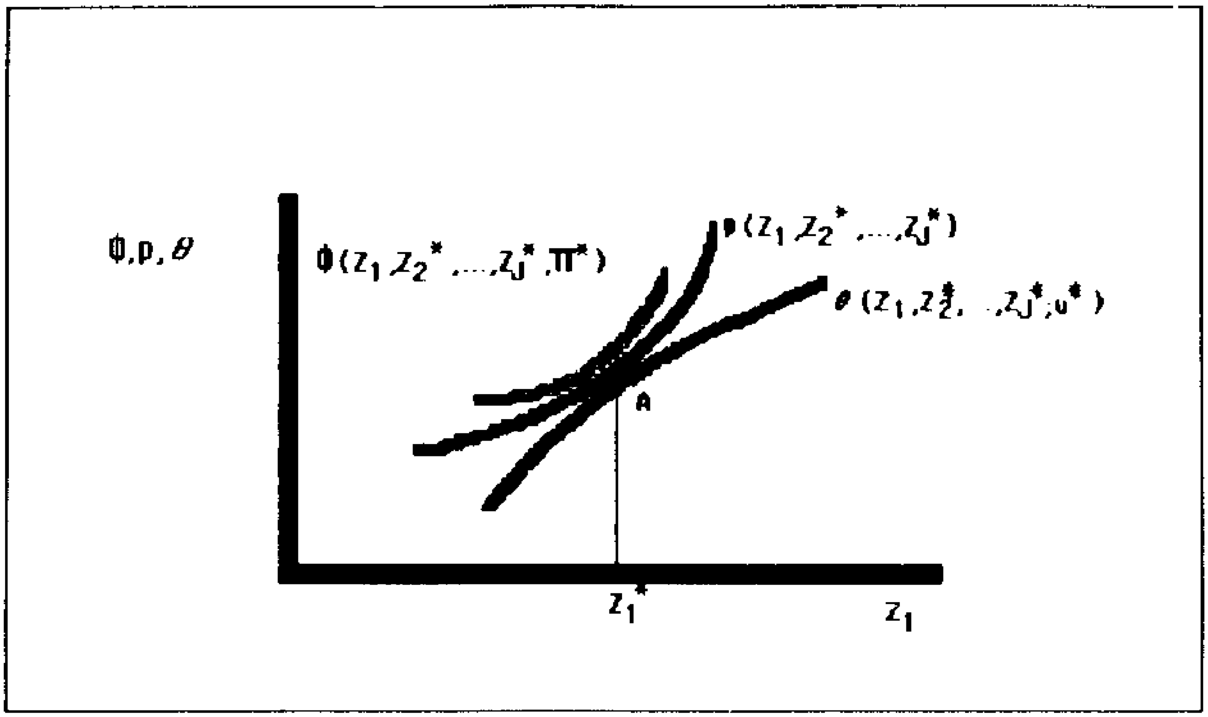

Figure 4. Market Equilibrium For a Characteristic.

Rosen concludes that[7] "observed marginal hedonic prices merely connect equilibrium reservation prices and characteristics and reveal little about underlying supply and demand functions".

Procedures Used in the Study

A hedonic price function is a regression of the observed price of a commodity against its quality attributes (Lucas). Hedonic pricing involves measuring the values of the quality attributes, or characteristics which describe a commodity,

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[7] A marginal hedonic price is equal to $\partial P(Z)/\partial Z_i$ which is equivalent to the premium or discounts from a linear specification of a hedonic price model as estimated in this dissertation.

rather than the price of the commodity. The underlying theory of hedonic pricing is that a commodity is valued for its utility bearing characteristics and that the price of the commodity varies as the level of those characteristics vary. In this context, the value of a commodity can be decomposed into its hedonic components.

Hedonic prices are a regression of the form (Lucas):

(2.3) $$P_i = P(V_{i1},..,V_{ij}, e_i),$$

where P_i (offer price) is the observed price of commodity i, V_{ij}, j=1,..,J measures the amount of quality per unit of commodity i, and e_i is a disturbance term. The V_{ij}'s are the quality factors which this study attempts to estimate.

Given that the data set is both cross sectional and a time series, a variable which captures the price variations over time must be included. Deaton and Muellbauer suggest using some type of index variable (Brorsen). This variable is an essential component of the hedonic price model because it captures the general economic conditions (supply and demand) that also jointly affect the price of rice along with the quality attributes of the commodity. Prices reported for milled rice by USDA Rice Market News will be used to capture these effects.

To estimate hedonic prices for rough rice in Louisiana, a linear specification of an index variable and of the quality factors will be used. The resulting model is:

$$(2.4) \quad P_t = \alpha o + \beta_1 P^m + \sum_{j=1}^{J} \beta_j V_j + e,$$

where P_t is the bid price for rough rice in the time t; P^m is the price of milled rice; and β_j is a vector of coefficients associated with the quality factor and e is a random disturbance term. The quality factors believed to affect the bid price of rice and their expected signs are head rice (+) due to increased milling yield, broken rice (+) also due to increased milling yield though expected to be less valuable than head rice, lot size (+) buyers prefer larger quantities, and season (+) due to returns to storage; all remaining variables are expected to have negative signs due to the fact that they are undesirable characteristics which millers often must attempt to remove in the milling process -- foreign seeds (-), heat (-), red rice (-), smut (-), peck (-), and chalk (-).

Premiums and discounts can be determined by estimating the parameters of equation two in an econometric framework through Ordinary Least Squares (OLS). Parameter estimates will indicate the per unit change in the bid price due to a per unit change in a given quality factor. These parameter estimates can be interpreted as the premiums or discounts associated with the selected quality factors. Box-Cox procedures will be used to determine if the linear specification is appropriate for each year and for each class of rough rice.

A major differentiation in rough rice is its class -- long, medium, or short grain. This differentiation has major production and marketing implications. For example, medium grain usually has a higher milling yield than long grain but is of less value than long grain due to a smaller demand. Long grain rice is deemed more desirable by some consumers while medium and short grain varieties are considered more desirable by others. Also, there are differences in cultural practices between long and medium grains. In consideration of the differences, hedonic models were estimated for both long and medium grain classes. In the Louisiana market, long grain is the most predominant class. Within classes, though not likely, there could be differences in premiums/discounts across varieties.

Previous research studies concerning hedonic price models have detected autocorrelation in the errors (Ethridge, 83). This is not unexpected since autocorrelation is common with time series data and there are seasonal price patterns in the rice market (Martinez, et. al). Also, it is expected that premiums and discounts are not constant throughout or across the marketing seasons or across producers a phenomenon that could give rise to non-constant error variances. These error problems were rigorously investigated and handled appropriately to ensure efficient estimates.

The South Louisiana rice market, in some respects, is at a slight advantage compared to that of Arkansas and California. A relatively early harvest may enable Louisiana rice producers to receive better prices early in the season. As in most commodity markets, the Louisiana rice market is characterized by seasonal prices (Martinez). These and other market conditions give rise to a hypothesis that differences in premiums/discounts exist across marketing seasons and also marketing years.

Premiums and discounts were estimated for early and late season for the two marketing years. The parameter estimates will be compared across marketing seasons and years. A Chow test was performed to determine if there are changes in the premiums and discounts associated with selected quality factors.

The value of the selected quality factors can be approximated by evaluating the premiums/discounts at given levels of quality per unit of the commodity. These values were compared to the marginal cost of controlling some of the negative quality factors and enhancing the positive quality factors for different quality levels. The cost of controlling quality factors through cultural practices were determined through very simple static budgeting procedures. Recommended cultural practices were obtained from past producer surveys, research of the Louisiana Agricultural Experiment Station and from Cooperative Extension Service recommendations.

Quality Factors Affecting Rough Rice Prices

A hedonic price model is a regression of observed prices on quality attributes e.g., characteristics that jointly describe the commodity being marketed. The first step in determining premiums and discounts in the Louisiana rice market is to identify those factors that affect the price of rough rice.

The quality factors considered were those observed in the Louisiana rice market. Rice is mainly produced in two different geographical areas in the state the southwest and northeast sections (Figure 5); the southwest area is the predominant, however and most of the data collected represents the southwest Louisiana market.

Various parties provided insights useful in making this study. Informal interviews were conducted with rice buyers, marketing agencies, Agricultural Experiment Station and extension personnel, and rice producers.

Rough rice price data and associated quality factors were obtained from LFBMA, Crowley, Louisiana for the 1986/87 and 1987/88 marketing years. All quality factors used to establish USDA grades were believed to affect rough rice prices and were included. Those factors included foreign seeds, heat damaged kernels, red rice, chalky kernels, and peck and smut damage. Previous studies have shown that USDA grades, and hence the factors determining the grades, inadequately capture all the existing quality factors (Brorson, et. al., 1984). Other quality factors believed to be important in affecting variations in rough rice value includes head rice, broken rice, and lot size.[8]

All of the above quality factors were observed in the Louisiana Rice market in both the 1986/87 and 1987/88 marketing years. Foreign seeds, red rice, and heat damaged kernels were observed in larger volumes in both years than peck, smut or chalk damage. This indicates that seed, heat, and red rice could be problem areas to Louisiana producers.

Hedonic Price Model for Rough Rice

A hedonic price function is a regression of an observed quality on the price of a commodity. This function was given earlier as:

(2.5) $Pi = f(Vi1,....Vij,Ui)$.

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[8] Total rice was not included because it is the sum of head and broken which creates a perfect linear combination in the design matrix. A premium for total rice would implicitly include an amount for head and brokens. There are separate markets for head and broken rice which also supports determining separate premiums.

The Vij components are the quality factors previously introduced. Equation (2.5) captures the underlying theory that a commodity is valued for its underlying quality attributes and variations in price can be explained by variations in quality. While this specification is correct for empirical purposes, it is not feasible.

Adelman and Griliches were the first to give an empirical anti-log of the hedonic price function.[9] He decomposed observed changes in commodity prices into two distinct components: (a) changes in quality, and (b) changes in price due to other factors or when quality did not change. What this indicates is that the model given by (2.5) in mis-specified.

The nature of the data set also has some empirical implications regarding the specification of the hedonic price model. The data set is pooled, time-series, cross sectional data. The time series component arises from the series of prices collected across the marketing season. The cross-sectional component arises from selecting a cross-section of lots for each sale. Sales are held as demand for them arises, once or twice a week throughout the marketing season.

This data set differs from most pooled, time-series, cross-sectional data used in econometrics because the number of cross-section observations differ across sales. Most

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[9] See Chapter II, Literature Review section for a detailed discussion of Griliches study.

studies using cross-sectional time series data follow an individual unit through a given time series; e.g., in cross-sectional time series studies, data from an individual producer is collected for a series of years. In this data set the individual lots are sold at auction, hence, individual units could not be followed. This data problem creates some limitations regarding the spectrum of feasible econometric estimation techniques. The use of this type of data in an applied context indicates a possibility for further econometric research.

Given these considerations, the literature suggests using some type of index variable [10] (Deaton and Muellbauer). Other studies have recognized the time series effects and have included linear and quadratic time trends to adjust the model for differences in market forces over time (Ethridge and Davis; Martinez, et.al.). Incorporating the index variable into equation (2.5) in a linear form yields;

$$(2.6) \qquad P_{it} = I_t + f(V_{i1}, \ldots, V_{ij}; U_i)$$

where P_{it} is now the observed price of commodity i in time t and I_t is the index variable for commodity i in time t.

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[10] Experimentation with hedonic price models in this study without an index variable as compared with models with an index variable also indicated that the index variable considerably improved the quality and accuracy of the hedonic estimation.

Following Brorsen, et.al., the Louisiana weekly mill price was used as the index variable. This variable is published weekly by the USDA in the periodical Rice Market News. This variable is an essential component of the model because it captures the aggregate supply/demand conditions that exist in the rice market each week. These conditions not only affect the observed commodity prices but also the implicit or hedonic prices.

Rough rice can be and is commonly differentiated in the market by its class. Rough rice is broken down into three varietal classes: (1) long, (2) medium, and (3) short. The class is based on the length of kernel. These class differences have major marketing and production implications. Cultural practices are also different for each of the classes of rice. Further, different classes of rice are said to be more productive in different areas e.g., short grain varieties may grow better in California than in Louisiana.

There are other marketing implications relative to the class of rice. Consumers, both domestic and international, have distinct preferences for the class of rice they consume. For example, Far East consumers prefer short and medium grain rice while consumers from middle eastern countries (Iraq, Iran, Saudi Arabia, etc.) and South Asia prefer long grain. In most but not all instances, long grain is considered to be the highest quality and receives a premium over medium and short grain in the market place most of the time. In

Louisiana, both long and medium grain rice are produced as is the case in most of the southern rice producing areas (Texas, Arkansas, Mississippi, and Louisiana). California is the major short grain producing area.

Previous studies of hedonic rice prices (Brorsen, et.al., 1984 and 1988) have concentrated on the long grain market. The medium grain as well as the long grain market are very important to the Louisiana rice industry. In this data set, which accounts for about 20% of the market in each of the years studied, medium grain volume made up 32.4% and 37.8% of the sample in the 1986/87 and 1987/88 marketing years, respectively. The market differences between classes of rice imply that separate hedonic models should be estimated for each class of rice (long and medium). These model differences are examined in more detail later in this chapter. Taking these considerations into account yields the following hedonic model specification for the Louisiana rice market (2.6).

$$(2.7) \qquad P_{itc} = P^{m}_{tc} + f(V_{ic1}, \ldots V_{icj}; u_i),$$
$$i = 1, \ldots I \qquad t = 1, \ldots, 52, \qquad c = 1, 2.$$

where P_{itc} is now the observed price of lot i in week t for class of rice c and P^{m}_{tc} is the Louisiana mill price in week t for class of rice c.

Past studies have suggested specifying the hedonic price function as a semi-logarithmic model (Deaton and Muellbauer). This specification was also selected, after some experimentation, by Adelman and Griliches in their application of hedonic pricing to automobiles in 1961. This specification gives rise to an equation of the form (4.4).

$$(2.8) \qquad \ln(P_{it}) = \ln(I_t) + f(V_{i1},\ldots,V_{ij};U_i)$$

which is identical to (2.6) with the exception that the price and index variables are transformed in terms of their respective logarithums. The implications of this specification are that the resulting estimated hedonic prices from 2.8 are interpreted as a percentage of price. That is, if the estimated parameter for V_{i1} was 0.1, this would imply that a one unit increase in V_{i1} would cause a 10% increase in the price of commodity i. A linear specification, as (4.2), implies these parameters are a constant.

The choice of a linear or semi-logarithmic specification depends on the assumptions one makes about the nature of the hedonic prices, i.e., are they constant or a function of the price level. Brorsen, et.al., chose a linear specification because they believed the premiums and discounts to be constant throughout the marketing season. This is also assumed to be the case in the Louisiana rice market. The main factors affecting the premiums and discounts are aggregate supply and demand conditions and technology relative to the quality factor neither of which changes drastically in a given marketing season.

The functional form was tested for long and medium grain models for the 1986/87 and 1987/88 marketing seasons. The functional form was tested using a Box-Cox transformation. [11] Results of the test indicated the linear specification was appropriate for long and medium grain models in 1986 while the semi-logarithmic model was more appropriate in 1987. The main reason for the change in functional form between marketing years was that the 1987/88 year was characterized by adverse weather conditions in Asia causing rough rice prices to rise from about \$4/cwt in the beginning of the marketing year to a peak of some \$12/cwt during the latter half of the season. These conditions were abnormal and rice prices are not that variable in a normal year. Therefore, hedonic models were estimated for long and medium grain in 1987 using both linear and semi-logarithmic models. However, the linear model was chosen as the base model for comparison purposes.

The resulting hedonic model for the Louisiana rice market is given by equation (2.9).

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[11] See Judge, 1985, p. 634 for details on the Box-Cox transformation and the specification criteria.

$$(2.9) \quad P_{ictk} = \alpha_{ck} + \beta_{ck}P^{m}_{ctk} + \beta_{ick}\ \text{Head}_i + \beta_{2ck}\ \text{Brokens}_i + \beta_{3ck}\ \text{Lot Size}_i + \beta_{4ck}\ \text{Seeds}_i + \beta_{5ck}\ \text{Heat}_i + \beta_{6ck}\ \text{Red Rice}_i + \beta_{7ck}\ \text{Peck}_i + \beta_{8ck}\ \text{Smut}_i + \beta_{9ck}\ \text{Chalk}_i + e_{ictk}$$

where P_{ictk} is the observed highest offer price for rice lot i of class c in week t of year k, i = 1,..,I, c = long or medium, t = 1,....,52, and k = 1986/87 or 1987/88, α_{ck} is the intercept term, P^{m}_{ctk} is the milled price for class of rough rice c in Louisiana during week t for the sale of rough rice lot i during week t in year k, β_{ck} is the parameter for milled rice price, $\beta_{ick},...\beta_{9ck}$ are the premiums/discounts associated with each quality factor and the error of the equation being approximated by e_{ictk}. The sign of β_{jck} indicates whether the factor receives a premium (+) or a discount (-). The respective quality factors (V_{icj} of equation (2.7)) for each lot of rough rice are:

Head_i = percent by weight of 3/4 or greater whole kernels in the sample;

Brokens_i = percent by weight of kernels less than 3/4 of whole kernels (total rice - head rice);

Lot Size_i = the size of the lot offered in number of cwt;

$Seed_i$ = number of foreign seeds in the sample, whole or broken;

$Heat_i$ = number of discolored and damaged kernels in the sample as a result of heating;

Red_i = percent by weight of whole or broken kernels of Red Rice (a wild rice);

$Peck_i$ = percent by weight of kernels damaged by stink bugs;

$Smut_i$ = percent by weight of kernels infested by smut;

$Chalk_i$ = percent by weight of chalky kernels.

These variables are often used to measure the level of quality of long and medium grain rough rice in the Louisiana rough rice market. Higher values for head, brokens, and lot size are expected to be desirable characteristics and exert a positive influence on prices. The remaining characteristics are expected to be undesirable in the market and exert a negative effect on price. The parameters $\beta_{ick}, \ldots \beta_{9ck}$ are the premiums/discounts for the respective quality factors. They indicate the change in price ($/cwt) from a one unit change in the respective quality factor.

The highest offer price for a given lot of rice was used as the dependent variable in this dissertation. Brorson, et al. 1987, suggested that this price represented demand because it was offered by the buyer (mill) and was not necessarily accepted by the producer (seller). He claimed that the final transaction price better represented producer level discounts and gave better information to producers about the cost/revenues of quality factors.

The data for 1986 used in this indicated a very small number of resales implying that most of the prices were transaction prices and thus good proxies for actual sales. The 1987 data had more resales, hence, more prices which were not final transaction prices. However, recall that 1987 was characterized by rising prices and producers were holding inventories on the chance that prices would rise even higher. Also, the Box-Cox model indicated that the premiums and discounts were partly a function of price during that year indicating that the structure of the hedonic model gives the economic condition ie., supply and demand is the central concern, not the specification of price.

CHAPTER III

ROUGH RICE PRICES AND ASSOCIATED QUALITY FACTORS FOR THE 1986/87 AND 1987/88 MARKETING YEARS

Rough Rice In Louisiana

Rough rice prices and other information, including quality surrounding individual sale transactions, were obtained for the 1986/87 and 1987/88 marketing years from LFBMA (Louisiana Farm Bureau Marketing Association) in Crowley, Louisiana. The marketing season for rough rice begins August 1 and ends July 31. The data set included 1851 lots of rice in the 1986/87 marketing year and 1774 lots in the 1987/88 marketing year, representing approximately 20% of the states production in each year. [12] The prices are essentially f.o.b. farm or commercial driers with delivery to be taken over about a two week period.

LFBMA offers rice auction sales for its members throughout most of the marketing season. The majority of the rice represented in the sample was produced in Southwest Louisiana. However, a small portion of the sample was produced in Central and Northeast Louisiana. Figure 5 shows the major rice producing parishes in Louisiana.

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[12] Rice production for Louisiana was 19,205,000 and 19,111,000 cwts in 1986 and 1987, respectively.

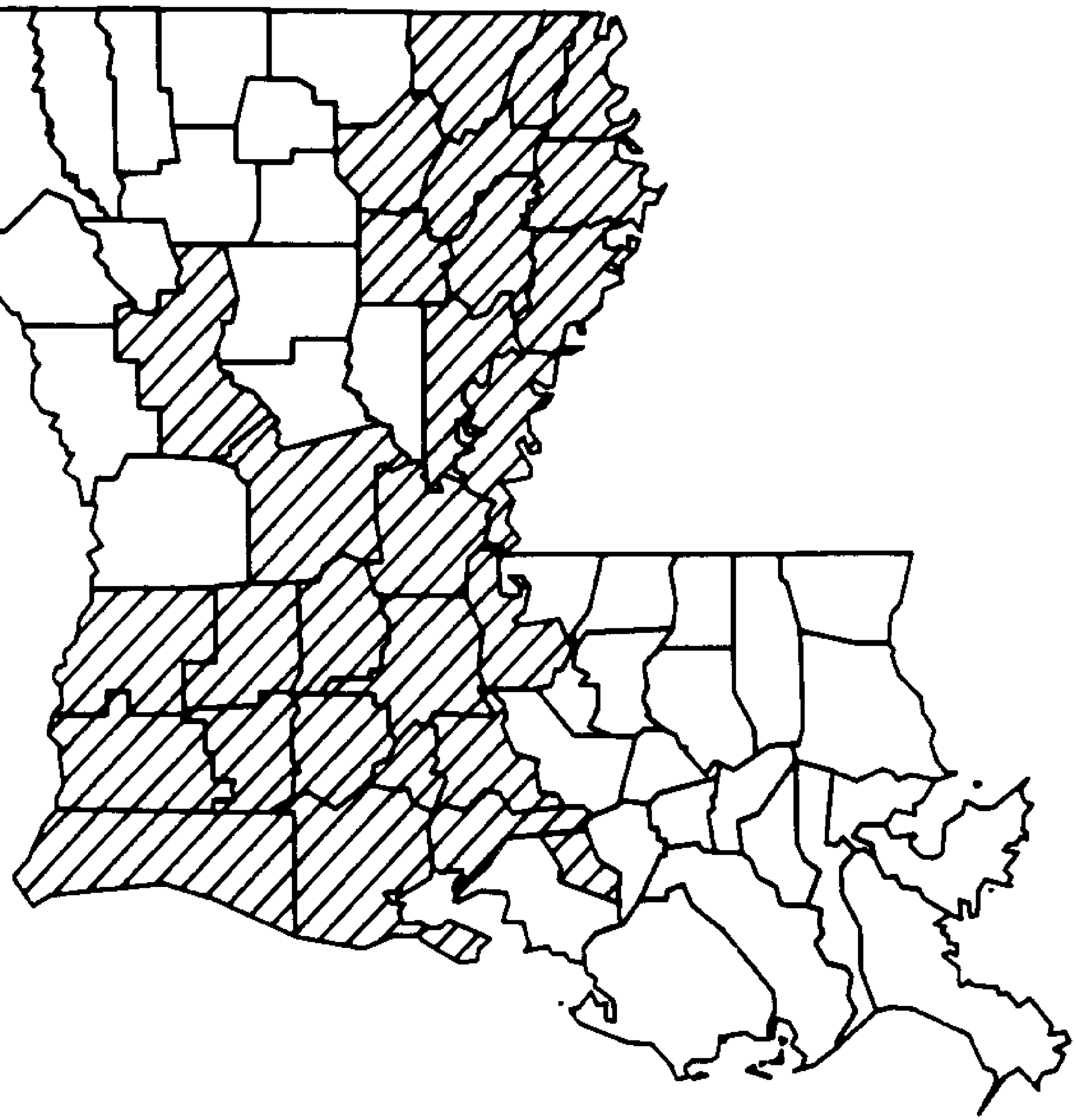

Figure 5. Rice Producing Areas in Louisiana, 1988.

Southwest Louisiana is the major rice area of the state, having produced 62% and 60% of the state total in 1986 and 1987, respectively (Zapata, et al., A.E.A. Research Report No. 69). Louisiana is the second largest rice state in terms of area harvested behind only Arkansas and third in terms of production behind California and Arkansas. Louisiana's production made up 14.5% and 15% of national production in 1986 and 1987, respectively (Agricultural Statistics Board, NASS, USDA).

In Louisiana, two different classes of rice are produced, (1) long grain, and (2) medium grain. Rice is planted from the beginning of March to the end of May and is harvested from the beginning of July through September. New crop rice begins appearing on the market in mid-July and marketing typically continues through April of the next year. The largest volume of rice is offered immediately after harvest (August-October) as is the case for most commodities.

Louisiana rice is marketed through bid/acceptance markets, private negotiated producer sales, and cooperative mills on a pooled basis. The rice price/quality data analyzed in this study were obtained from a bid/acceptance market. In a bid/acceptance market, producer lots of rice are inspected by buyers who submit a bid that in turn is either accepted or declined by the producer. If the bid is accepted, the rice is delivered f.o.b. farm or commercial driers from which point it is transported to the mill where it is processed and marketed as milled rice and byproducts.

Rice Prices and Quality

Primary data representing lots of rough rice offered through LFBMA, Crowley, Louisiana were obtained for the 1986/87 and 1987/88 marketing years. The 1986/87 data set includes information from 47 rough rice auctions representing over 2.5 million cwt of long grain and 1.2 million cwt of medium grain rough rice. The 1987/88 data set includes information for 39 rough rice auctions representing over 2.3 million cwt of long grain and 1.4 million cwt of medium grain rough rice. In 1986, the period analyzed ranged from July 23, 1986 (sale #1) to April 1, 1987 (sale #47). In 1987, the period ranged from August 5, 1987 (sale #1) to March 9, 1988 (sale #39).

The data base specifically includes the highest offer price for individual producer lots along with associated quality and nonquality information for that lot of rice. The information is essentially a pooled, time series, cross sectional data set comprised of a cross-section of producers over two marketing seasons.

The data set is not a classical pooled time-series in which a signal cross-sectional unit (e.g., a firm) is traced over time in the sense that each cross-sectional unit (a lot of rice) is different in each time frame. The data set included the highest offer price, the overall estimated U.S. grade, the milling yield, the estimated government loan price, a numerical grade for each set of quality factors that are used to determine the U.S. grade, lot size (quantity of rice being offered for sale), sale number and date, producer location, class of rice (long or medium grain), and the variety of rice. The weekly price of long and medium grain milled rice was also collected (Rice Market News, USDA) for the study and matched for each lot of rough rice sold according to the sale date.

The set of quality factors collected includes: (1) red rice, an undesirable wild rice; (2) quantity of foreign seeds; (3) heat damage, often but not exclusively, caused by applying excess heat during the drying process and causing discoloration in the rice kernels; (4) chalk, a failure of the kernel to develop completely; (5) peck, caused mainly by stink bug damage; and (6) smut, caused by diseases.

All of the quality factors except for foreign seeds is reported as a numerical grade (1-7) based on standards set by the USDA (Table 1). For interpretational purposes, the grades were converted to percent damage using the U.S. grade standards reported in Table 1. The mid point of the allowable range for a specific grade was used to convert the numeric grade to a proxy for percent damage.

Sample for the 1986/87 Marketing Year

Tables 2 and 3 present a descriptive statistical summary of the quality and nonquality information collected for the long and medium grain rough rice for the 1986/87 marketing year. The average long and medium grain bid price was #3.96/cwt and $4.08/cwt, respectively, in 1986. This relationship between the prices is inconsistent with expectations since long grain is usually thought to be more valuable. The average prices indicate the overall depressed general price level of rough rice in 1986 which was below the average cost per cwt ($10.14) for a typical southwest Louisiana rice farmer (McManus).

For both classes of rice the prices appear to have been fairly stable throughout that year with respective standard deviations of $0.45/cwt and $0.55/cwt. The average weekly milled price for long and medium grain, respectively, was $10.32/cwt and $10.15/cwt. Similar to that for rough rice, the price for milled rice was fairly stable through the marketing year for both long and medium grain (standard deviations of $0.44/cwt and $0.19/cwt, respectively).

Milling yield is the amount of whole and broken kernels produced in the milling of 100 pounds of rough rice. The sum of whole and broken kernels is termed total rice. Milling yield is usually reported as percent total rice is to rough rice. In 1986, milling yield for long grain averaged 69.4% total rice and 52.6% head rice. The remaining 30.6% is

Table 2. A Statistical Descriptive Summary of Quality and Non Quality Factors, Long Grain Rough Rice, Louisiana, 1986.

Variable	Units	Mean	Standard Deviation	Minimum Value	Maximum Value	Standard Error Of Mean	Sum	Variance	Coefficient of Variation
Bid Price	$/cwt	3.99	0.45	1.11	7.40	0.01	5096.72	0.20	11.20
Mill Price	$/cwt	10.32	0.44	9.63	11.75	0.01	13183.06	0.19	4.25
Loan Value	$/cwt	6.57	2.22	0.00	8.63	0.06	8396.61	4.95	33.86
Head Rice	%	52.65	7.49	6.00	67.00	0.21	67286.00	56.12	14.23
Total Rice	%	69.47	2.59	54.00	74.00	0.07	88777.00	6.71	3.73
Broken Rice	%	16.82	6.48	5.00	68.00	0.18	21491.00	42.04	38.56
Lot Size	cwt	1961.27	1720.95	30.00	17112.00	48.14	2506508.00	2961682.62	87.75
Foreign Seed	seeds	13.76	50.27	0.00	830.00	1.41	17579.00	2527.41	365.49
Heat Damage	kernels	2.47	5.54	1.50	75.00	0.16	3152.50	30.71	224.64
Red Rice	%	1.10	1.67	0.25	15.00	0.05	1402.50	2.78	151.90
Peck Damage	%	0.50	0.05	0.50	1.50	0.00	642.00	0.00	9.64
Smut Damage	%	0.54	0.20	0.50	2.50	0.01	690.00	0.04	37.00
Chalk Damage	%	1.13	0.53	0.50	5.00	0.01	1450.00	0.28	46.36

Note: All statistics were derived from auction data. Number of observations equal 1278.

Table 3. A Statistical Descriptive Summary of Rice Prices, Quality and Non Quality Factors, Medium Grain Rough Rice, Louisiana 1986.

Variable	Units	Mean	Standard Deviation	Minimum Value	Maximum Value	Standard Error Of Mean	Sum	Variance	Coefficient of Variation
Bid Price	$/cwt	4.08	0.55	1.00	5.00	0.02	2337.33	0.31	13.56
Mill Price	$/cwt	10.16	0.19	9.63	11.75	0.01	5819.97	0.04	1.90
Loan Price	$/cwt	5.90	1.79	0.00	8.16	0.07	3378.07	3.21	30.40
Head Rice	%	56.37	8.15	11.00	69.00	0.34	32300.00	66.49	14.46
Total Rice	%	69.86	1.93	59.00	74.00	0.08	40031.00	3.73	2.76
Broken Rice	%	13.49	7.41	3.00	50.00	0.31	7731.00	54.87	54.90
Lot Size	cwt	2091.65	1840.44	24.00	16933.00	76.89	1198513.00	3387233.40	87.99
Foreign Seed	seeds	8.32	24.40	0.00	240.00	1.02	4770.00	595.44	293.13
Heat Damage	kernels	4.16	10.63	1.50	75.00	0.44	2383.50	112.96	255.51
Red Rice	%	0.91	0.92	0.25	5.00	0.04	521.75	0.84	100.61
Peck Damage	%	0.52	0.16	0.50	2.50	0.01	299.50	0.03	30.68
Smut Damage	%	0.52	0.14	0.50	2.50	0.01	296.50	0.02	27.79
Chalk Damage	%	2.60	0.87	1.00	9.00	0.04	1487.00	0.76	33.57

Note: All statistics were derived from auction data. Number of observations equal 573.

virtually all accounted for in two byproducts, rice bran and rice hulls. No attempt was made to evaluate byproducts in this dissertation.

The average milling yield for medium grain, which was expected to be higher than long grain with respect to head rice was 69.8% total rice and 56.4% head rice. Notice from Tables 2 and 3 that head rice is much more variable than total rice for both long and medium grain. This indicates that while producers are consistently able to produce stable total yield, that the quality of that yield (head rice) is quite variable. [13]

The lot size variable is the quantity of rough rice offered for sale. The average quantity of long and medium grain offered in 1986 was 1,916 and 2,091, respectively. Even though the mean lot size was larger for medium grain, the sum of the lots confirm the popularity of long grain relative to medium grain varieties (2.5 million cwt vs 1.2 million cwt).

The total seed variable is the combined count of foreign seed and weed seeds. The average seed count for long and medium grain was 13.7 and 8.3, respectively. The total seed count varied considerably across lots for both long and medium grain. Total seed in long grain size ranged from 0 to 830 with a standard deviation of 50 seeds. Total seeds in medium

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[13] The descriptive statistics discussed in Tables 1 - 4 relate to the sample. Each lot size is weighted the same regardless of the quantity being sold in it.

grain rice were slightly less variable ranging from 0 to 240 seeds with a standard deviation of 24 seeds. The most predominant seeds observed were indigo and water parsley.

The remaining quality factors included in the data base are heat damage, red rice damage, peck damage, smut damage, and chalk damage, which are all undesirable characteristics. All remaining variables are measured in % damage.

Heat damage often occurs during the drying process. It causes discoloration of the kernel. The average heat damage for long and medium grain was 2.46% and 4.16%, respectively. Red rice is an undesirable type of wild rice often found in South Louisiana rice farms. The average percent red rice for long and medium grain was 1.09% and 0.91%, respectively. Peck damage, caused mainly by stink bugs, may cause the kernel to be prone to breaking. The average peck damage for both long and medium grain was 0.5%. The average damage for smut and chalk for long and medium grain was 0.54%, 1.13%, 0.517%, and 2.6%, respectively.

Directly comparing the undesirable quality factors presented above, peck and smut appear to pose the least problem. The coefficient of variation indicates that heat and red rice are more variable (Tables 2 and 3).

Sample for the 1987/88 Marketing Year

Tables 4 and 5 present a descriptive statistical summary for the 1987/88 marketing year. The 1987/88 marketing year

Table 4. A Statistical Descriptive Summary of Rice Prices, Quality and Non Quality Factors, Long Grain Rough Rice, Louisiana 1987.

Variable	Units	Mean	Standard Deviation	Minimum Value	Maximum Value	Standard Error Of Mean	Sum	Variance	Coefficient of Variation
Bid Price	$/cwt	8.42	2.91	2.46	14.40	0.09	9138.19	8.49	34.60
Mill Price	$/cwt	18.05	4.67	10.50	24.50	0.14	19587.55	21.85	25.89
Loan Price	$/cwt	6.66	1.22	0.00	8.07	0.04	7228.66	1.49	18.33
Head Rice	%	53.10	8.13	14.00	69.00	0.25	57618.00	66.15	15.32
Total Rice	%	70.00	2.41	57.00	73.00	0.07	75952.00	5.83	3.45
Broken Rice	%	16.90	6.84	4.00	51.00	0.21	18334.00	46.79	40.48
Lot Size	cwt	2160.94	1881.10	57.00	20219.00	57.11	2344621.00	3538537.77	87.05
Foreign Seed	seeds	6.84	25.40	0.00	500.00	0.77	7418.00	645.28	371.55
Heat Damage	kernels	2.52	6.53	1.50	75.00	0.20	2735.50	42.69	259.15
Red Rice	%	1.27	1.62	0.25	15.00	0.05	1378.25	2.63	127.67
Peck Damage	%	0.74	0.44	0.50	2.50	0.01	803.50	0.19	59.18
Smut Damage	%	0.52	0.19	0.50	4.00	0.01	561.00	0.04	37.35
Chalk Damage	%	0.99	0.62	0.50	8.00	0.02	1077.00	0.39	62.85

Note: All numbers were derived from auction data. Number of observations equal 1085.

Table 5. A Statistical Descriptive Summary of Rice Prices, Quality and Non Quality Factors, Medium Grain Rough Rice, Louisiana 1987.

Variable	Units	Mean	Standard Deviation	Minimum Value	Maximum Value	Standard Error Of Mean	Sum	Variance	Coefficient of Variation
Bid Price	$/cwt	7.28	1.83	1.79	12.77	0.07	5014.10	3.35	25.13
Mill Price	$/cwt	16.79	2.84	11.00	24.50	0.11	11566.67	8.06	16.91
Loan Value	$/cwt	6.31	0.98	0.00	7.44	0.04	4348.63	0.97	15.58
Head Rice	%	56.18	8.76	7.00	70.00	0.33	38709.00	76.68	15.59
Total Rice	%	69.50	2.16	60.00	77.00	0.08	47885.00	4.66	3.11
Broken Rice	%	13.32	7.67	1.00	56.00	0.29	9176.00	58.89	57.62
Lot Size	cwt	2063.35	1637.83	93.00	11340.00	62.40	1421647.00	2682491.29	79.38
Foreign Seeds	seeds	4.46	11.29	0.00	95.00	0.43	3074.00	127.38	252.97
Heat Damage	kernels	3.05	7.69	1.50	75.00	0.29	2103.00	59.13	251.94
Red Rice	%	1.36	1.76	0.25	15.00	0.07	937.75	3.10	129.43
Peck Damage	%	0.94	0.53	0.50	4.00	0.02	645.00	0.29	57.04
Smut Damage	%	0.50	0.03	0.50	1.00	0.00	345.50	0.00	5.37
Chalk Damage	%	2.40	0.96	1.00	5.00	0.04	1655.00	0.92	39.95

was quite different from the 1986/87 marketing year in terms of the general price level. In response to increased exports and adverse weather conditions in Asia, rice prices climbed from the \$4-\$5/cwt range to the \$10-\$12 cwt/range.

The average rough rice price for long and medium grain for that year was \$8.42/cwt and \$7.28/cwt, respectively. The standard deviations for long and medium grain, \$2.91 and \$1.83/cwt, respectively, indicate variability in the market in 1987 relative to that for 1986. In 1987, the price relationships between long and medium grain were more consistent with expectations ie. long grain rice was more highly valued per unit than medium grain.

The average weekly mill price for long and medium grain was \$18.05/cwt and 16.79/cwt, respectively. Like rough rice prices, milled price were also quite variable, \$4.67/cwt and \$2.84/cwt, respective standard deviations.

The mean levels and variability of the quality factors for the 1987/88 marketing year were fairly consistent with the 1986/87 marketing year in general. The average milling yields for long grain were 70% total rice and 53.1% head rice while for medium grain it was 69.4% total rice and 56.2% head rice. Again notice the difference in variability between total and head rice.

The average lot size in 1987 was about the same as in 1986. The mean for long and medium grain was about 2161 cwt and 2063 cwt, respectively. The total seed count for the

1987/88 sample was less than the total seed count for 1986/87 and also less variable. The average seed count for long and medium grain was 6.8 and 4.5 seeds, respectively. The standard deviation for long and medium grain were 25.4 seeds and 11.3 seeds, respectively. In respect to specific seeds, indigo and water parsley were also the most predominant.

Mean levels for heat, red rice, peck smut, and chalk were consistent with the previous year. The respective mean levels for long grain were 2.52%, 1.27%, 0.74%, 0.52%, and 1.19%. For medium grain the respective mean levels were 3.05%, 1.36%, 0.94%, 0.5%, and 2.4%. Heat, red rice, and chalk are the major damaging factors in terms of amounts present.

In comparing the variability of the set of quality factors for both long and medium grain across marketing years there are several variables that are consistently more variable than others. The coefficient of variation (CV) measures variation in percentage terms thus permitting comparison among variables that are measured in different units. Total seeds was consistently the most variable quality factor (Tables 2 - 5). Heat and red rice damage were the second and third most variable quality factors (Tables 2 - 5). This high degree of variability across producers and years indicate these factor could be some of the more important quality variables affecting the variation in rough rice prices.

With regard to making inferences about the general quality of rough rice in Louisiana, the mean levels reported in Tables 2 - 5 are biased upward. The reason for the bias is that each lot was weighted equally with regard to lot size. That is, a 200 cwt lot with 75 seeds is weighted the same as a 2,000 cwt lot with 0 seeds. In order to make a more reliable estimate about the general level of quality of rough rice in Louisiana, a weighted average was computed for the set of quality factors and the variables weighted by their lot size.

Table 6 presents weighted averages for the quality factors for long and medium grain for the 1986/87 and 1987/88 marketing years. Weighting individual lots by the quantity of rice sold significantly affected only the mean measure of foreign seeds for both years and across classes of rice. In

Table 6. Weighted Means of Quality Factors for Long and Medium Grain Rough Rice, 1986/87 and 1987/88, Louisiana.

Quality Factors	Units	LG 1986	MG 1986	LG 1987	MG 1987
Head Rice	%	53.84	56.98	54.82	56.62
Total Rice	%	69.99	70.00	70.40	69.70
Broken Rice	%	16.14	13.02	15.59	18.08
Foreign Seeds	%	6.52	5.95	3.30	3.30
Heat Damage	%	2.40	5.06	2.51	3.32
Red Rice	%	0.87	0.83	1.19	1.29
Peck Damage	%	0.50	0.51	0.78	0.96
Smut Damage	%	0.54	0.52	0.51	0.50
Chalk Damage	%	1.05	2.61	0.96	2.50

all cases, the mean level of seeds were reduced indicating that producers were concentrating seedy lots of rice in small quantities.

Frequency bar charts for quality factors and correlation matrices for all variables, including price variables, in the hedonic model are presented in Appendix A. The histograms indicate that head rice, broken rice, foreign rice, foreign seeds, and red rice were the larger (more variation) distributions. The coefficient of variation for these variables reported in Tables 2 - 5 also confirm this variation. The remaining factors, peck, smut, and chalk had considerably less variation, as confirmed by their respection coefficient of variation. Their respective histograms also confirm their lack of presence in the market. These basic trends did not substantially change across data sets.

The descriptive statistics and figures presented here and in Appendix A provide a great deal of information which can be used to help identify the structural model and identify possible problems associated with estimation of the premiums/discounts which is the primary goal of this study.

The large coefficients of variation and spreads in the histograms associated with some of the quality factors imply that these factors are probably highly stochastic which is in violation of the OLS assumptions. For the variables peck, smut, and chalk the histograms were largely a single bar. This indicates for most of the observations each lot of rice had the same level of quality. Stated differently, they basically comprise a constant. These pieces of information are used in detail later in the study to help re-specify the hedonic model and identify the error-in-variables problem.

CHAPTER IV

HEDONIC PRICES FOR LONG AND MEDIUM GRAIN ROUGH RICE FOR THE 1986/87 AND 1987/88 MARKETING YEARS IN LOUISIANA

Estimates of the Hedonic Price Models: Premiums/Discounts for Long and Medium Grain Rough Rice for the 1986/87 and 1987/88 Marketing Years

Equation (4.5) was estimated using ordinary least squares (OLS) regression techniques. OLS minimizes the squared deviation of the dependent variable about its mean.[14] The hedonic model was estimated for both long and medium grain classes for the 1986/87 and 1987/88 marketing years (a total of 4 models).

Table 7 presents the OLS estimates of the four hedonic price models for Louisiana. The estimated parameters describes the pricing structure of long and medium grain rough rice in the Louisiana rough rice bid/acceptance market studied in this dissertation. There are other such markets in the state but they are believed to be much smaller than the one used in this study. The parameters indicate the resulting dollar per hundredweight (cwt) change in price from a one unit change in a quality factor. Statistical results across both

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[14] The classical assumption of OLS, which via the Gauss Markov Theorem provides the "Best Linear Unbiased" (BLUE) parameter estimates, are: (a) $e \sim N(0,\sigma^2 I)$, (b) the X (design matrix is non-stochastic and of full column rank. The notation (a) above states the expected value of e is zero, its covariance matrix has a constant variance σ^2, and the errors are not serially correlated.

Table 7. OLS Estimates Of A Hedonic Price Model For Long and Medium Grain Rough Rice for 1986 and 1987 in Louisiana.

Quality Factors	Long Grain 1986	Medium Grain 1986	Long Grain 1987	Medium Grain 1987
Constant	0.848 (3.04)*	0.288 (0.29)	-17.56 (13.93)*	-11.389 (8.19)*
Mill Price	-0.101 (5.95)*	-0.076 (0.97)	0.512 (63.29)*	0.424 (35.14)*
Head Rice	0.070 (22.36)*	0.072 (8.44)*	0.267 (15.75)*	0.175 (10.48)*
Broken Kernels	0.031 (9.08)*	0.030 (3.24)*	0.150 (7.62)*	0.064 (3.39)*
Lot Size	0.000014 (3.11)*	0.000022 (2.63)*	0.000025 (1.28)	0.000025 (1.26)
Foreign Seeds	-0.00144 (9.792)*	-0.003 (4.69)*	-0.0071 (4.86)*	-.0142 (4.67)*
Heat Damage	-0.0026 (1.98)*	-0.0087 (5.98)*	-0.0312 (5.69)*	-.0405 (9.42)*
Red Rice	-0.0157 (3.39)*	-0.046 (2.63)*	-0.0581 (2.59)*	-0.0276 (1.46)
Peck Damage	-0.088 (0.589)	0.052 (0.54)	-0.0310 (0.36)	-0.016 (0.25)
Smut Damage	-0.0066 (0.18)	-0.43 (0.40)	-0.0432 (0.23)	1.715 (1.42)
Chalk Damage	0.018 (1.21)	0.0575 (3.21)*	0.2055 (3.54)*	0.0601 (1.71)
R^2	67%	58%	84%	79%
Mean Square Error	0.067	0.131	1.356	0.7209
F-Statistic	255.19	77.932	571.7	251.5
Breusch-Pagan Statistic	163.2**	9.7	26.1**	2.54
Durbin-Watson	1.41***	1.28***	1.07***	1.38***

Notes: Absolute t-values in parenthesis; * indicates parameter is significantly different from zero at 95 % level; ** indicates significant heteroscedasity; *** indicates significant first order autocorrelation.

classes of rice and marketing years indicate that head rice and red rice were the two most important and consistent quality factors. The general pricing structure between marketing years was substantially different, however. For all of the statistically significant quality factors, the magnitude of the premiums/discounts dramatically increased between the 1986/87 and 1987/88 marketing years. Changing supply and demand conditionsp1279[illegible]ng implications on the hedonic price model.

The overall fit of each of the four hedonic models was good as indicated by the R^2s for the respective models. The R^2 for the long grain 1986 (LG86), medium grain 1986 (MG86), long grain 1987 (LG87), and medium grain 1987 (MG87) indicate that the hedonic models accounted for 67, 58, 84, and 79 percent of the variations in rough rice prices. All R^2 values were statistically significant as indicated by the F-Statistic for the respective models.[15]

Notice the differences in F-values between long and medium grain and between marketing years within a respective class. The F-values are larger in the 1987/88 marketing year and the F-values associated with long grain are higher than the medium grain values. This relationship also holds for the R^2 values indicating that the long grain market is better

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[15] This F-Statistic is for the null hypothesis that the parameter values are jointly equal and equal to zero i.e. $H_0 = \beta_1 = \beta_2, \ldots, = \beta_k = 0$.

captured by the above hedonic models than is the medium grain market; also that in a year in which the market was characterized by large variations in commodity prices the hedonic model was more explanatory.

Premiums per percent head rice for long grain ranged from $0.07 per cwt in 1986 to $0.27 per cwt in 1987 and for medium grain $0.07 per cwt in 1986 to $.175 per cwt in 1987.*p2Al69X coefficients were significant at the 95% level (absolute t-values of 22.36, 8.44, 15.75, and 10.48 for LG86, MG86, LG87, and MG87, respectively).[16] These premiums indicate that a producer of long grain rough rice in 1987 would receive a $0.267/cwt premium for each one percent increase in head rice.

Premiums for one percent broken kernels in the long grain market ranged from $0.031/cwt in 1986 to $0.15/cwt in 1987 and for medium grain ranged from $0.03/cwt in 1986 to $0.065/cwt in 1987. All premiums were statistically significant at the 95% level (absolute t-values of 9.08, 3.24, 7.62, and 3.39 for LG86, MG86, LG87, MG87, respectively).

Premiums for larger lot sizes were quite small and statistically insignificant for both long and medium grain rice in 1987. The premiums were significant in 1986 but very small e.g., LG86 premiums was $0.000014/cwt.

Discounts for foreign seed in the long grain market ranged from $0.0014/cwt in 1986 to $0.0071/cwt in 1987 and in

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[16] T-values are for the null-hypothesis that individual parameters are not different from zero i.e., $\beta_1 = 0$).

the medium grain market from $0.003/cwt in 1986 to $0.014/cwt in 1987. Interestingly, the discounts for seeds were higher in the medium grain market which could indicate that seeds are more of a problem in medium grain rice than long grain rice. All parameters were significant at the 95% level (absolute t-values of 9.79, 4.69, 4.86, and 4.67 for LG86, MG86, LG87, MG87, respectively).

Discounts for heat damage indicate that, behind red rice, heat damage was the next most costly quality factor to Louisiana rice producers. Heat damage mainly occurs during the drying process and can, to some extent, be controlled through management of that process. Discounts for a heat damaged kernel in the long grain market ranged from $0.0026/cwt in 1986 to $0.031/cwt in 1987 and ranged in the medium grain market from $0.0087/cwt in 1986 to $0.0405/cwt in 1987. As was the case of seeds, the discount for heat damage was larger in the medium grain market. All discounts were statistically significant (absolute t-values of 1.98, 5.98, 5.69, and 9.42 for LG86, MG86, LG87, and MG87, respectively). Notice the t-values are higher in the medium grain market.

Discounts associated with red rice were consistently higher than any other undesirable quality factors indicating the severity of red rice infestation in Louisiana rice land. This is not unexpected given the red rice problem in the state. Red rice is a serious cultural hindrance to rice producers, especially in Southwest Louisiana.

Discounts for one percent red rice kernels in the long grain market ranged from $0.015/cwt in 1986 to $0.058/cwt in 1987 and ranged in the medium grain market from $0.046/cwt in 1986 to $0.0276/cwt in 1987. Often adverse to the milling process, red rice plants also compete with desired rice plants for nutrients causing adverse yield effects. All discounts associated with red rice were statistically significant at the 95% level except in the medium grain market in 1987, which was significant at the 80% level (absolute t-values of 3.39, 2.66, 2.59, and 1.46 for LG86, MG86, LG87, and MG87, respectively).

The remaining quality factors -- peck, smut, and chalk were found to be statistically insignificant at the 95% level with the exception of chalk in the medium grain market in 1986 and in the long grain market in 1987. However, the chalk parameters had the opposite effect on price than expected. Peck and smut generally had negative signs (discounts) across classes and years as expected. The lack of significance does not imply that these factors cannot have adverse effects on prices in given years and markets. It simply implies that they did not pose problems to Louisiana producers in the long and medium grain rough rice markets during the periods studied. They are important quality factors that affect rough rice prices in some years and in certain markets. These factors were found to be significant in certain periods analyzed separately. Models which estimated the hedonic models for different marketing periods (e.g., harvest vs. post harvest) are presented in the Appendix C and discussed later in this chapter.

The milled rice price was a significant variable in all models except the medium grain market in 1986 (absolute t-values of 5.45, 0.87, 63.24, and 35.44 for LG86, MG86, LG87, and MG87, respectively). The milled price was included to improve the model specification. It is very interesting to note that the sign on mill price changed significantly between the two years in both the long and medium grain markets. The negative sign for the 1986/87 market indicates the very depressed state of the rice market. The negative coefficient strongly suggests a lack of demand in the rice market. The supply of rough rice was large relative to demand.

Market conditions in 1987/88 changed dramatically causing dramatic price increases during that year. The coefficient on mill price in 1987/88 highlights these conditions, as evidenced by the large positive parameters and extremely high t-values. These results provide strong support for the inclusion of mill price as a component of the hedonic model.

The cross-sectional time series nature of the data gave a prior indication of possible error problems i.e., errors from OLS regression which violate classical assumptions. Table 7 also gives error diagnostic statistics for two common econometric problems associated with cross-sectional time-series data; heteroscedasticity and autocorrelation. The Breuch-Pagan (BP) statistic is a test for an unknown form of heteroscedasticity and the Durbin-Watson (DW) statistic is a test for first order autocorrelation.

All four models indicated significant first order autocorrelation (DW values of 1.41, 1.28, 1.07, 1.3 for LG86, MG86, LG87, and MG87, respectively). The DW statistic for rejection of the null (no first order autocorrelation) should take a value around 2. The presence of autocorrelation affects the efficiency of the parameter estimates. The premiums are unbiased but are not as efficient, i.e., more variable than if no autocorrelation were present. First order autocorrelation means that the error associated with sale t is correlated with the error for sale t-1.

Significant heteroscedasticity was found in the long grain market in both the 1986/87 and 1987/88 marketing years. Heteroscedasticity, similar to autocorrelation, causes the parameters (premiums/discounts) to be inefficient. Heteroscedasticity means that there is some factor in the data or in the economic or physical process, that generates the data that causes the variance to differ across lots of rice. The BP statistic for LG86, MG86, LG87, and MG87 was 163.2, 9.7, 26.1, and 2.54, respectively. The BP statistic is a Chi-Square statistic (see Judge, 1985, for more details). The heteroscedasticity was confirmed by the White test, which is another test for an unknown form of heteroscedasticity (see Judge, 1980, for details). The White test supported the BP test, but, because of computational difficulties associated with the White test, the BP was used for further testing.

The results of the DW and BP test provoked a more detailed diagnosis of the error terms. ARIMA (Auto-regressive Interactive Moving Average) models were estimated for the errors from each of the four hedonic models using the ARIMA procedure in SAS (Statistical Analysis System) computer software. The ARIMA models help identify the structure of the auto-correlation. Appendix B shows the auto-correlations of the errors, as well as other error diagnostics, from the respective models studied.

These figures can be used to determine the degree (structure) of autocorrelation. For all models, the structure of the autocorrelation was greater than a first order. For example, an AR(4) (fourth order auto-regressive structure means that the information from four previous rice sales are playing a significant role in the parameter estimate). These structures are identified for the four hedonic models and autoregressive procedures were used to correct the model for the autocorrelation.[17]

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[17] The lagged structures used to correct the models were AR(7), AR(5), AR(5), and AR(5) for the LG86, MG87, LG87, and MG87 markets, respectively.

The errors were also examined to identify the heteroscedasticity. Heteroscedasticity is associated with non-constant variance among the error components. This violates one of the assumptions of OLS i.e, that errors have a constant variance σ^2. Violation of this assumption affects the efficiency of the parameter estimates. A common diagnostic procedure for dealing with heteroscedasticity is to plot the errors against the independent variables to see if some pattern between the residuals and an independent variable can be detected. The residuals plot should appear random. If some type of pattern can be detected, such as an increasing or decreasing variance as the values of the independent variables are increased, then one can use this knowledge to transform the data. The goal of transforming the data to remove the factor causing the non-constant variances.

An applied example of heteroscedasticity is often observed in the estimation of a consumption function when income is expressed as a function of consumption and the data is comprised of a cross-section of consumers. The heteroscedastic errors arise due to the fact that, normally, the consumption associated with low income households are less variable than that of high income households. A plot of the errors against income would show a pattern resembling a bell laying on its side, with the bell end of the bell (the large variance in errors) being associated with large income households.

Error plots of this nature were conducted for both long grain models. The errors were plotted against all independent variables. The observation of the plots indicated a large variance of the errors associated with small lot sizes and small levels of foreign seeds with the variance reducing as lot size increased and number of seeds increased. This large variance associated with small lots arises from some small lots being of high quality and others being of very low quality. Many producers will isolate poor quality rice in small lots so as not to contaminate a large lot. Other producers sell small high quality lots because the lot is just small (e.g. landowner's share). The identification of these two factors was used to attempt removal of the heteroscedastic component in the data.

Table 8 presents estimates of the hedonic models for long and medium grain markets in 1986 and 1987 which were estimated using autoregressive procedures. That is, the estimates were corrected for autocorrelation. However, the estimation of the autoregressive model also indicated significant levels of heteroscedasticity.

The autoregressive estimates in Table 8 are more efficient than the OLS estimates reported in Table 7 because the autocorrelation has been removed. The errors were

Table 8. Autoregressive Estimates of a Hedonic Price Model For Long and Medium Grain Grain Rough Rice For 1986 And 1987 In Louisiana.

Quality Factors	Long Grain 1986	Medium Grain 1986	Long Grain 1987	Medium Grain 1987
Constant	0.852 (2.57)*	1.175 (0.29)	-15.05 (13.89)*	-12.225 (9.56)*
Mill Price	-0.117 (5.02)*	-0.15 (0.9)	0.507 (45.76)*	0.431 (28.07)*
Head Rice	0.072 (23.07)*	0.071 (8.44)*	0.236 (16.38)*	0.186 (11.96)*
Broken Kernels	0.034 (9.84)*	0.028 (3.24)*	0.116 (6.93)*	0.076 (4.39)*
Lot Size	0.000014 (3.43)*	0.000023 (2.63)*	0.000047 (6.44)*	0.000034 (1.81)*
Foreign Seeds	-0.00146 (10.747)*	-0.002 (4.69)*	-0.0078 (2.89)*	-0.0118 (4.29)*
Heat Damage	-0.0033 (2.77)*	-0.0075 (5.98)*	-0.0219 (4.90)*	-0.0372 (9.49)*
Red Rice	-0.0186 (4.33)*	-0.058 (2.63)*	-0.0594 (3.10)*	-0.0422 (2.38)*
Peck Damage	-0.028 (0.217)	0.102 (0.54)	-0.0657 (0.85)	-0.017 (0.29)
Smut Damage	-0.0086 (0.24)	-0.55 (0.40)	-0.0316 (1.96)*	1.742 (1.62)
Chalk Damage	0.0110 (0.73)	0.0341 (3.21)*	0.0797 (1.52)	0.0029 (0.80)
R^2	72%	66%	89%	82%
Mean Square Error	0.057	0.108	0.980	0.6116
Breuch-Pagan Statistic	175.9**	5.5	43.4**	4.8

Notes: Absolute t-values in parenthesis; * indicates parameter is significantly different from zero at 95 % level; ** indicates significant heteroscedasity.

analyzed through ARIMA procedures to assure that all autoregressive-moving average components were removed.

Appendix B presents error diagnostics for the OLS and autoregressive models for the four markets studied. The error diagnostics presented are: (1) a frequency bar chart of the errors used to examine the normality of the errors; (2) a plot of the errors against the predicted values of the bid price. This plot is used to identify the presence of heteroscedasticity; and (3) autocorrelations, partial autocorrelations, and a check for white noise are presented to address the serial correlation problem among the errors. There are a total of 24 figures presented in Appendix B which are made up from three error figures for two types of errors (OLS and autoregressive) for 4 different markets. For each market the OLS errors are presented first followed by the autoregressive errors.

To clarify the usefulness of these figures for the OLS and autoregressive errors for the Long Grain 1986 market, Appendix B Figure 1 shows a histogram of the OLS errors. The mass of errors are collected about zero. This indicates the errors do approximately have an expected value of zero as the assumptions state. Appendix B Figure 2 shows the plot of the OLS errors against the predicted values for bid price. This plot should appear random if no heteroscedasticity exists. The OLS errors appear to be somewhat random though a V shape pattern toward higher bid prices seems apparent. This indicates a larger variance in the errors associated with lower bid prices.

Appendix B, Figure 3 presents output estimated through the ARIMA procedures. The ARIMA procedures in SAS give the mean, standard deviation, and number of observations of the errors. Also, autocorrelations, and CHI-square statistics for white noise of the errors are presented. Notice in Appendix B Figure 3 that both the autocorrelations and partial autocorrelations up to a 7 period lag are greater than two standard errors. This indicates that information from at least the seven previous sales is playing a significant role in the current time period. Notice also the CHI-square statistic for a 6 period lag is 367.19. This extremely large value indicates, with a high degree of probability, that the errors in the previous 6 periods are correlated.

Comparing the autoregressive errors for the LG86 market, presented in Appendix B Figures 4 - 6, the histogram is about identical to that of the OLS errors. the plot of the errors against the predicted values appear to be more random than the OLS errors, but a similar V-pattern still exists.

The results of the ARIMA procedures are quite conclusive that the autoregressive procedures removed the serial correlation. Notice in Appendix B Figure 6 that the standard deviation of the autoregressive errors is smaller than with the OLS errors. Also, all auto and partial correlations fell within 2 standard errors and the CHI-Square statistic was substantially lower (.56) indicating an acceptance of the null hypothesis of no serial correlation within the first 6 periods. Similar results can be observed in the other markets by reviewing the remainder of Appendix B.

The higher R^2 values and lower mean square errors from the four models indicate better performance in terms of the model's explanatory power and low variances. Individual premiums and discounts also improved. For example, the discount associated with red rice in the medium grain market in 1987 became statistically significant at the 95% level. Also, the discount for smut damage in the long grain 1987 model became significant.

In general, however, the premiums/discounts did not change in terms of size, significance, and patterns discussed earlier. The main advantage of these estimates is in the efficiency of the parameter estimates. Analysis of the errors from the regression model indicated significant heteroscedasticity. Heteroscedasticity, like autocorrelation, affects the variance of the parameter estimates. It increases the variance, hence, reducing the precision of the estimate, i.e., affecting the standard error of the estimate.

The cross-sectional characteristics of the data are the most probable cause of the non-constant variance of the errors. Recall each data set is comprised of a cross-section of producer lots over the marketing season. There are efficient means of correcting data for both autocorrelation and heteroscedasticity. A pooled, cross-section, time series estimation model is described by Kementa (1974, pp. 505-514) and by Judge (1985, p. 518). The Shazam econometric software package offers this option for estimation purposes. The problem with this method for these data is that it assumes a one cross-sectional unit traced over time, ie., that data is collected on an individual economic agent over time. Most of the existing theory for correcting heteroscedasticity is based on this assumption about the cross-sectional nature of the data. The lack of conformity between the data and the technique prevented its use.

An alternative procedure was used in an attempt to estimate a hedonic model which yielded good errors (i.e., no autocorrelation or heteroscedasticity). The procedure used was in two steps. The first step involved a transformation of the data to remove the factors causing the non-constant error variances. The second step was to estimate the hedonic model, using the transformed data, via autoregressive techniques.

The transformation was made by adjusting the dependent and independent variables by each observation's respective variance. The procedures outlined in Judge (1982, pp. 415-418) were used to generate the individual variances. The data were transformed according to the generalized least squares estimation.[18] The individual estimated error variances were generated assuming lot size and foreign seeds were the factors causing the non-constant variances. These variables had been identified by analyzing plots of the residual against independent variables.

Table 9 presents the results from the autoregressive generalized least squares transformation for the long grain 1986 and 1987 models. The BP statistics indicates a significant reduction in the level of heteroscedasticity for the long grain 1986 and 1987 models. In neither model, however, was the heteroscedasticity completely removed. This implies that the efficiency of the correction technique was not very good and there still remains some systematic component in the data causing a non-constant error variance.

Individual parameter estimates using this procedure were consistent with those reported in Tables 7 and 8. These models did, however, have a higher mean square error. One major difference was observed in the long grain 1987 model. The sign on both lot size and foreign seeds changed which was not expected nor believed, especially for foreign seeds. In evaluating the two sets of models presented in Tables 8 and

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[18] For more details on the generalized least squares estimation, see Judge, 1982, Chapter 10.

Table 9. Autoregressive Estimates of a Hedonic Price Model for Long Grain Rough Rice, Corrected for Heteroscedasticity for 1986 and 1987 in Louisiana.

Quality Factors	Long Grain 1986	Long Grain 1987
Constant	2.8298 (3.13)*	-19.52 (13.32)
Mill Price	-0.121 (5.50)*	0.51 (46.64)*
Head Rice	0.072 (23.58)*	0.229 (15.7)*
Broken Kernels	0.033 (9.99)*	0.109 (6.52)*
Lot Size	0.000029 (4.18)*	-0.00004 (2.30)*
Foreign Seeds	-0.00291 (6.99)*	0.009 (3.92)*
Heat Damage	-0.0033 (2.91)*	-0.0213 (4.77)*
Red Rice	-0.0224 (5.06)*	-0.272 (12.9)*
Peck Damage	-0.039 (0.312)	-0.079 (1.04)
Smut Damage	-0.0165 (0.474)	-0.34 (2.11)*
Chalk Damage	0.0138 (0.93)	0.7928 (9.67)*
R^2	83%	89%
Mean Square Error	0.475	1.666
Breusch-Pagan Statistic	50.9**	32.12**

Notes: Absolute t-values in parenthesis; * indicates parameter is significantly different from zero at 95 % level; ** indicates significant heteroscedasity.

9, more confidence can be placed on the estimates given in Table 8. The models corrected for heteroscedasticity are free of any autocorrelation effects but the transformation was not efficient in removing the heteroscedasity; hence, the possible effects of the transformation are uncertain. In this consideration, the premiums/discounts reported in Table 8 are more accurate, at least based on a mean square error criterion.

Estimation of Semi-Logarithmic Models for the 1987/88 Marketing Year

As discussed earlier, model specification tests were performed to determine the appropriate functional structure for hedonic prices of rough rice in Louisiana. Results of the tests indicated that a semi-logarithmic specification was appropriate for the 1987/88 marketing year for both long and medium grain rough rice. Table 10 presents results from the estimation of the semi-log model for long and medium grain rice for the 1987/88 marketing season. The models were estimated using autoregressive techniques. Analysis of the OLS residuals indicated significant autocorrelation and heteroscedasticity in the long grain model. The autoregressive procedure removed all autocorrelation.

The main differences in the premiums/discounts reported in Table 10 as compared to those in Tables 7, 8, or 9, is that the Table 10 values are a function of price i.e., the premiums/discounts are a percentage of price. For example,

Table 10. Auto-Regressive Estimates of a Hedonic Price Model for Medium and Long Grain Rough Rice for 1986 and 1987 in Louisiana, Semi-Log Model.

Quality Factors	Semi-Log Medium Grain 1987	Semi-Log Long Grain 1987
Constant	-2.703 (13.6)*	-2.896 (21.98)*
Mill Price	1.0113 (31.61)*	1.083 (53.57)*
Head Rice	0.029 (13.14)*	0.0305 (19.0)*
Broken Kernels	0.011 (4.52)*	0.0156 (8.37)*
Lot Size	0.000003 (1.18)	0.000005 (2.61)*
Foreign Seeds	-0.00291 (4.87)*	-0.001 (7.49)*
Heat Damage	-0.0058 (10.5)*	-0.0023 (4.61)*
Red Rice	-0.0056 (2.26)*	-0.007 (3.31)*
Peck Damage	0.004 (0.475)	-0.0056 (0.654)
Smut Damage	0.1274 (0.838)	-0.028 (1.55)
Chalk Damage	-0.0009 (0.17)	0.0086 (1.48)
R^2	85%	92%
Mean Square Error	0.0123	0.0120
Breusch-Pagan Statistic	1.57	110.95**

Notes: Absolute t-values in parenthesis; * indicates parameter is significantly different from zero at 95 % level; ** indicates significant heteroscedasity.

the premium for an extra percent head rice for long grain is 0.0305 or 3.05 percent of the price of rough rice. This means that if the market price of rough rice were \$10/cwt, a producer would estimate his discount at \$0.305/cwt for each percent infestation of red rice by weight. Overall, the model performed well in terms of its explanatory power and precision. The R^2 for both long and medium grain classes indicated that the hedonic model explained 92 and 85 percent of the variation in rough rice prices, respectively, in 1987. The mean square errors for the long and medium grain models were 0.012 and 0.0123, respectively.

In terms of significance and signs the estimated premiums/discounts were consistent with previous results. Head rice, broken kernels, and lot size were all positive and significant with the exception of lot size in medium grain which was positive but insignificant. Foreign seeds, heat, and red rice were all negative and significant. In both long and medium grain the discount for heat damage was at 0.23 and 0.58 percent of price for long and medium grain, respectively. Peck, smut, and chalk discounts were not statistically significant in either the long or medium grain market which is basically consistent with previously reported results.

In order to compare the premiums/discounts as estimated by a linear model to those estimated by a semi-logarithmic model, the premiums/discounts were evaluated at the mean rough rice price level for the data in 1987. Table 11 presents two sets of premiums/discounts for head rice, broken kernels, lot size, foreign seeds, heat, and red rice for long and medium grain in 1987. The first set (first two columns) was generated from the linear model (Table 7) while the second was generated from the semi-logarithmic model (Table 9).

When the premiums/discounts were evaluated at mean price levels, the values are very similar to those obtained from the linear model (Table 11). However, if the premiums/discounts had been calculated using either harvest prices or spring prices for the 1987/88 marketing year, large differences would have been observed.

Table 11. Comparison of Selected Premiums/Discounts for Long and Medium Grain Rough Rice, Between Linear and Semi-Logarithmic Models, Louisiana, 1987.

	Linear Model		Semi-Logarithmic Model	
Quality Factor	LG	MG	LG*	MG**
Head Rice	0.236	0.186	0.257	0.211
Broken Kernels	0.116	0.076	0.131	0.08
Lot Size	0.000047	0.000034	0.00004	0.00002
Foreign Seeds	-0.0078	-0.00118	-0.0084	-0.0212
Heat Damage	-0.0219	-0.0372	-0.019	-0.0422
Red Rice	-0.0594	-0.0422	-0.058	-0.0041

* Calculated using mean level long grain price ($8.42).

** Calculated using mean level medium grain price ($7.28).

Premiums and Discounts Across Marketing Seasons, Marketing Years, and Classes of Rice

Data on rough rice prices and associated quality factors were collected for the 1986/87 and 1987/88 marketing season for both the long and medium grain classes of rice. This data set enables the testing of several hypothesis about the hedonic rough rice price models for Louisiana.

The Louisiana rough rice market begins in late July and continues into March and early April of the next calendar year. Compared to other rice markets (rice producing areas), the Louisiana marketing season begins early. Harvest of Arkansas and Mississippi produced rice doesn't begin until late August or early September. California produced rice isn't harvested until October. This relatively early harvest is said to enable Louisiana rice producers to receive better prices early in the season. As in most commodities, the Louisiana rice market is characterized by several price patterns (Martinez, et.al). The changing supply and demand, as well as other market conditions (year to year changes in supply and demand), give rise to the hypothesis that premiums/discounts differ across the marketing season and marketing years.

A second hypothesis that has been, up to this point, implicitly rejected is that premiums/discounts differ across classes of rice. The class of rice is the major characteristic by which rice is differentiated. This differentiation has major production and marketing implications.

These hypotheses are tested by segmenting the data into different groups depending on the relevant hypothesis. For example, to examine the hedonic models for differences between marketing years the data are combined for both years and the hedonic model for the combined years is compared to the models for the individual years.

A Chow test is used to examine for differences in the hedonic model (equation) across the given periods. This procedure tests for overall equality of regression equations instead of equality of individual parameters. The Chow test compares the error sum of squares of the individual periods (e.g., 1986/87, 1987/88) to the error sum of squares for the combined period (e.g., 1986 and 1987). The formula is given by equation (4.8);

$$(4.8) \qquad Chow = \frac{ESS - ESS_1 - ESS_2/K}{ESS_1 + ESS_2/T_1 + T_2 - 2K}$$

where ESS is the error sum of squares from the combined model, ESS_1 is the error sum of squares for the first period, ESS_2 is the error sum of squares for the second period, K is the number of explanatory variables, T_1 is the number of observations in the first period and T_2 is the number of observations in the second period. The Chow statistic is distributed as a F-statistic with numerator degrees of freedom of K and denominator degrees of freedom of $T_1 + T_2 - 2K$.

A total of eight different null hypotheses were tested concerning shifts or overall changes in the hedonic price model for rough rice in the Louisiana market. The null hypotheses tested were that hedonic price relationships for long and medium grain were unchanged between: (1) marketing years, (2) between harvest and post harvest seasons, and (3) between classes of rough rice (long and medium) for the two marketing seasons, respectively. [19]

The analyses for the marketing years were straightforward. The data were segmented by marketing years. The analysis of marketing seasons required making a decision relative to where in the marketing season (i.e., at what point in time) does the change in the hedonic model occur. The data were divided between harvest and post harvest seasons because between those points there is a natural change in the marketing strategies of producers, i.e., they have either sold the commodity or have decided to store it. To test for differences between classes of rice (long and medium), the long and medium grain data sets were combined for each marketing year and compared to their separate counterparts.

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[19] The Chow analysis of the specification for the hedonic model can be questioned due to the violation of the assumptions relative to ordinary least squares estimation.

Hedonic models were estimated for the combined marketing years 1986/87 and 1987/88; for the harvest and post harvest season in 1986 and 1987 for both long and medium grain rough rice, and models for combined long and medium grain rice in 1986 and 1987. Appendix C presents the estimated models. All hedonic models for the above identified groups possessed significant F-statistics. In terms of signs and statistical significance, the patterns for individual groups were similar to the results previously presented. Significant premiums/discounts included head rice, broken kernels, foreign seeds, heat, and red rice. Other factors that were not significant (chalk, smut, and peck) did at certain times (harvest or post harvest, in a given year for either long or medium grain) come into the model at significant levels.

Tables 12, 13, 14, and 15 present a summary of the hedonic models for the different groups. The tables give the error sum of squares for the individual and combined groups. Also, the Chow F-statistic is given. These tables give the information necessary to draw conclusions about the differences in the hedonic rough rice price models between marketing years between seasons of the year and between classes of rough rice.

Table 12 gives the results from the analysis of marketing years for long and medium grain. The Chow statistic for differences in the long grain hedonic model between 1986 and 1987 was 87.01. This high level of significant difference was

Table 12. Error Sum of Squares for Long and Medium Grain Models, 1986, 1987, and 1986-1987 Years Combined, and Chow F-Statistics for Differences in Regression Equations Between Marketing Years for Long and Medium Grain Rough Rice.

Marketing Season	Error Sum of Squares	
	Long Grain	Medium Grain
1986/87	84.50	73.32
1987/88	1456.03	488.74
1986-87 Combined	2170.78	745.44
Chow F-Statistic	87.01*	36.77*

* Indicates significant difference between hedonic models at the 95 % level.

Table 13. Error Sum of Squares for Long and Medium Grain Models, Harvest, Post-Harvest and Seasons Combined, 1986, and Chow F-Statistics for Differences in Regression Equations Between Marketing Years for Long and Medium Grain rough Rice, 1986.

Marketing Season	Error Sum of Squares	
	Long Grain	Medium Grain
Harvest	35.82	55.46
Post Harvest	39.73	11.74
1986-87 Marketing Year	84.50	73.32
Chow F-Statistic	13.53*	4.56*

* Indicates significant difference between hedonic models at the 95 % level.

Table 14. Error Sum of Squares for Long and Medium Grain Models, Harvest, Post-Harvest Models and Seasons Combined, 1987, and Chow F-Statistics for Differences in Regression Equations Between Marketing Seasons for Long and Medium Grain Rough Rice, 1987.

Marketing Season	Error Sum of Squares	
	Long Grain	Medium Grain
Harvest	36.97	37.73
Post Harvest	1071.37	391.81
1987-88 Marketing Year	1456.03	488.74
Chow F-Statistic	30.32*	8.36*

* Indicates significant difference between hedonic models at the 95 % level.

Table 15. Error Sum of Squares for 1986/87 and 1987/88 Marketing Years, Long Grain, Medium Grain, and Long-Medium Grain Combined, and Chow F-Statistics for Differences in Regression Equations Between Long and Medium Grain Rough Rice for 1986 and 1987.

Class of Rice	Error Sum of Squares	
	1986/87	1987/88
Long Grain	84.50	1456.03
Medium Grain	73.32	488.74
Long and Medium Grain Combined	164.49	2191.12
Chow F-Statistic	7.02*	20.18*

* Indicates significant difference between hedonic models at the 95 % level.

expected because of the major market differences observed between the two years. Also, the Box-Cox method indicated two different functional forms for the two years. The Chow statistic for the medium grain model (36.77) also indicated a significant difference in the hedonic model between marketing years for medium grain.

Table 13 gives the results from the analysis of marketing seasons in 1986 for long and medium grain models. The Chow statistic indicated a significant difference in the hedonic model for both long and medium grain in 1986 between harvest and post harvest seasons (Chow statistic of 13.53 and 4.56 for long and medium grain, respectively). The Chow value for the long grain model was more significant than that of the medium grain model indicating a larger difference in the hedonic model between marketing seasons in long grain than in the medium grain market.

Table 14 gives the results from the analysis of marketing seasons in 1987 for long and medium grain models. The Chow statistic indicated a significant difference in the hedonic models in both the long and medium grain markets in 1987 between harvest and post harvest seasons (Chow statistic values of 30.32 and 8.36 for long and medium grain, respectively). Similar to the results in 1986, the difference in the long grain market was greater between seasons than was that of the medium grain market as indicated by the higher Chow value. When the Chow values for differences in marketing season in 1986 are compared to those of 1987 the differences were greater in 1987 than in 1986. This is because of the major differences in the market conditions over the seasons in the two years. For the 1987-88 period, the price level during the 1987 harvest season was one-half of the price level of rough rice in the mid to late post harvest season.

Table 15 gives the results from the analysis of classes of rice for 1986 and 1987. The Chow statistics indicate, as expected, significant differences in the hedonic price model between long and medium grain in both 1986 and 1987 (values of 7.02 and 20.18 for 1986 and 1987, respectively). The differences between classes were greater in 1987 than 1986 as was the general case for the other analysis in 1987. These differences between long and medium grain validate the assumption made earlier about the differences in the rice market relative to class of rice.

Monetary Value of Selected Quality Factors For Long and Medium Grain for The 1986/87 and 1987/88 Marketing Years in Louisiana

The monetary values of selected quality factors were determined for both long and medium grain rice. The factors were selected based on their significance in the estimated hedonic models. The monetary value is determined by evaluating the premium/discount for a given level of quality e.g., two percent red rice infestation. The value is determined on a per unit of output (cwt) basis. The monetary value on a per acre basis can be determined by multiplying the per unit premium/discount by the expected yield (cwt/acre).

The monetary value is the marginal revenue obtainable from either increasing or decreasing the quality factor. These values are very important in determining optimal input usage for control or enhancement of quality factors. Optimal input allocation implies that an input is used to point where its marginal revenue equates the marginal cost of the input. This section provides information on the marginal revenue of selected quality factors and the marginal cost of controlling or enhancing the selected quality factors. The next section discusses all of the quality factors included in the hedonic model from a production point of view. The cultural factors affecting the respective quality factors are discussed and costs where applicable are established.[20]

Cultural Factors Affecting Quality Factors

Head Rice:

Head rice is, as previously discussed, the percent nearly whole kernels obtained after milling. Head rice is the most valuable of the quality characteristics examined in this study.

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[20] The discussion on cultural factors affecting quality is based on personal interviews with researchers from the Louisiana State University Rice Experiment Station, Crowley, Louisiana.

The amount of head rice produced is mainly an inheritable trait. There is no standard cultural practices recommended to enhance the level of head rice. There are varietal differences and producers can, and do, evaluate potential milling yields when making varietal choices.

The level of head rice is within certain limits however dependent on environmental factors (e.g., moisture, humidity, and heat). The moisture level of the rice at harvest is an important factor affecting the amount of head rice. If the rice plant is allowed to dry excessively in the field the kernels are more prone to break and thus less head rice will result from the milling process. Combine settings during harvest also affect the amount of brokens as do the methods used for artificial drying.

There are certain management practices that can be employed to enhance the milling yield i.e., optimum moisture level harvesting, setting combines properly, and care in the drying and milling processes.

Foreign Seeds:

Foreign seeds are those found in a sample of rough rice which is not a rough rice seed. The major seeds observed in the data were curly indigo, water parsley, and morning glory. All of these seeds are noxious plants which compete for nutrients; hence, they affect the yield as well as quality. All of these seeds can be controlled through the use of

Phenoxy herbicides (2,4-D).

The use of 2,4-D is recommended for application after visual inspection confirms a weed problem. Recommended rate is one pint to the acre. Current price for 2,4-Daccamine is now about $15.00 per gallon or $1.875 per pint which gives a chemical cost of $1.875 per acre. The herbicide is applied aerially at a cost of $4.20 per acre. Summing the chemical and aerial cost yields a total cost of $6.075 per acre to control weed seeds. These practices assume that normal cultural practices were used in the growing of the rice (e.g., a post-emerge or pre-plant herbicide was used). All costs were obtained from McManus, 1989.

Heat Damage:

Heat damage occurs when the grain is allowed to generate excessive internal heat from a combination of high moisture and lack of aeration. Heat damage is strictly a management problem. It most commonly occurs from lack of proper aeration immediately post-harvest i.e., prior to artificial drying when rice is still at high moisture levels. If rice is properly dried (post-harvest management) little heat damage will occur. Heat damage discounts were found to be one of the most costly quality factors found in this study.

Red Rice:

Red rice is a wild rice whose kernels have a red bran. The red rice plant grows wild and is commonly found in Southwest Louisiana. Red rice seed may lie dormant in the ground and its germination varies from year to year and field to field depending on the concentration of seed and management practices. The control of red rice is mainly a matter of management. A wide spectrum of methods is used to control red rice ranging from crop rotation to the use of herbicides.

Rice researchers at the Louisiana State University Rice Research Experiment Station in Crowley, Louisiana recommend the following general practices to suppress red rice infestation. The program includes either a four pound per acre application of Bolero herbicide pre-plant surface applied or a four pound per acre pre-plant incorporated application of Ordrame in conjunction with a pin point flood. Also the rice should be water planted. The researchers said that the herbicide and its application would be the only additional direct cost. The pin point flooding would not cause an increase in irrigation cost.[21]

The herbicide cost for Bolero and Ordram range from $17.50/acre (Bolero) to $18.50/acre (Ordram 8E). The application cost will vary depending upon the method used to

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[21] For more detail on pin point flooding see the Rice Production Handbook, Louisiana State University Agricultural Center.

apply it. The herbicide applied pre-plant can be applied with a ground rig or can be applied aerially. The maximum cost would be an aerial application amounting to $4.20/acre. Therefore, the total cost of this program would be approximately $22/acre.

Rice researchers indicate that water management is a key factor in the suppression of red rice. They suggest that if the soil never completely dries the red rice seed will not germinate.

Peck Damage:

Peck damage is usually caused by stink bugs (insect). The stink bug punctures the grain damaging and often breaking the kernel. The control of stink bugs involves checking fields for infestation (common management practice) and using an insecticide for eradication if the bug count gets above threshold levels. Threshold levels for the period of heading to two weeks post heading is three bags per ten sweeps with a standard whoop net. For the next two weeks the threshold level increases to ten bags per ten sweeps. The recommended insecticide is Methyl Parathion at a rate of one pint per acre for a cost of $1.9375. The combined chemical and aerial cost are $6.7375 per acre. If the infestation is very high the rate of insecticide uses should be increased.

Smut:

Smut or kernel smut is a fungal disease. It causes a black mass of spores to replace all or part of the endo-sperm of the grain (Rice Production Handbook). The spore mass is visible as a black mass. There currently is no recommended control method. The disease is usually minor in Louisiana but can become epidemic in localized areas. (Rice Production Handbook)

Chalk Damage:

Chalk damage occurs when the kernel does not harden. It turns to a white chalk. There is no recommended control for chalk. There is some varietal differences relative to its frequency.

Monetary Value for Selected Quality Factors

Tables 16, 17, 18 and 19 present the monetary value for head rice, broken kernels, foreign seeds, heat damage, and red rice for long and medium grain rough rice for the 1986/87 and 1987/88 marketing years. Those factors were selected based on their consistent statistical significance. The tables give the monetary value of the factors in three forms. First, the premium/discounts are again reported. These values come directly from Table 8. Second, the premium/discounts are expressed as a value per 100 pounds (cwt) of rice. The values are calculated using the mean level of the quality factors given in Tables 2 - 5. Third, the monetary value is expressed

Table 16. Monetary Value of Selected Quality Factors for Long Grain in Louisiana, 1986.

Quality Factor	Units	Premium/ Discount	Monetary Value	
		($/Cwt/Unit)	($/Cwt)	($/Acre)
Head Rice	% Weight	0.072	3.790	174.755
Broken Kernels	% Weight	0.034	0.571	26.3636
Foreign Seeds	Per Seed	-0.0014	-0.020	-0.9261
Head Damage	Per Kernel	-0.003	-0.008	-0.3757
Red Rice	% Weight	-0.018	-0.020	-0.9432

Table 17. Monetary Value of Selected Quality Factors for Medium Grain Rough Rice in Louisiana, 1986.

Quality Factor	Units	Premium/ Discount	Monetary Value	
		($/Cwt/Unit)	($/Cwt)	($/Acre)
Head Rice	% Weight	0.071	4.002	184.505
Broken Kernels	% Weight	0.028	0.377	17.413
Foreign Seeds	Per Seed	-0.002	-0.016	-0.767
Heat Damage	Per Kernel	-0.008	-0.031	-1.438
Red Rice	% Weight	-0.019	-0.053	-2.433

Table 18. Monetary Value of Selected Quality Factors for Long Grain in Louisiana, 1987.

Quality Factor	Units	Premium/ Discount	Monetary Value	
		($/Cwt/Unit)	($/Cwt)	($/Acre)
Head Rice	% Weight	0.230	12.213	563.019
Broken Kernels	% Weight	0.110	1.859	85.700
Foreign Seeds	Per Seed	-0.008	-0.053	-2.459
Heat Damage	Per Kernel	-0.022	-0.055	-2.544
Red Rice	% Weight	-0.059	-0.075	-3.477

Table 19. Monetary Value of Selected Quality Factors for Medium Grain in Louisiana, 1987.

Quality Factor	Units	Premium/ Discount	Monetary Value	
		($/Cwt/Unit)	($/Cwt)	($/Acre)
Head Rice	% Weight	0.186	10.449	481.721
Broken Kernels	% Weight	0.076	1.012	46.668
Foreign Seeds	Per Seed	-0.012	-0.133	-6.141
Heat Damage	Per Kernel	-0.037	-0.113	-5.230
Red Rice	% Weight	-0.042	-0.057	-2.645

in value per acre by multiplying the 100 pound value by 46, which is the average cwt yield for long and medium grain rough rice in Southwest Louisiana (McManus, 1989). Figure 6 presents the values of head rice for long and medium grain rice in 1986. The illustration indicates that there is no difference in the premium between the two classes of rice.

Table 16 gives the monetary value of the selected quality factors for the long grain market in 1986. Head rice was worth $174.75/acre and broken kernels were worth $26.36/acre. On the cost side foreign seeds, heat, and red rice cost producers on the average 0.92, 0.375, and 0.94 dollars per acre, respectively. These figures indicate that the average producer was not being discounted enough to employ any further control. It is not known how much control was applied by producers during the seasons. If they had not done so the amount of these negative factors in the market would likely have been greater and their value greater.

The cost of red rice control was given at $22/acre. It is important to note, however, that there are also adverse field yield effects associated with its presence.

Figure 7 depicts the discounts for red rice at different levels of infestation for long and medium grain in 1986. The graph gives the cost per acre for different levels of red rice. The graph shows, at high levels of infestation, that it would pay to employ additional control measures. One problem is that the control must be applied before the level

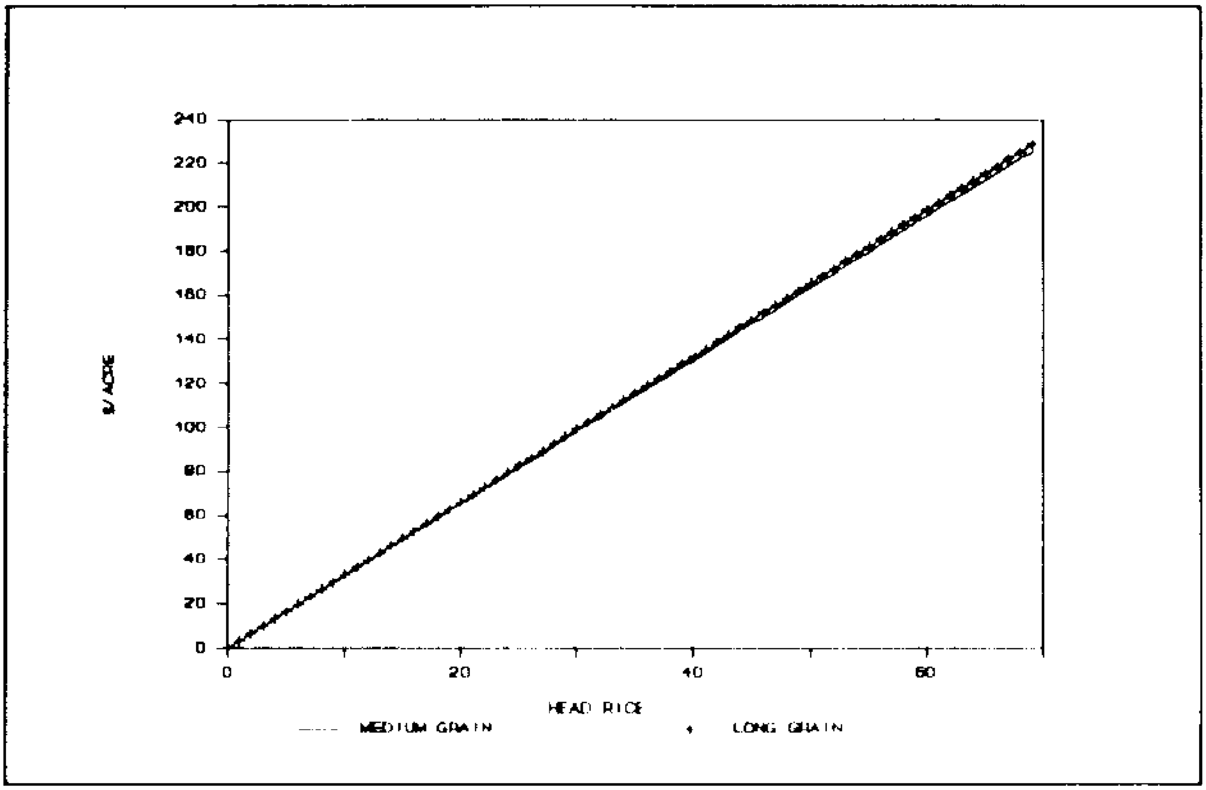

Figure 6. VALUE OF HEAD RICE FOR LONG AND MEDIUM GRAIN ROUGH RICE, 1986.

of infestation is known. For other factors (seeds and peck), the level of infestation is considered before control is employed.

Table 17 gives the monetary value of selected quality factors for medium grain varieties in 1986. Head and broken kernels were worth $184.50/acre and $17.41/acre respectively. Foreign seeds, heat damage, and red rice cost producers on the average $0.767/acre, $1.438/acre, and $2.433/acre, respectively. Red rice and heat damage costs were higher for medium grain than for long grain in 1986.

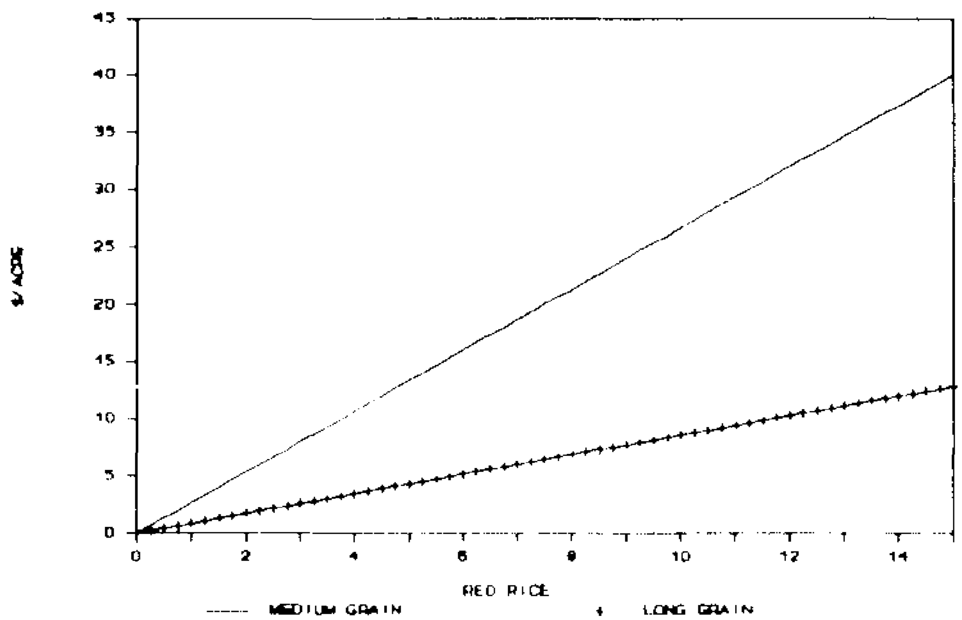

FIGURE 7. COST OF RED RICE FOR LONG AND MEDIUM GRAIN ROUGH RICE, 1986.

Table 18 gives the monetary value for selected quality factors for long grain in 1987. The increase in premiums/discounts in 1987 over 1986 caused the monetary value of the factors to dramatically increase. Head rice and broken kernels were worth $563.02/acre and $85.69/acre. Figure 8 shows the monetary value of head rice for long and medium grain in 1987.

Seeds, heat damage, and red rice cost producers on the average $2.59/acre, $2.54/acre, and $3.47/acre, respectively, in 1987. These values are considerably higher than those of 1986. These values were calculated at mean levels of infestation which were not severe. It would not take much of an increase in levels of seeds or red rice before additional control measures would be economically feasible. Figure 9 presents red rice cost for long and medium grain rice for different levels of infestation. The graph indicates that at about nine percent infestation by weight the additional control measures would be economically justifiable. In the 1987 season red rice in long grain was more costly than red rice in medium grain, just the opposite of that of 1986.

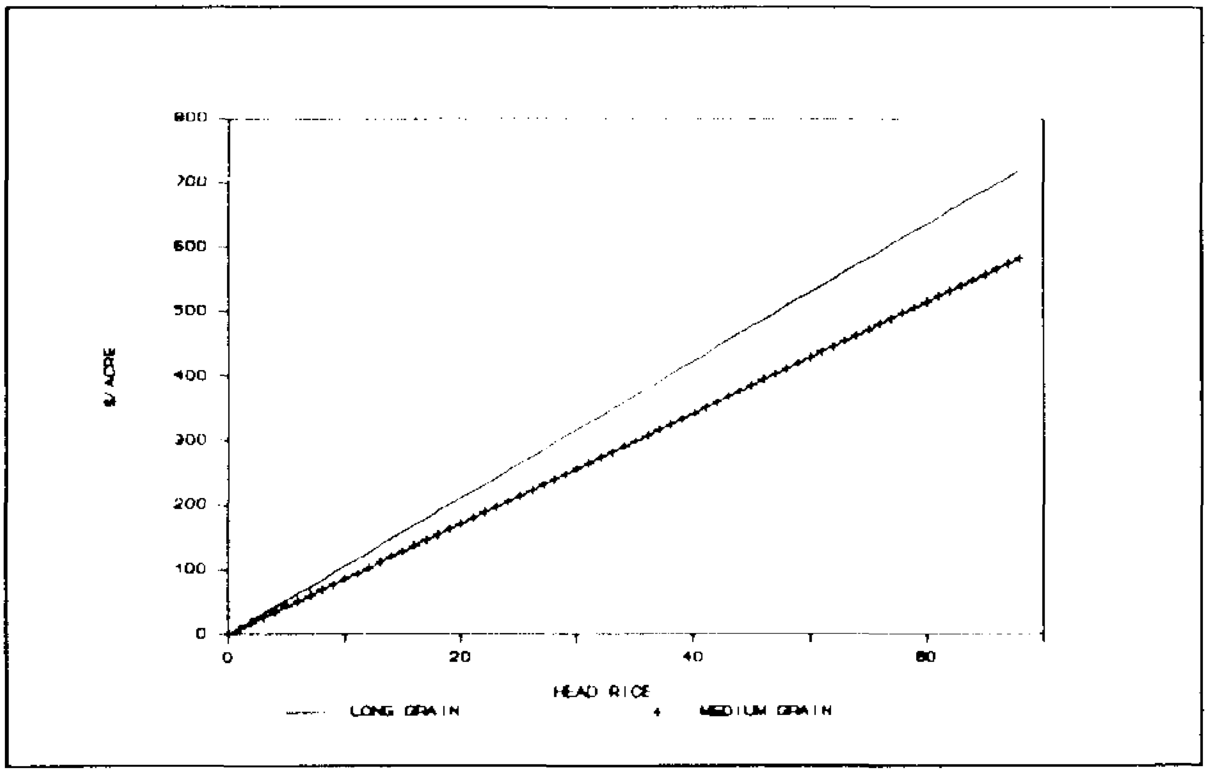

FIGURE 8. VALUE OF HEAD RICE FOR LONG AND MEDIUM GRAIN ROUGH RICE, 1987.

Table 19 gives the monetary value for selected quality factors for medium grain variety rice in 1987. Head rice and broken kernels were worth $481.72/acre and $46.67/acre, respectively, which was considerably higher than the values for head in 1986. Seeds, heat damage, and red rice cost producers on the average $6.14/acre, $5.23 and $2.65/acre, respectively. The cost of seeds was extremely high on the average because of the high discount and large number of seeds. Further control measures for seeds would have been economically justifiable at mean levels in 1987.

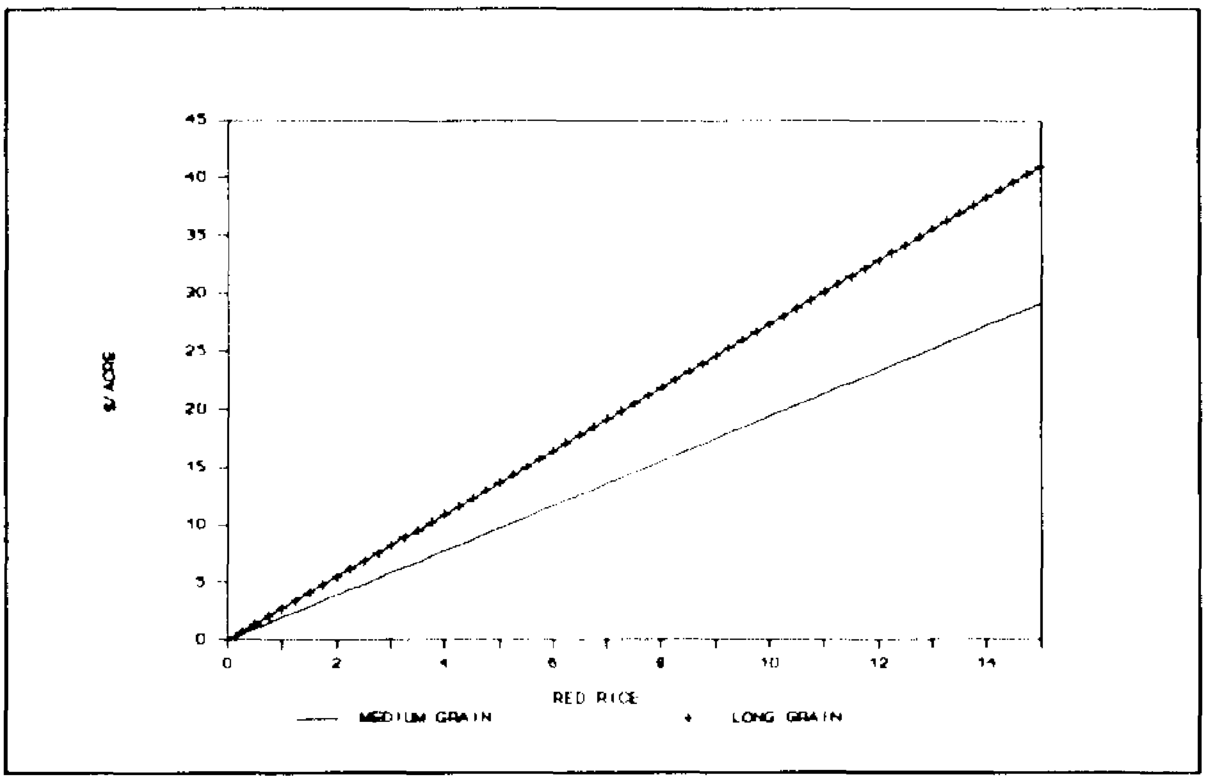

FIGURE 9. THE COST OF RED RICE FOR LONG AND MEDIUM GRAIN ROUGH RICE, 1987.

Premiums and Discounts With Uncertainty In The Regression Coefficients

Two key questions concerning the hedonic prices estimated are: 1) Do they posses the correct sign?; 2) How reliable are the estimates? If the hedonic model for rough rice is specified correctly, and the data conform to all the assumptions relative to least squares estimation techniques, the hedonic prices are unbiased estimates and their uncertainty is reported through the standard errors of the parameters.

This section of the dissertation addresses two problems, thus far largely ignored, which affect both the signs and reliability of the estimated hedonic prices. The first centers about the measurement of the set of quality factors (the independent variables). The second deals with the specification of the hedonic model. The procedures applied here address these problems and provide a considerable amount of additional information about the premiums/discounts for rough rice over that previously presented.

In most applications, in agricultural economics and in other areas, the possibility of measurement error in the set of explanatory variables is ignored. When an inexact relationship exists between the "true" variable and what is observed, the use of OLS results in inconsistent and biased estimates in both large and small samples [Feldstein (1974)].

Measurement error occurs when the value observed cf a variable takes on a value other than its' true value. OLS regression analysis assumes all regressors are non-stochastic and observable. The properties of the estimates are based on this assumption as well as the other classical assumptions. The problem addressed here deals with the measurement of the quality factors specified in the hedonic function.

There are a number of reasons to suspect measurement error in the quality factors or error in variables (EV). The first is due to the multiple grading that occurs in the buying and selling of rough rice. Each potential buyer as well as the marketing agent (LFBMA) grade the sample of rice. This means that specific quality data used in this study to generate hedonic prices was taken exactly from the agent offering the price (bid price). While there are grading standards (Table 1), buyers do not strictly adhere to them and many use different technical methods of grading e.g., different sample sizes (500 grams vs. 1000 grams).

The second main reason to suspect measurement error involves the method used to report some of the quality factors. For the set of quality factors: red rice, heat damage, peck damage, smut damage, and chalk damage, the level of quality is reported in numerical grades one through seven. Each grade represents a range of quality. For example, a red rice grade of 3 indicates an infestation of 1.51 percent red rice kernels to 2.5 percent red rice kernels. For this particular grade there is a one percentage point margin for error. As the grade factor becomes larger the margin for error widens. As indicated previously the mid-point of the ranges reported in Table 1 was used to convert the grade factors to percent infestation. Interpretational reasons justified the transformation. It is easier for a producer to, at mid-season, estimate his red rice infestation in terms of percentages than associate a grade factor to his infestation. The implication of this data problem is that the true level of red rice, or any of the other factors, is a continuous variable. However, the level of quality observed is a discrete variable.

To address this measurement problem, a set of consistent estimates were calculated using an errors-in-model (EVM). The EVM produces a set of k+1 parameter estimates where k is the number of explanatory variables. The EVM method constructs k+1 regressions each differing in the direction which minimizes the residual sum-of-squares. OLS minimizes the residual sum-of-squares in the direction of the dependent variable (bid price). Therefore, the OLS estimates will be in the set estimated here.

A convenient way to compute these k+1 regressions is to invert the moment matrix S (Klepper and Leamer)

$$(4.9) \qquad S^{-1} = \begin{bmatrix} s^2_y & r' \\ r & N \end{bmatrix} \qquad \begin{bmatrix} a_1 & a_2 & . & . & . & a_{k+1} \\ c_1 & c_2 & . & . & . & c_{k+1} \end{bmatrix} \quad ,$$

where s^2_y is the sample variance of y, r is a vector of sample covariances between y and X and N is the matrix of variances and covariances of X. For the right hand side of (4.9) a' is the first row of the inverse. Then the k+1 regressions are $-c_j/a_j$, j=1,2,...,k+1 (Klepper and Leamer). These k+1 coefficients were computed for all four markets studied.

The problem with the set of estimates calculated here is that they may not be identified or bounded. This implies that they may not all be in the same orthant. If this is the case, the traditional estimates provide no information about the true signs or magnitude of the parameters (Klepper and Leamer). Appendix D Table 10 presents the upper and lower bounds for the four models previously introduced.

For all the quality factors in all four markets studied the set of estimates were unidentified i.e., the range went from a positive upper bound to a negative lower bound. Also, the range in magnitude of many of the quality factors were extremely large (Appendix D Table 12). The estimation of these parameters assume that the correlation between y and x goes to one as the measurement becomes more accurate.[22] This is not very realistic. No one would logically expect the R^2 to be one if there were no measurement error. A more meaningful problem to address is: How large could the squared

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[22] The estimations also assume the variances among the independent variables are solely due to measurement error which is highly unlikely. This assumption is not addressed here but assumed to be true.

multiple correlation (R^2) of y and the x's be if there were no measurement error? This identifies a relationship between the range consistent estimates, the measurement error and the maximum value of the R^2 if the measurement error in the explanatory variables were removed. This is denoted by R^{*2}_m.

Figure 10 presents this theoretical relationship. The vertical axis represents the range of possible values a parameter might take (+/-). The horizontal axis represents the degree of correlation (0-1) between y and the x's (R^2). Point A represents the OLS point estimate, which is calculated for a $R^{*2} = R^{*2}_o$, where R^{*2}_o is the R^2 calculated from the OLS regression. The two rays identify the range of estimates as a function of the R^{*2}. As the rays indicate, in this particular instance the parameter is not bounded. As the R^{*2} approaches 1, the parameter value can be either positive or negative. Points B and C represent bounds for the parameter value for the largest value of R^{*2} (R^{*2}_m) when all measurement error is removed. From figure 10 it is clear that a consistent set of parameters exists if R^{*2}_m can be found. Graphically the consistent range of parameters would be in the triangle ΔABC. The data summarized in Appendix D Table 12 is for a R^{*2} of 1. If the R^2 is expected to be one, when no measurement error was present, this would be the consistent set. However, this is not reasonable and the data conveys this. Once the R^{*2}_m is found, the regressions can be adjusted by this factor to account for the error-in-variables.

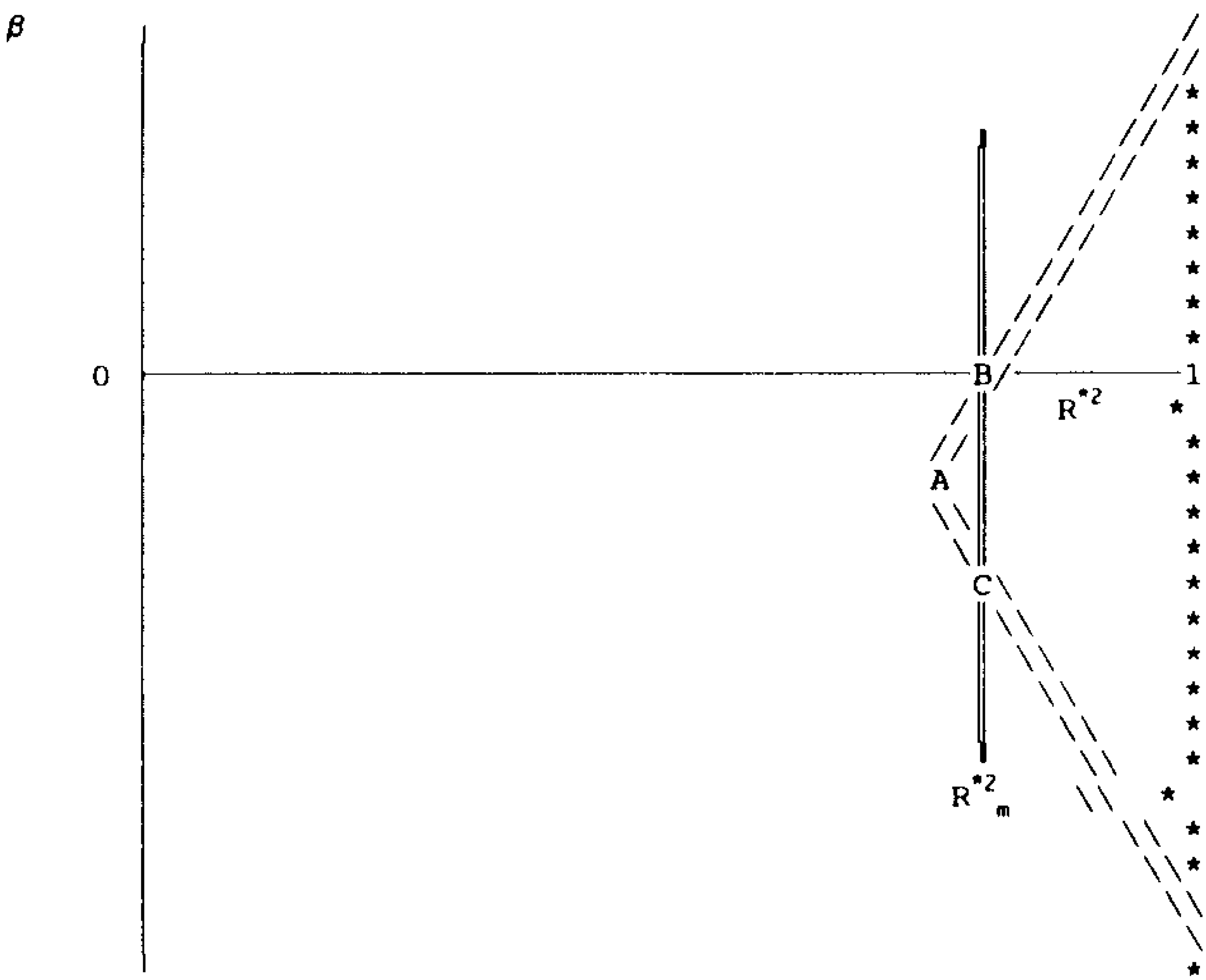

Figure 10. Parameter Bounds as a Function of R^{*2}.

A set of bounded parameters can be ensured by replacing S^2_y by R^{*2} S^2_y (Klepper and Leamer) in (4.9) and calculating the new regressions as previously described. R^{*2}_m is calculated using (4.10) as given by Klepper and Leamer:

$$(4.10)\quad R^{*2}_m = R^{*2}_o + (1-R^{*2}_o)\min_{ij}[(1-(\beta_{ij}/b_j))^{-1}],$$

where β_{ij} is the set of k+1 parameter estimates computed by the EVM, b_j is the vector of least squares estimates and $_{i,j}$ select only those estimates opposite in sign, $\beta_{ij}/b_j < 0$.

Another way of reporting this measure offered by Klepper and Leamer is to estimate the gap between $R^{*2} = R^{*2}_o$ and $R^{*2} = 1$ that can be attributed to measurement error without causing the set of estimates to be unbounded. This gap is reported as the g-statistic and is given by: (4.11) (Klepper and Leamer)

$$(4.11)\quad g = \begin{cases} 1 \text{ if the k+1 regressions are in the same orthant} \\ (R^{*2}_m - R^{*2}_o)/(1 - R^{*2}_o). \end{cases}$$

The g-statistic represents the degree of measurement error. The higher the statistic the larger the amount of measurement error present in the data.

The R^{*2}_m was calculated for all four markets for the full model as specified by equation (4.5). The four models were then re-estimated using the adjusted regressions. Estimates were also calculated for correlations greater than the R^{*2}_{m} to get an idea of the spread of likely values. This range of "likely" values was useful in identifying mis-specifications. The adjusted regressions did bound some of the variables. However, the results were still inconsistent with reasonable beliefs about premiums and discounts (Appendix D Table 12). In studying the specification of the models (equation 4.5) a number of factors became apparent which led to re-specifying the model. The model was re-specified by incorporating prior market information about the quality factors.

In studying the quality factors, researchers indicated there was no recommended control for smut and chalk damage. Since there is little a producer can do to reduce these factors they were deleted from the specification of the model. Also the descriptive data about the quality factors indicated low levels of infestation of both smut and chalk across both years in the Louisiana rough rice market (Appendix A).

Another variable which was deleted from all the models was broken kernels. Broken kernels is the difference between total milled rice and head rice (or whole kernels) i.e., what is not head rice is brokens. As expected there is a high degree of inverse correlation between head rice and broken kernels for all four markets. The correlation coefficient between head rice and broken kernels for all four markets was greater than -0.94 (Appendix Tables 2 - 4). This high degree of correlation was the main reason for deleting brokens from the model. It is common in the rice industry to value brokens at half the value of head rice. The premiums previously estimated for head rice and broken kernels confirm this approximation.

For the 1986/87 marketing year a fourth variable was deleted: peck damage. Peck damage was basically not observed during the year and so was very little variation in its level. A large proportion of the lots reported no peck damage at all. The lack of this variable's presence dictated its removal from the model specification. These re-specifications were made to the four models. Equations (4.12) and (4.13) present the new specifications for the 1986/87 and 1987/88 marketing years respectively.

(4.13) $Bid_{1986/87}$ = f(red rice, mill price, head rice, lot size, foreign seeds, heat, e).

(4.14) $Bid_{1987/88}$ = f(red rice, mill price, head rice, lot size, foreign seeds, heat, peck, e).

The four models were re-estimated using the EVM procedures discussed. The R^{*2}_{m} was calculated and the regressions were adjusted and a set of k+1 consistent estimates were made for each quality factor. Estimates were also made for higher levels of correlation. Table 20 presents the R^{*2}_{m} and the g-statistics for the four models. The g-statistic indicates

Table 20. R^{*2}_m and g-statistic for Long Grain 1986, Medium Grain 1986, Long Grain 1987, and Medium Grain 1987, Louisiana.

Markets	R^{*2}_m	g-statistic
Long Grain 1986	0.698	0.1559
Medium Grain 1986	0.631	0.1500
Long Grain 1987	0.843	0.0697
Medium Grain 1987	0.789	0.0312

the measurement error was greatest in the 1986/87 marketing season and in the long grain market.

Tables 21 - 24 summarize the results for all four markets. Each table presents the upper and lower bounds of the parameter estimates for $R^{*2} = R^{*2}_o$, $R^{*2} = R^{*2}_m$ and three higher levels of correlation.[23] The first column shows the OLS point estimates (no range). The second column shows the consistent set of hedonic prices. Notice for all quality factors across all four models the hedonic prices are identified i.e., the range of likely values is contained in either a positive or negative set. When the regressions were adjusted all quality factors across all markets provided ranges which were consistent with prior beliefs. All factors that are considered to be detrimental had a negative

[23] Tables 21 - 24 summarize a set of k+1 parameters and the R^{*2}_m calculations. Appendix D Tables 13 - 19 presents a series of matrices used to derive Table 21 (long grain 1986).

Table 21. Premiums and Discounts as a Function of R^{*2}, Long Grain 1986, Louisiana.

R^{*2} Quality Factors	R^2 0.646	R^{*2}_M 0.698	0.70	0.80	0.90	1.0
Red Rice:UB	-0.02135	-0.00000	0.00082	0.04210	0.08339	0.12467
Red Rice:LB	-0.02135	-0.21279	-0.22018	-0.59033	-0.96048	-1.33064
Mill Price:UB	-0.08400	-0.06491	-0.06418	-0.02727	0.00964	0.04654
Mill Price:LB	-0.08400	-0.75552	-0.78140	-2.07977	-3.37813	-4.67649
Head Rice:UB	0.04348	0.04945	0.04968	0.06122	0.07276	0.08431
Head Rice:LB	0.04349	0.03307	0.03266	0.01252	-0.00762	-0.02776
Lot Size:UB	0.00001	0.00023	0.00023	0.00064	0.00104	0.00144
Lot Size:LB	0.00001	0.00000	-0.00000	-0.00004	-0.00007	-0.00011
Seeds:UB	-0.00146	-0.00057	-0.00054	0.00119	0.00292	0.00465
Seeds:LB	-0.00146	-0.00439	-0.00450	-0.01014	-0.01578	-0.02142
Heat:UB	-0.00292	-0.00262	-0.00260	-0.00200	-0.00141	-0.00081
Heat:LB	-0.00292	-0.11805	-0.12249	-0.34509	-0.56769	-0.79029

Table 22. Premiums and Discounts as a function of R^{*2}, Medium Grain 1986, Louisiana.

R^{*2} Quality Factors	R^2 0.565	R^{*2}_M 0.636	0.70	0.80	0.90	1.0
Red Rice:UB	-0.04687	0.00000	0.04264	0.10935	0.17607	0.24279
Red Rice:LB	-0.04687	-0.63446	-1.16892	-2.00517	-2.84142	-3.67767
Mill Price:UB	-0.05451	-0.03408	-0.01550	0.01358	0.04266	0.07174
Mill Price:LB	-0.05451	-10.66630	-20.31860	-35.42131	-50.52402	-65.62673
Head Rice:UB	0.04449	0.05236	0.05952	0.07073	0.08193	0.09313
Head Rice:LB	0.04449	0.02782	0.01265	-0.01109	-0.03482	-0.05856
Lot Size:UB	0.00002	0.00030	0.00055	0.00095	0.00134	0.00174
Lot Size:LB	0.00002	-0.00000	-0.00002	-0.00006	-0.00009	-0.00012
Seeds:UB	-0.00330	-0.00125	0.00062	0.00355	0.00648	0.00940
Seeds:LB	-0.00330	-0.01447	-0.02462	-0.04051	-0.05640	-0.07228
Heat:UB	-0.00894	-0.00562	-0.00260	0.00214	0.00687	0.01161
Heat:LB	-0.00894	-0.03066	-0.05040	-0.08129	-0.11218	-0.14308

Table 23. Premiums and Discounts as a function of R^{*2}, Long grain 1987, Louisiana.

R^{*2} Quality Factors	R^2 0.831	R^{*2}_M 0.843	0.80	0.85	0.95	1.0
Red Rice:UB	-0.08041	-0.05432	-0.03890	0.07193	0.18276	0.29359
Red Rice:LB	-0.08041	-0.56806	-0.85632	-2.92746	-4.99861	-7.06975
Mill Price:UB	0.05130	0.52318	0.52915	0.57204	0.61493	0.65782
Mill Price:LB	0.005130	0.00973	-0.28781	-2.42565	-4.56349	-6.70133
Head Rice:UB	0.14113	0.21557	0.25956	0.57567	0.89179	1.20790
Head Rice:LB	0.14113	0.08731	0.05548	-0.17316	-0.40180	-0.63044
Lot Size:UB	0.00002	0.00115	0.00181	0.00656	0.01131	0.01606
Lot Size:LB	0.00002	-0.00000	-0.00002	-0.00013	-0.00025	-0.00036
Seeds:UB	-0.00909	0.00000	0.00538	0.04401	0.08264	0.12127
Seeds:LB	-0.00909	-0.02735	-0.03814	-0 11567	-0.19320	-0.27073
Heat:UB	-0.03477	-0.03399	-0.03352	-0.03017	-0.02681	-0.02346
Heat:LB	-0.03477	-0.10321	-0.14367	-0.43434	-0.72501	-1.01568
Peck:UB	-0.03533	-0.00067	0.01982	0.16706	0.31430	0.46153
Peck:LB	-0.03533	-16.92432	-26.90787	-98.63910	-170.37034	-242.10157

Table 24. Premiums and Discounts as a function of R^{*2}, Medium Grain 1987, Louisiana.

R^{*2} Quality Factors	R^2 0.789	R^{*2}_M 0.782	0.80	0.85	0.95	1.0
Red Rice:UB	-0.03080	-0.02185	0.05793	0.12380	0.18966	0.25553
Red Rice:LB	-0.03080	-0.28285	-2.52857	-4.38252	-6.23646	-8.09041
Mill Price:UB	0.42577	0.43289	0.49631	0.54867	0.60103	0.65339
Mill Price:LB	0.42577	0.00002	-3.79345	-6.92514	-10.05682	-13.18850
Head Rice:UB	0.11997	0.12267	0.14667	0.16649	0.18631	0.20612
Head Rice:LB	0.11997	0.11130	0.03400	-0.02982	-0.09364	-0.15745
Lot Size:UB	0.00003	0.00028	0.00248	0.00429	0.00610	0.00791
Lot Size:LB	0.00003	0.00003	-0.00005	-0.00012	-0.00019	-0.00025
Seeds:UB	-0.01575	-0.01118	0.02964	0.06333	0.09702	0.13072
Seeds:LB	-0.01575	-0.06171	-0.47112	-0.80911	-1.14709	-1.48508
Heat:UB	-0.04210	-0.04128	-0.03392	-0.02784	-0.02177	-0.01569
Heat:LB	-0.04210	-0.12229	-0.83673	-1.42653	-2.01633	-2.60614
Peck:UB	-0.00924	-0.00000	0.08233	0.15030	0.21826	0.28623
Peck:LB	-0.00924	-9.52490	-94.30940	-164.30288	-234.29635	-304.28983

relationship with price and those believed to enhance quality had a positive relationship with price.

The premiums/discounts estimated by the adjusted regressions were substantially different from those previously discussed. In the LG86 market the range for red rice, one of the most important factors, ranged from 0.00 to -0.21 dollars per cwt per percent infestation. In the LG87 market the range was from -0.05 to -0.56. For head rice, the premium ranged from 0.03 to 0.05 and 0.08 to 0.21 dollars additional pound of head rice for the LG86 and LG87 markets, respectively. The pattern of increased ranges across years was consistent in all markets. The range in the discounts for heat damage was also quite large indicating the potential for substantial monetary consequences.

To illustrate the consequences of using the OLS point estimate of a discount in a decision framework when it is likely that the discount could be quite high, consider the quality factor red rice for the 1986/87 marketing year. Using the mean level of red rice infestation for long grain rough rice in 1986, 1.10% which is relatively low, Table 16 reported a discount of $0.018/% infestation or $0.02/cwt or $0.94/acre. This low discount implies it is not worth while to employ any additional control measures for this low average level of infestation. How reliable is this estimate? The discounts reported using the EVM which accounts for the uncertainty in the estimates, indicated it is likely that the discount for red rice in long grain 1986 market could be as large as $0.21/% infestation. Converting this discount to per unit of output basis and per acre basis yields discounts of $0.23/cwt and $10.63/acre. These discounts are considerably larger than those previously quoted. If the potential monetary loss is $10/acre it is likely that some form of additional prevention or control will be economically justifiable even at relatively low levels of red rice infestation. For an infestation of only 3% red rice, the cost would be approximately $30/acre. If a producer made a decision based on the OLS estimates, he stands a chance of choosing wrongly. Similar comparisons can be made for other quality factors studied.

Tables 25 - 28 present upper and lower bounds for the monetary values for selected quality factors for LG86, MG86, LG87, and MG87 markets, respectively. The values were calculated using the premiums/discounts reported in Table 21 - 24 as estimated via EVM model. These values, both upper and lower bounds, are reported again in Tables 25 - 28. The monetary value is presented in two forms, $/cwt and $/acre, as previously reported in Tables 16 - 19.

Tables 25 and 26 present the monetary values for LG86 and MG86 markets. The values for head rice ranged from approximately $180/acre to $70/acre. The OLS estimates yielded premiums of $175/acre and $184/acre for the LG86 and MG86 markets, respectively. Comparing the two results, the OLS estimates are relatively high. Discounts for seeds in

Table 25. Monetary Value for the Upper and Lower Bounds of Selected Quality Factors for Long Grain, 1986, Louisiana.

Quality Factor	Units	Premium/ Discount ($/cwt/unit)	Monetary Value ($/cwt)	Monetary Value ($/acre)
Head Rice:UB	% Weight	0.049	3.7908	174.7558
Head Rice:LB	% Weight	0.033	1.73745	80.09644
Foreign Seeds:UB	Per Seed	-0.00057	-0.00784	-0.36157
Foreign Seeds:LB	Per Seed	-0.0044	-0.06054	-2.79107
Heat Damage:UB	Per Kernel	-0.0026	-0.00642	-0.29605
Heat Damage:LB	Per Kernel	-0.118	-0.29146	-13.4363
Red Rice:UB	% Weight	0	0	0
Red Rice:LB	% Weight	-0.213	-0.2343	-10.8012

Table 26. Monetary Value for the Upper and Lower Bounds of Selected Quality Factors for Medium Grain, 1986, Louisiana.

Quality Factor	Units	Premium/ Discount ($/cwt/unit)	Monetary Value ($/cwt)	Monetary Value ($/acre)
Head Rice:UB	% Weight	0.052	4.00227	184.5046
Head Rice:LB	% Weight	0.028	1.57836	72.76239
Foreign Seeds:UB	Per Seed	-0.0013	-0.01081	-0.49861
Foreign Seeds:LB	Per Seed	-0.01447	-0.12039	-5.54999
Heat Damage:UB	Per Kernel	-0.0056	-0.02329	-1.07394
Heat Damage:LB	Per Kernel	-0.031	-0.12896	-5.94505
Red Rice:UB	% Weight	0	0	0
Red Rice:LB	% Weight	-0.634	-0.57694	-26.5969

Table 27. Monetary Value for the Upper and Lower Bounds of Selected Quality Factors for Long Grain, 1987, Louisiana.

Quality Factor	Units	Premium/ Discount ($/cwt/unit)	Monetary Value ($/cwt)	($/acre)
Head Rice:UB	% Weight	0.0216	12.213	563.0193
Head Rice:LB	% Weight	0.087	4.6197	212.9681
Foreign Seeds:UB	Per Seed	0	0	0
Foreign Seeds:LB	Per Seed	-0.027	-0.18468	-8.51374
Heat Damage:UB	Per Kernel	-0.034	-0.08568	-3.94984
Heat Damage:LB	Per Kernel	-0.103	-0.25956	-11.9657
Red Rice:UB	% Weight	-0.039	-0.04953	-2.28333
Red Rice:LB	% Weight	-0.568	-0.72136	-33.2546

Table 28. Monetary Value for the Upper and Lower Bounds of Selected Quality Factors for Medium Grain, 1987, Louisiana.

Quality Factor	Units	Premium/ Discount ($/cwt/unit)	Monetary Value ($/cwt)	($/acre)
Head Rice:UB	% Weight	0.123	6.91014	318.5574
Head Rice:LB	% Weight	0.0111	0.623598	28.74786
Foreign Seeds:UB	Per Seed	-0.011	-0.12419	-5.72515
Foreign Seeds:LB	Per Seed	-0.062	-0.69998	-32.2690
Heat Damage:UB	Per Kernel	-0.041	-0.12505	-5.76480
Heat Damage:LB	Per Kernel	-0.122	-0.3721	-17.1538
Red Rice:UB	% Weight	-0.022	-0.02992	-1.37931
Red Rice:LB	% Weight	-0.283	-0.38488	-17.7429

1986 ranged from a low of $0.36/acre in LG86 market to a high of $5.55/acre in the MG86 market. The maximum discount is considerably larger than that generated by the OLS errors. Discounts for heat damage ranged from a low of $0.29/acre in the LG86 market to a high of $13.55/acre in LG86 market. Red rice discounts ranged from a low of no discount to a high of $26.60/acre. While the ranges in the monetary value for all quality factors are large, the range indicates it is likely that control of the quality factors was economically justifiable in 1986. This is in direct controversy with previous conclusions which indicated control was probably not justifiable.

Tables 27 and 28 present the upper and lower bounds for the monetary values for the LG87 and MG87 markets. As was the case for the 1986 year, the ranges were large. However, in 1987 the ranges were higher in terms of magnitude than in 1986. Table 27 indicates that head rice was the most valuable component with a maximum value of $563/acre for the LG87 market and red rice was the most costly factor with a maximum discount of $33.25/acre. In the MG87 market, head rice was again the most valuable function at $318.55/acre and seeds was the most costly factor with a maximum discount of $32.27/acre.

Comparison to Previous Hedonic Studies of Rough Rice

This section compares the results of the hedonic models of rough rice estimated in this observation to that of two previous studies conducted for the Texas rough rice market (Brorsen, et. al, 1984; and Brorsen, et. al, 1988).

This study included the same set of quality factors as did the two previous studies except for the variable test weight which was excluded in this study. Test weight measures the weight of a specific volume of rice. This information was not recorded in the data collected from LFBMA for the present study. The 1984 study of Brorsen, et. al. examined only one year of data ane their 1988 study examined three years of data. A basic difference between the Texas studies and this study is that both long and medium grain markets were analyzed here and not in the Texas studies.

In the 1984 study, correct signs were found on all variables except smut and chalk. This is consistent with the results found in this study with the exception that correct signs were found for smut damage in both long grain markets in the present study.

In terms of significance and magnitude of premiums/discounts, the present study and the 1984 study found the same set of variables to be significant (head rice, seeds, red rice, heat damage, and mill price). In terms of parameter size, the premiums/discounts estimated in this study were consistently smaller in both years than those estimated from the Texas market for the 1981/82 marketing year.

The 1988 study of Brorsen, et. al. examined 3 years of data across 5 markets (locations). Consistently across years and markets they found correct signs on head rice, brokens, seed, red rice, and peck damage. These variables were also significant. Signs on heat, chalk, and smut were inconsistent across years and markets. These results are slightly different than those of the Louisiana market for long grain in 1986 and 1987 in that all variables except chalk were found to have the correct sign.

In terms of the magnitude of the premiums/discounts, their results for head rice, brokens, and seeds for 1982/83 and 1983/84 marketing years were more in line with those estimated in this study. However, their estimates of discounts for red rice and peck damage were considerably larger than those estimated through the OLS models in this study.

Other differences in the Texas studies as compared to this study are the error problems identified, the functional form, the model specification problem, and the measurement error problem in the quality factors identified. In neither of the Texas studies were the errors analyzed. A linear specification was found to be best for all years and markets in Texas. Also, the problem of leaving brokens and whole kernels in the model, which are highly correlated, was not addressed in that study. Nor, was the error in variable problem discussed even though data were very similar in nature.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The central theme of this dissertation has been to measure and analyze the effects of quality on prices paid producers for rough rice in Louisiana. Specifically, this dissertation has: (1) developed a data base of rough rice cash prices and associated quality and non-quality factors, (2) identified quality and non-quality factors that affect prices received by farmers for both long and medium grain rough rice varieties, (3) developed a hedonic price model that captures the price quality effects that exist in the Louisiana market for long and medium grain rough rice, (4) determined if premiums and discounts associated with selected quality factors differ throughout the marketing season and across marketing years, and (5) estimated the monetary value of selected quality factors and compared those values to marginal costs of controlling them.

The effects of quality on rough rice prices influence producer decisions. The quality of an individual lot of rice determines the net price received. The net price realized is determined by adjusting the market price for quality through individual premiums and discounts. The level of quality and its associated premiums and discounts also determine which cultural practices are employed to enhance quality. Most of the quality factors affecting rough rice prices are directly related to other pre or post harvest management practices.

The central problem addressed in this study dealt with the lack of specific information about the premiums and discounts being received by Louisiana rough rice producers. Currently, there is no widely accepted set of premiums or discounts reported for any of the quality factors believed to affect rice prices. This dissertation addresses the problem by systematically estimating premiums and discounts for a set of quality factors believed to influence rice prices in the Louisiana rough rice market. Economically, sound production and marketing decision making requires accurate and timely information on these factors.

The information provided will benefit the industry through increased efficiency because more accurate knowledge concerning prices and quality will be transferred to producers and agribusiness firms causing rice to be produced closer to what the market needs than is now the case. This information can be used to make more optimal decisions both about selling and the control of quality factors that affect the net prices received for various lots of rice. It will also aid rice researchers in identifying costly quality factors and provide insight as to the maximum cost producers should be willing to pay for control of the factors.

Methods and Data Used

The problem, as outlined above, is defining the relationship between the price of rough rice offered by buyers and the quality attributes or characteristics that are embodied in it. A hedonic model was developed and estimated for the 1986/87 and 1987/88 marketing years for the Louisiana rough rice market. The hedonic price theory basically holds that a good is valued for its utility bearing characteristics and as the level of quality associated with a good varies, so does the price, ceterus paribus. Given this theoretical framework, the market price for rough rice is expressed as a function of a vector of quality factors, an index variable to capture the variations in supply and demand that occur during the marketing season, and an error component. This relationship between price and quality can be measured by statistically estimating the above model through standard regression procedures. The partial regression coefficients associated with the vector of quality factors represent the per unit change in price due to a per unit change in quality. These partial coefficients are the premiums and discounts associated with each quality factor.

To analyze these price/quality effects, rough rice prices and other information, including quality, surrounding individual sales transactions were collected for the 1986/87 and 1987/88 marketing years from LFBMA in Crowley, Louisiana. This marketing organization conducts rough rice auctions for producers throughout the marketing season. This marketing environment is characterized as a bid/acceptance market. In a bid/acceptance market, a bid is made by a buyer and the seller either accepts or declines the bid.

LFBMA grades each lot of rough rice for the information of its members. A sample of the rice is distributed to each potential buyer. Each buyer also grades the rice and submits a bid. Grades are based on standards established by the USDA and were reported in Table 1. In the grading process, a sample of rough rice is milled, weighed, and inspected for quality. An overall grade is established and individual grades are given for each factor in a set of quality factors. The individual grades represent a range of quality. The ranges and numeric grades differ across quality factors and classes of rice.

The data base includes information on individual producer lots submitted to LFBMA for sale between July 1986 and March 1988. It contains over 3000 observations of the highest offered price and the associated information. The data are essentially a pooled, time series, cross-sectional data set comprised of a cross-section of producers over two marketing seasons.

Premiums and discounts were estimated for the 1986/87 and 1987/88 marketing season for the Louisiana rough rice market. Because of the major marketing and production differences between classes of rice (long and medium), separate hedonic models were estimated for both long and medium grain rice in each of the two marketing seasons. A total of four base models were estimated; LG86, MG86, LG87, and MG87. The quality factors believed to affect the price of rice and included in the hedonic models, were: foreign seeds, heat damaged kernels, red rice, chalky kernels, and peck and smut damaged kernels. All of these factors are used to establish USDA rough rice grades. Other factors believed to be important quality factors affecting variations in rough rice include: head rice, broken rice, and lot size. All of these factors were observed in the Louisiana market in both marketing years. Foreign seeds, red rice, and heat damaged kernels were observed in larger volumes in both years than peck, smut or chalk damage.

A final base equation (2.9), which was estimated for both long and medium grain rough rice in both the 1986/87 and 1987/88 marketing seasons. The equation includes all the above mentioned quality factors and the Louisiana milled rice price as independent variables. The purpose of including the milled rice price in the hedonic specification was to capture the price level variations that occur throughout the marketing season. The dependent variable was specified as the bid price.

A linear specification was chosen because of the belief that the premiums and discounts were constants and not a function of price. This assumption was confirmed for the 1986/87 season in both the long and medium grain markets by testing the functional form using a Box-Cox transformation. However, the Box-Cox transformation indicated a semi-logarithmic specification was more appropriate for the 1987/88 marketing year. Therefore, for the 1987/88 marketing season, the hedonic models for the long and medium grain market were also estimated using a semi-logarithmic specification.

Results

Premiums and discounts are first reported as constants (Table 7, Chapter 4). These premiums and discounts were derived by statistically estimating equation 4.5 through OLS regression procedures. Results of the estimations indicated that the hedonic models were significant and had a high degree of fit. In the long grain market across both marketing years, all factors had correct signs on the respective quality factors except for chalk. The sign determines if presence of the factor dictates a premium (+) or discount (-). In the medium grain market, all variables had expected signs except for peck and chalk in 1986/87 and smut and chalk in 1987/88. In terms of parameter significance, all factors were statistically significant at the 95% level across markets and years except for peck, smut and chalk damage.

In terms of monetary importance (actual premiums or discounts), head rice and red rice were consistently the most important. The magnitude of the parameters varied substantially across the two marketing seasons, however. All the premiums and discounts were quite high in the 1987/88 marketing season compared to that of 1986/87. The 1987/88 season was characterized by adverse weather conditions in Asia that created tight world supplies causing domestic prices to increase three fold during the marketing year.

Analysis of the OLS errors from all the hedonic models indicated significant autocorrelation in all four models and significant heteroscedasticity in both of the long grain models. The OLS models were analyzed by estimating autocorrelations and partial autocorrelations through an ARIMA model. This information is necessary to remove the correlation from the error components. Also, the errors were plotted against all independent variables to identify factors causing the non-constant error variances.

Two more sets of models were estimated to correct for error problems. The four base models were reestimated using autoregressive procedures to correct for the autocorrelation.

Estimating the hedonic models via autoregressive techniques was successful in removing the autocorrelation. The autoregressive models had a better fit than the OLS models and a smaller mean square error. Individual parameter estimates were consistent with the OLS models. Significant heteroscedasticity was still present in the long grain models, however.

Plots of the OLS errors, from the two long grain models, against independent variables identified a relationship between the error component and lot size and foreign seeds. This information was used to generate individual variances. These variances were used to transform the data. The data was transformed according to generalized least squares estimation procedures. The transformed data were then estimated using autoregressive procedures which were successful in reducing the level of heteroscedasticity. However, significant heteroscedasticity was still present.

Hedonic models were also estimated for the 1987/88 marketing year for long and medium grain rice using a semi-logarithmic specification. The difference between the premiums/discounts estimated from a semi-logarithmic model compared to a linear model is that the premiums/discounts are a function of price versus a constant. Premiums/discounts estimated here are a percent of price. Therefore, as the market price increases so do the premiums/discounts.

The premiums/discounts were estimated using autoregressive procedures and compared to those estimated by the linear model. The premiums/discounts quoted as a percent of price were converted to constants using mean level prices for the 1987/88 marketing year. These values were very close to those values estimated from the linear model in both the long and medium grain markets.

Premiums and discounts were also analyzed across marketing seasons, marketing years and classes of rice. The data were segmented for each year by class of rice into harvest and post harvest seasons. Hedonic models were estimated for each of these marketing seasons and compared to their respective marketing years. Also, the data for the two marketing years were combined and hedonic models were estimated for the long and medium grain rough rice for the two marketing years combined. These results were compared to the individual years. Data for long and medium grain rough rice were combined and a hedonic model was estimated for all classes of rice combined and compared to the hedonic models estimated for the individual classes.

The estimation of the above mentioned models permitted the testing of several hypothesis about hedonic rough rice price models in Louisiana. A total of eight different null hypotheses were tested about shifts or overall changes in the hedonic price model. The null hypotheses tested were that hedonic price relationships for long and medium grain rice were unchanged between: (1) marketing years, (2) between harvest and post harvest seasons in 1986 and 1987, and (3) between classes of rough rice (long and medium) for the two marketing seasons, respectively.

These hypothesis were tested by segmenting the data into their respective groups, depending on the hypothesis, and estimating individual hedonic models. A Chow test was constructed to test for differences in the hedonic models for rough rice across the given periods and classes or rice.

Results of the Chow test suggest that there are overall differences in the hedonic rough rice models between: (1) marketing years; (2) marketing seasons; and (3) classes of rice. Specific results of the individual models are reported in Appendix C.

The premiums and discounts estimated for long and medium grain rough rice for the 1986/87 and 1987/88 marketing years were used to estimate the monetary value of selected quality factors. The factors were selected based on their significance in the estimated models. The monetary value was calculated for head rice, broken kernels, foreign seeds, heat damage, and red rice. The monetary value is determined by evaluating the premium/discount for a given level of quality. This gives a value on a per unit basis. The monetary value on a per acre basis was demonstrated by multiplying the per unit premium/discount by an expected yield.

This section of the dissertation also discusses recommended cultural practices related to the control or enhancement of these quality factors. Where applicable, the marginal cost of controlling certain quality factors were established and compared to the monetary value of the quality factor.

The final section addresses the uncertainty in estimated premiums and discounts. The uncertainty was believed due to the possibility of mis-specification of the models and measurement error in the independent variables. The measurement error causes the parameter estimates to be unbounded or not identified i.e., take on either positive or negative values. To address this problem, an EVM was estimated for all four markets. The EVM produces a set or range of values instead of a point estimate. Through the EVM the relationship between the set of parameters and the squared multiple correlation (R^2) coefficients between the dependent variable and the independent variables are analyzed. This helps in identifying mis-specifications. To correct for the measurement error, the maximum R^2 for which no measurement error in independent variables is present was calculated. This value was used to adjust the regression. The adjusted regressions provided a set of consistent estimates.

Prior market information was used to re-specify the hedonic rough rice models. Smut and chalk damage were removed from the specification because they are basically not controllable by the producer. Because of the high correlation between head rice and broken kernels, broken kernels were also removed and for the 1986 marketing year peck was deleted due to the lack of its presence.

The re-specified models were estimated using the EVM and a set of consistent hedonic prices were derived through the adjusted regressions. The range of premiums/discounts were bounded for all variables. The range was large for red rice and heat damage indicating the possibility of substantial economic consequences of these factors.

Conclusions

The analyses of the effects of quality factors on the price of rough rice in Louisiana have revealed several conclusions about quality and price relative to the Louisiana rough rice market. The most obvious conclusion, which was the foundation of this study, is that quality is an important factor affecting prices paid producers for long and medium grain rough rice. This study found a significant relationship between the level of quality and the price of rough rice in both the long and medium grain markets.

The quality factors found to be important in determining the net price received by Louisiana long and medium grain rough rice producers were: head rice, broken kernels, lot size, foreign seeds, heat damage, peck damage, smut damage, and chalk damage. Also, an index variable was found to improve the specification of the model. This variable captured the aggregate supply and demand effects. The inability to control smut and chalk damage and the high correlation between head and broken kernels ultimately forced the removal of these variables from the specification. This is a substantial conclusion since other studies (Brorsen, et. al., 1984 and 1987) included these variables. Therefore, in the set of quality factors found to be important head rice, lot size, foreign seeds, heat damage, and red rice were the most significant across both marketing years and both classes of rice. Of this subset, head rice and red rice were the most important monetarily.

The estimation of the hedonic models were found to be sensitive to the general price level of rice. That is, as the price level increased, so did the premiums and discounts. Also, a semi-logarithmic specification was found to better specify the hedonic model when rice prices were highly volatile.

The estimation of hedonic models revealed a number of statistical problems associated with the properties of the errors associated with the hedonic models. The errors from the hedonic models were heteroscedastic and serially correlated. Autoregressive estimation procedures adequately removed all of the serial correlation. However, in the long grain models, the heteroscedasticity was not successfully removed. A relationship between foreign seeds and lot size with errors were observed. These observations imply that when empirically estimating hedonic models using similar data the errors should be rigorously examined. This is also a main conclusion since previous hedonic rice studies using similar data did not reveal such problems.

Estimation of the hedonic models across marketing seasons, years, and classes of rice gave some insight into the structure of the hedonic models. The hedonic models were found to differ between harvest and post harvest seasons for both long and medium grain rough rice. The hedonic models also differed between marketing years for both classes of rice studied and between long and medium classes of rough rice.

The rice quality data were found to be measured in error. The error-in-variables in the quality factors caused uncertainty in the premiums and discounts. This implies that, when analyzing price quality effects using similar data, OLS estimates could be poor estimates. The hedonic model was also found to be very sensitive to the specification of the model.

The lack of any widely accepted premiums/discounts associated with quality factors affecting rough rice prompts researchers to continue investigating and reporting price premiums/discounts associated with quality factors. Premiums and discounts certainly exist in the rice market and are implicitly being quoted in the price paid producers. The characteristics of errors and the problems incurred in addressing the characteristics associated with the hedonic rough rice models certainly suggest further research is needed in empirically estimating the hedonic models.

The nature of the form of the data for some of the quality factors also prompts the need for further research in the quality area. The application of computerized grading and electronic markets could help reduce some of the uncertainty and multiple gradings that occur in the rice market.

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APPENDIX A
DESCRIPTIVE STATISTICS

Appendix A Table 1. 1989 Wheat Discount Tables.

	Bunge	Cargill	Consolidated	Continental	
Test Weight	(cents per bu.)	(cents per bu.)	(cents per bu.)	Grade Factor	(cents per bu.)
57.9-57.5	0.02	0.02	0.02	59.9-59.0	.005
57.4-57.0	0.04	0.04	0.04	58.9-58.0	.01
56.9-56.5	0.06	0.06	0.06	57.9-57.0	.02
56.4-56.0	0.08	0.08	0.08	56.9-56.0	.03
55.9-55.5	0.11	0.10	0.10	55.9-55.0	.04
Moisture	(% of weight)	(% of price)	(cents per bu.)	Grade Factor	Discount (cents per bu.)
13.6-14.0	1	1	3 1/2	13.51-13.75	2 1/2
14.1-14.5	2	2	7	13.76-14.00	5
14.6-15.0	3	3	10 1/2	14.01-14.25	7 1/2
15.1-15.5	4	4	14	14.26-14.50	10
15.6-16.0	5 1/2	5	17 1/2	14.51-14.75	12 1/2
16.1-16.5	7	6	21	14.76-15.00	15
16.6-17.0	8 1/2	7	25	15.01-15.25	17 1/2
Damage	(cents per bu.)	(cents per bu.)	(cents per bu.)	(cents per bu.)	
2.1-3.0	0.00	0.00	0.02	0.00	
3.1-4.0	0.00	0.00	0.04	0.00	
4.1-5.0	0.02	0.02	0.06	0.01	
5.1-6.0	0.04	0.04	0.08	0.02	
6.1-7.0	0.06	0.06	0.10	0.03	
7.1-8.0	0.08	0.09	0.12	0.04	
F.M.	(cents per bu.)	(cents per bu.)	(cents per bu.)	(cents per bu.)	
1.1-2.0	0.01	0.02	1.1-1.5 .01	.6-1.0	0.01
2.1-3.0	0.02	0.04	1.6-2.0 .02	1.1-1.5	0.02
Shrunken and Broken					
5.1-6.0	0.01	5.1-7.9 .02		5.1-6.0	0.01
6.1-7.0	0.02	8.0-11.9 .04		6.1-7.0	0.02
Defects	(cents per bu.)	(cents per bu.)		(cents per bu.) *	
5.1-6.0	0.02	0.01		5.1-6.0	0.01
6.1-7.0	0.04	0.02		6.1-7.0	0.02
7.1-8.0	0.06	0.03		7.1-8.0	0.03

All dockage will be deducted from the gross weight.
All discounts subject to revision without notice.
* No discounts will be taken here if discounts are taken on individual factors.
Source: Louisiana Farm Bureau Marketing.

Appendix A Table 2. Correlation Coefficients For Main Variables Included in Study, Long Grain Rough Rice, Louisiana, 1986.

Variables	Bid Price	Mill Price	Loan Value	Market Fees	Head Rice	Total Rice	Brokens	Lot Size	Seeds	Red Heat	Rice	Peck	Smut	Chalk
Bid Price	1.000	0.07088	0.51205	0.17883	0.77252	0.55437	-0.67110	0.22936	-0.28265	-0.03911	-0.30674	0.00601	0.05073	-0.31125
Mill Price	0.070	1.00000	0.13789	-0.04880	0.17256	0.20679	-0.11676	0.15821	-0.07039	-0.05003	-0.03784	-0.00244	0.02068	-0.14988
Loan Value	0.512	0.13789	1.00000	0.20997	0.44796	0.43281	-0.34466	0.24895	-0.47970	-0.21830	-0.40886	0.02275	0.04474	-0.28266
Market Fee	0.178	-0.04880	0.20997	1.00000	0.19007	0.08090	-0.18729	0.03750	-0.08704	0.00929	-0.11434	0.02708	0.12663	-0.06554
Head Rice	0.772	0.17256	0.44796	0.19007	1.00000	0.53576	-0.94137	0.18186	-0.13821	-0.00735	-0.26991	0.02170	0.05069	-0.36687
Total Rice	0.554	0.20679	0.43281	0.08090	0.53576	1.00000	-0.21948	0.22879	-0.12718	-0.04515	-0.28111	-0.00872	0.09723	-0.33133
Brokens	-0.671	-0.11676	-0.34466	-0.18729	0.94137	-0.21948	1.00000	-0.11871	0.10887	-0.00955	0.19955	-0.02856	-0.01972	0.29151
Lot Size	0.229	0.15821	0.24895	0.03750	0.18186	0.22879	-0.11871	1.00000	-0.16414	-0.01272	-0.15266	0.00748	-0.00843	-0.18873
Seeds	-0.282	-0.07039	-0.47970	-0.08704	-0.13821	-0.12718	0.10887	-0.16414	1.00000	0.00095	0.13523	-0.01328	-0.00051	0.12849
Heat	-0.039	-0.05003	-0.21830	0.00929	-0.00735	-0.04515	-0.00955	-0.01272	0.00095	1.00000	0.00677	-0.00847	-0.03134	0.10463
Red Rice	-0.306	-0.03784	-0.40886	-0.11434	-0.26991	-0.28111	0.19955	-0.15266	0.13523	0.00677	1.00000	-0.02467	-0.05812	0.24938
Peck	0.006	-0.00244	0.02275	0.02708	0.02170	-0.00872	-0.02856	0.00748	-0.01328	-0.00847	-0.02467	1.00000	0.07127	-0.05854
Smut	0.050	0.02068	0.04474	0.12663	0.05069	0.09723	-0.01972	-0.00843	-0.00051	-0.03134	-0.05812	0.07127	1.00000	0.07181
Chalk	-0.311	-0.14988	-0.28266	-0.06554	-0.36687	-0.33133	0.29151	-0.18873	0.12849	0.10463	0.24938	-0.05854	0.07181	1.00000

Appendix A Table 3. Correlation Coefficients for Main Variables Included in Study, Medium Grain Rough Rice, Louisiana, 1986.

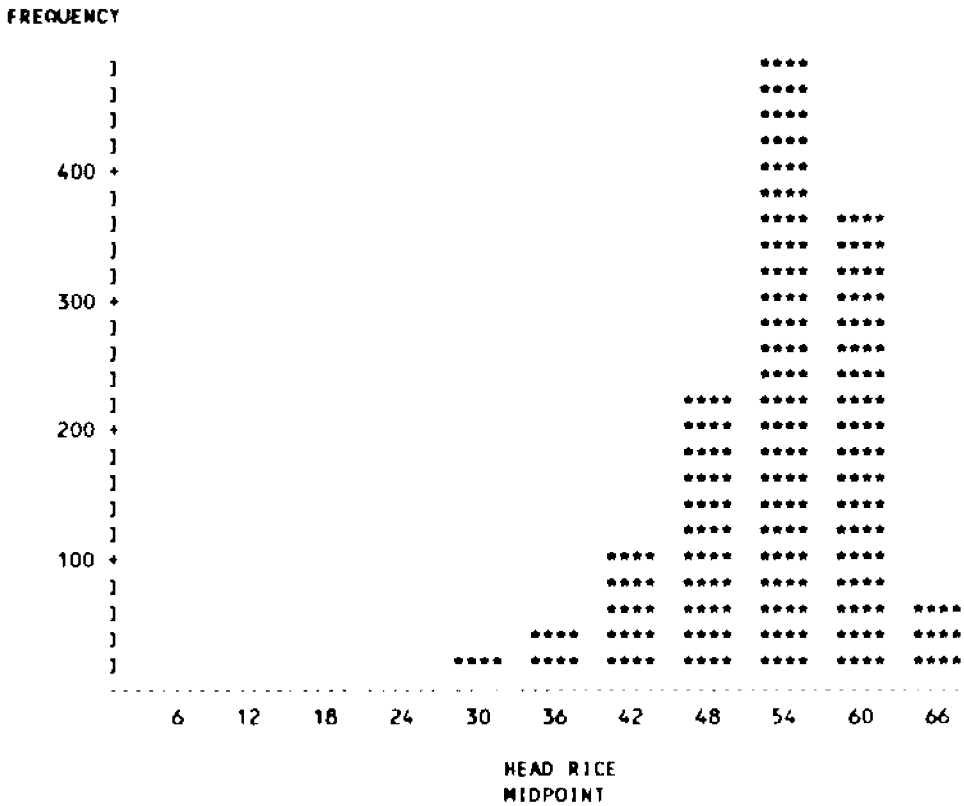
Variables	Bid Price	Mill Price	Loan Value	Market Fees	Head Rice	Total Rice	Brokens	Lot Size	Seeds	Heat	Red Rice	Peck	Smut	Chalk
Bid Price	1.000	-0.05543	0.42042	0.10979	0.70836	0.46526	-0.65846	0.14161	-0.21467	-0.21553	-0.26543	0.06824	0.07076	-0.03166
Mill Price	-0.055	1.00000	-0.00022	-0.14374	-0.06091	0.00774	0.06906	0.03592	-0.03874	0.02217	0.01403	-0.01585	-0.11314	0.04614
Loan Value	0.420	-0.00022	1.00000	0.06135	0.34253	0.37046	-0.28049	0.11019	-0.49568	-0.47527	-0.18056	0.06711	0.06660	-0.06193
Market Fees	0.109	-0.14374	0.06135	1.00000	0.12215	-0.00803	-0.13655	-0.01786	-0.06000	0.14128	-0.04332	-0.00536	0.00707	0.01155
Head Rice	0.708	-0.06091	0.34253	0.12215	1.00000	0.48722	-0.97375	0.08577	-0.09081	-0.07126	-0.24504	0.07380	0.09290	-0.14083
Total Rice	0.465	0.00774	0.37046	-0.00803	0.48722	1.00000	-0.27567	0.08563	-0.17914	-0.12238	-0.23678	0.11743	0.07796	-0.11225
Brokens	-0.658	0.06906	-0.28049	-0.13655	-0.97375	-0.27567	1.00000	-0.07209	0.05327	0.04654	0.20801	-0.05063	-0.08194	0.12576
Lot Size	0.141	0.03592	0.11019	-0.01786	0.08577	0.08563	-0.07209	1.00000	-0.11068	0.09681	-0.09636	-0.03803	0.02416	0.02524
Seeds	-0.214	-0.03874	-0.49568	-0.06000	-0.09081	-0.17914	0.05327	-0.11068	1.00000	-0.01176	0.04402	-0.04612	-0.01657	0.00340
Heat	-0.215	0.02217	-0.47527	0.14128	-0.07126	-0.12238	0.04654	0.09681	-0.01176	1.00000	0.07421	-0.03034	-0.02471	0.05836
Red Rice	-0.265	0.01403	-0.18056	-0.04332	-0.24504	-0.23678	0.20801	-0.09636	0.04402	0.07421	1.00000	-0.01889	0.01187	0.14074
Peck	0.068	-0.01585	0.06711	-0.00536	0.07380	0.11743	-0.05063	-0.03803	-0.04612	-0.03034	-0.01889	1.00000	0.05863	-0.15942
Smut	0.070	-0.11314	0.06660	0.00707	0.09290	0.07796	-0.08194	0.02416	-0.01657	-0.02471	0.01187	0.05863	1.00000	0.05651
Chalk	-0.031	0.04614	-0.06193	0.01155	-0.14083	-0.11225	0.12576	0.02524	0.00340	0.05836	0.14074	-0.15942	0.05651	1.00000

Appendix A Table 4. Correlation Coefficients for Main Variables Included in Study, Long Grain Rough Rice, Louisiana, 1987.

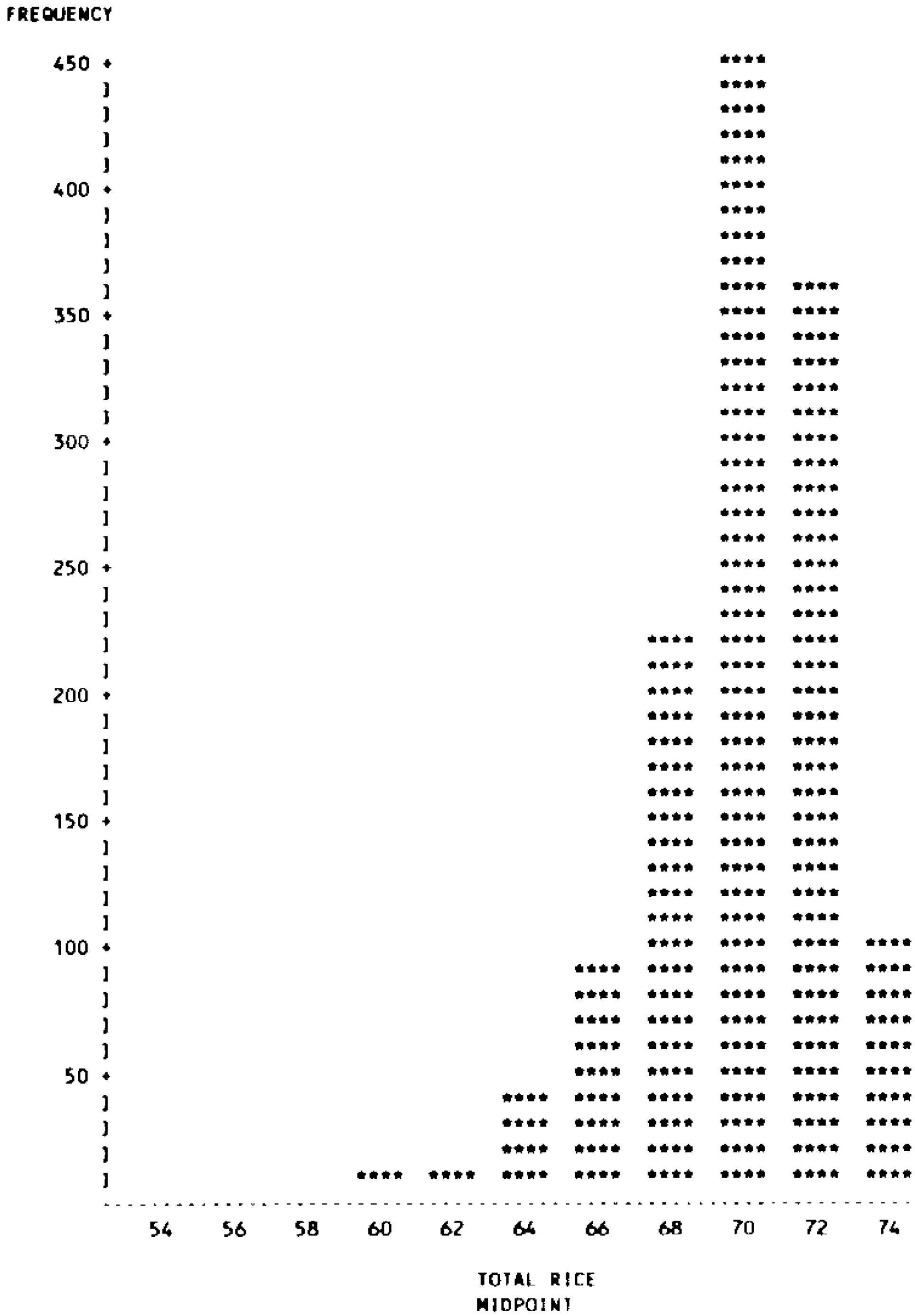
Variables	Bid Price	Mill Price	Loan Value	Market Fees	Head Rice	Total Rice	Brokens	Lot Size	Seeds	Red Heat	Rice	Peck	Smut	Chalk
Bid Price	1.00000	0.79785	0.27575	0.38035	0.39743	0.30082	-0.36639	0.10726	-0.10792	-0.01501	-0.12249	-0.20986	-0.03707	0.09418
Mill Price	0.79785	1.00000	-0.12807	0.34701	-0.03475	-0.07285	0.01562	-0.02506	0.07279	0.09946	-0.02020	-0.32769	0.01292	0.12697
Loan Value	0.27575	-0.12807	1.00000	0.06393	0.62756	0.61476	-0.52924	0.22781	-0.42033	-0.30012	-0.31322	0.16157	-0.05450	-0.08580
Market Fees	0.38035	0.34701	0.06393	1.00000	0.10719	0.02676	-0.11801	0.02659	-0.05336	0.05585	-0.01663	-0.10819	0.04794	0.10243
Head Rice	0.39743	-0.03475	0.62756	0.10719	1.00000	0.64143	-0.96266	0.24198	-0.21869	-0.05260	-0.15843	0.12340	-0.10097	-0.13611
Total Rice	0.30082	-0.07285	0.61476	0.02676	0.64143	1.00000	-0.40979	0.19085	-0.24759	-0.08640	-0.20597	0.12602	-0.11484	-0.08422
Brokens	-0.36639	0.01562	-0.52924	-0.11801	-0.96266	-0.40979	1.00000	-0.22037	0.17266	0.03205	0.11569	-0.10225	0.07953	0.13211
Lot Size	0.10726	-0.02506	0.22781	0.02659	0.24198	0.19085	-0.22037	1.00000	-0.16008	-0.00241	-0.05720	0.09361	-0.02653	-0.05777
Seeds	-0.10792	0.07279	-0.42033	-0.05336	-0.21869	-0.24759	0.17266	-0.16008	1.00000	-0.00179	0.00400	-0.08613	-0.01626	-0.03439
Heat	-0.01501	0.09946	-0.30012	0.05585	-0.05260	-0.08640	0.03205	-0.00241	-0.00179	1.00000	-0.03003	-0.07314	-0.01381	-0.00981
Red Rice	-0.12249	-0.02020	-0.31322	-0.01663	-0.15843	-0.20597	0.11569	-0.05720	0.00400	-0.03003	1.00000	-0.05165	-0.03682	0.05645
Peck	-0.20986	-0.32769	0.16157	-0.10819	0.12340	0.12602	-0.10225	0.09361	-0.08613	-0.07314	-0.05165	1.00000	-0.00491	-0.12002
Smut	-0.03707	0.01292	-0.05450	0.04794	-0.10097	-0.11484	0.07953	-0.02653	-0.01626	-0.01381	-0.03682	-0.00491	1.00000	-0.00853
Chalk	0.09418	0.12697	-0.08580	0.10243	-0.13611	-0.08422	0.13211	-0.05777	-0.03439	-0.00981	0.05645	-0.12002	-0.00853	1.00000

Appendix A Table 5. Correlation Coefficients for Main Variables Included in Study, Medium Grain Rough Rice, Louisiana, 1987.

Variables	Bid Price	Mill Price	Loan Value	Market Fees	Head Rice	Total Rice	Brokens	Lot Size	Seeds	Heat	Red Rice	Peck	Smut	Chalk
Bid Price	1.0000	0.61815	0.44676	0.27113	0.56945	0.37363	-0.54463	0.07395	-0.20382	-0.10827	-0.18138	-0.11016	-0.02782	0.17906
Mill Price	0.6180	1.00000	-0.12306	0.27660	-0.04500	-0.07302	0.03080	0.00006	0.05092	0.07676	-0.02997	-0.25158	-0.00072	0.18292
Loan Value	0.4467	-0.12306	1.00000	0.10267	0.62319	0.52574	-0.56315	0.07915	-0.48741	-0.42210	-0.29642	0.13910	-0.03385	0.06334
Market Fees	0.2711	0.27660	0.10267	1.00000	0.11690	0.02549	-0.12622	0.14294	-0.09570	0.03075	0.01723	-0.14046	0.00188	0.23245
Head Rice	0.5694	-0.04500	0.62319	0.11690	1.00000	0.59353	-0.97402	0.06276	-0.22862	0.02908	-0.19750	0.03388	-0.09361	-0.00368
Total Rice	0.3736	-0.07302	0.52574	0.02549	0.59353	1.00000	-0.39585	0.11463	-0.22631	-0.01816	-0.18032	0.09260	-0.07499	0.01241
Brokens	-0.5446	0.03080	-0.56315	-0.12622	-0.97402	-0.39585	1.00000	-0.03936	0.19718	-0.03829	0.17462	-0.01260	0.08571	0.00769
Lot Size	0.0739	0.00006	0.07915	0.14294	0.06276	0.11463	-0.03936	1.00000	-0.13013	0.04396	-0.05375	0.06105	-0.01058	0.13110
Seeds	-0.2038	0.05092	-0.48741	-0.09570	-0.22862	-0.22631	0.19718	-0.13013	1.00000	0.00244	0.15935	-0.12377	-0.02134	-0.09123
Heat	-0.1082	0.07676	-0.42210	0.03075	0.02908	-0.01816	-0.03829	0.04396	0.00244	1.00000	0.00767	-0.13785	-0.01090	-0.10803
Red Rice	-0.1813	-0.02997	-0.29642	0.01723	-0.19750	-0.18032	0.17462	-0.05375	0.15935	0.00767	1.00000	-0.03378	-0.00723	0.02428
Peck	-0.1101	-0.25158	0.13910	-0.14046	0.03388	0.09260	-0.01260	0.06105	-0.12377	-0.13785	-0.03378	1.00000	-0.04410	-0.02357
Smut	-0.0278	-0.00072	-0.03385	0.00188	-0.09361	-0.07499	0.08571	-0.01058	-0.02134	-0.01090	-0.00723	-0.04410	1.00000	-0.02262
Chalk	0.1790	0.18292	0.06334	0.23245	-0.00368	0.01241	0.00769	0.13110	-0.09123	-0.10803	0.02428	-0.02357	-0.02262	1.00000



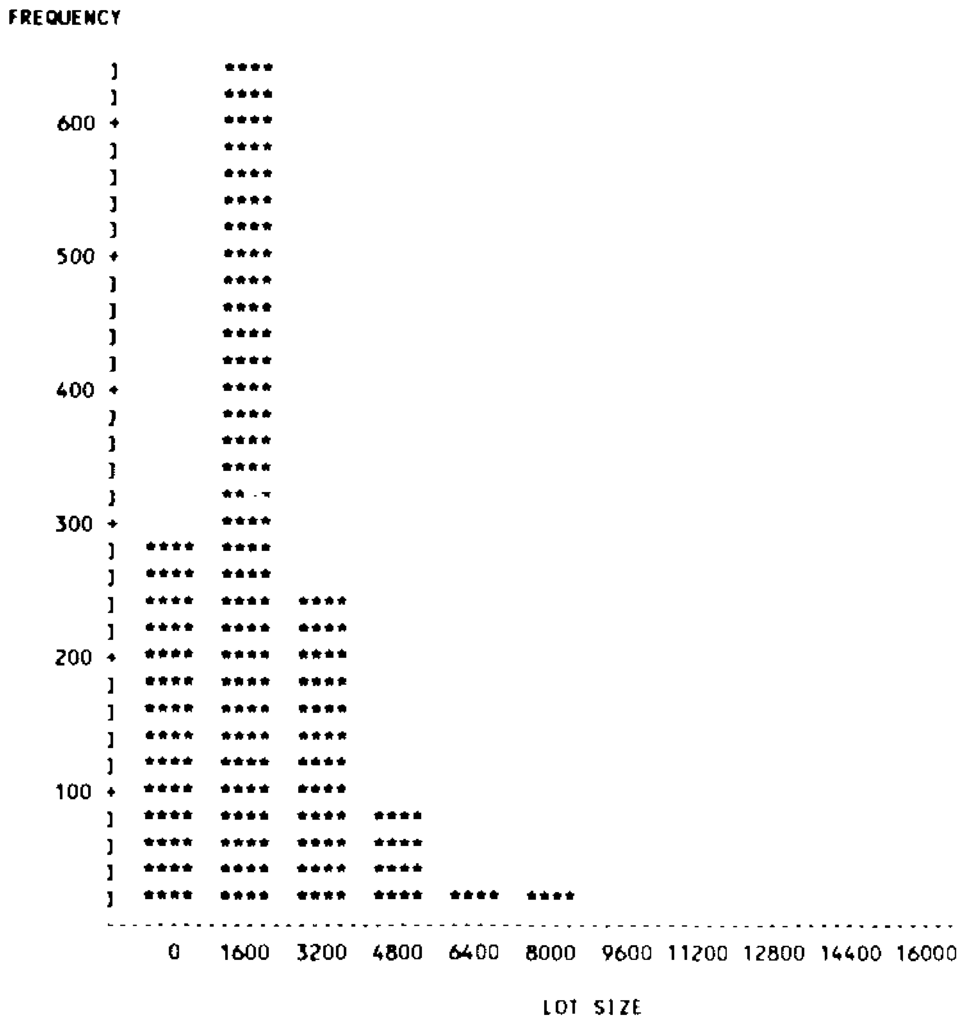
Appendix A Figure 1. Frequency Bar Chart for Head Rice, Long Grain Rough Rice, Louisiana, 1986.



Appendix A Figure 2. Frequency Bar Chart for Total Rice, Long Grain Rough Rice, Louisiana, 1986.

```
FREQUENCY

500 +               ****
    ]               ****
    ]       ****    ****
    ]       ****    ****
    ]       ***^    ****
400 +       ****    ****
    ]       ****    ****
    ]       ****    ****
    ]       ****    ****
    ]       ****    ****
300 +       ****    ****
    ]       ****    ****
    ]       ****    ****
    ]       ****    ****
    ]       ****    ****
200 +       ****    ****
    ]       ****    ****    ****
    ]       ****    ****    ****
    ]       ****    ****    ****
    ]       ****    ****    ****
100 +       ****    ****    ****
    ]       ****    ****    ****
    ]   ****    ****    ****    ****    ****
    ]   ****    ****    ****    ****    ****
    ]   ****    ****    ****    ****    ****    ****
    ---------------------------------------------------------------------------------------------
         6      12      18      24      30      36      42      48      54      60      66

                                    BROKEN KERNALS
                                    MIDPOINT
```

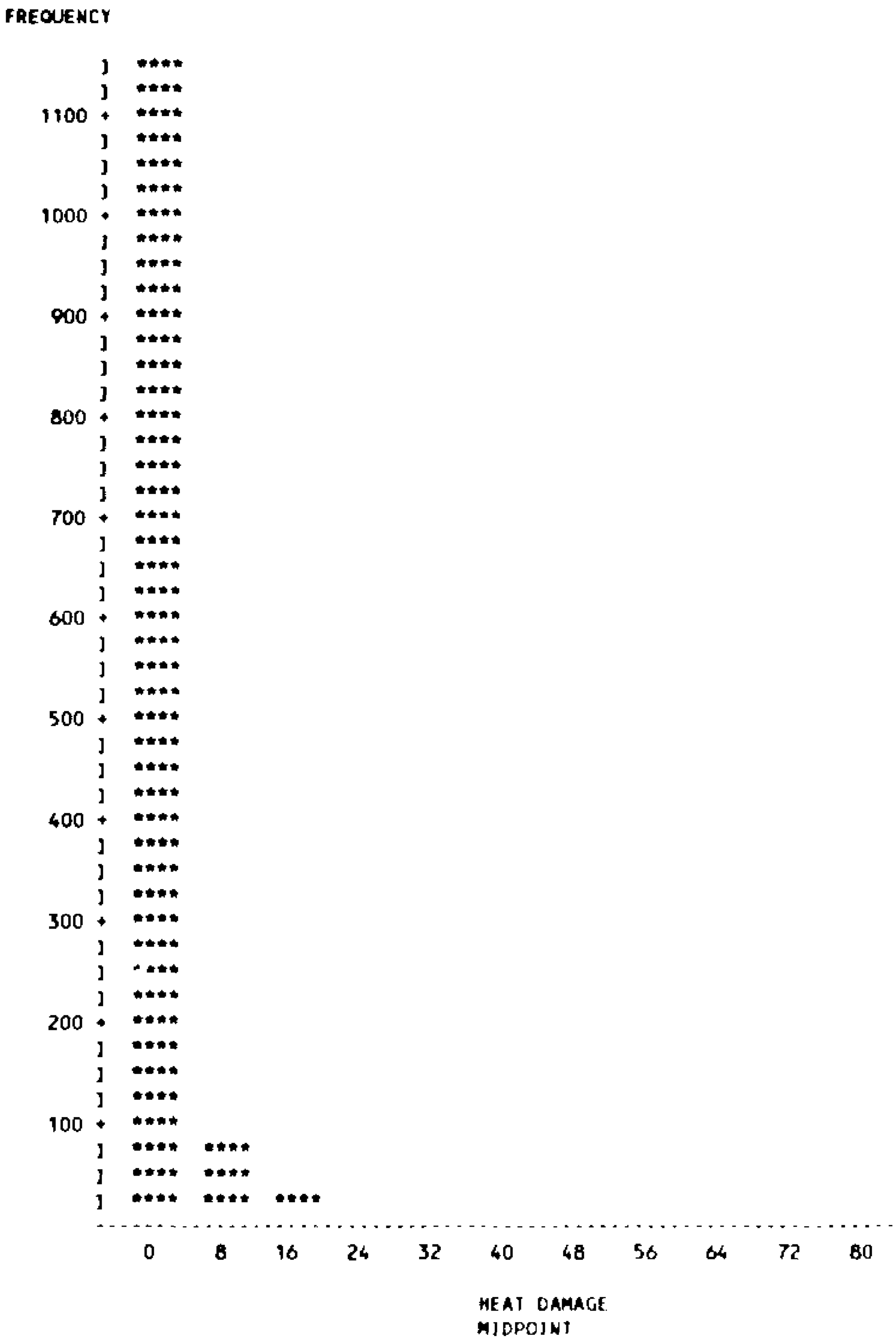
Appendix A Figure 3. Frequency Bar Chart for Broken Kernals, Long Grain Rough Rice, Louisiana, 1986.



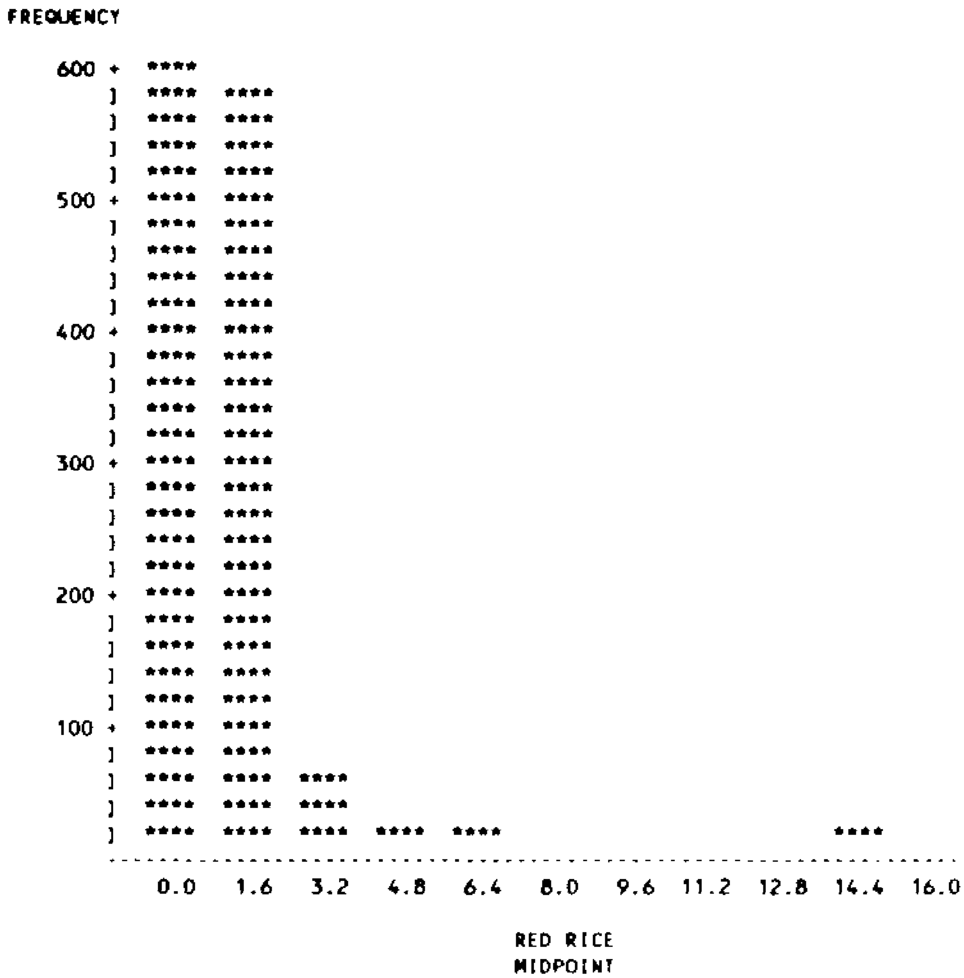
Appendix A Figure 4. Frequency Bar Chart for Lot Size, Long Grain Rough Rice, Louisiana, 1986.

```
FREQUENCY
      ]  ****
      ]  ****
      ]  ****
 1100 +  ****
      ]  ****
      ]  ****
      ]  ****
 1000 +  ****
      ]  ****
      ]  ****
      ]  ****
  900 +  ****
      ]  ****
      ]  ****
      ]  ****
  800 +  ****
      ]  ****
      ]  ****
      ]  ****
  700 +  ****
      ]  ****
      ]  ****
      ]  ****
  600 +  ****
      ]  ****
      ]  ****
      ]  ****
  500 +  ****
      ]  ****
      ]  ****
      ]  ****
  400 +  ****
      ]  ****
      ]  ****
      ]  ****
  300 +  ****
      ]  ****
      ]  ****
      ]  ****
  200 +  ****
      ]  ****
      ]  ****
      ]  ****
  100 +  ****
      ]  ****  ****
      ]  ****  ****
      ]  ****  ****  ****
      ------------------------------------------------------------------------------------------
          0     80    160    240    320    400    480    560    640    720    800

                                   TOTAL SEEDS
                                   MIDPOINT
```

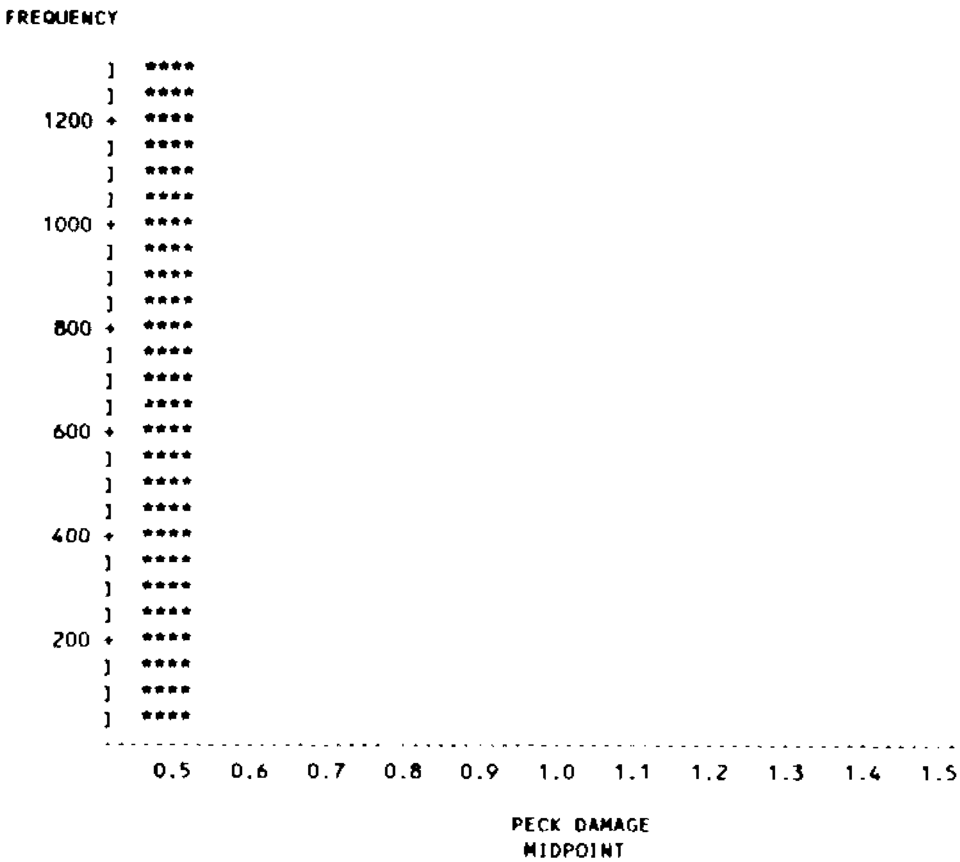
Appendix A Figure 5. Frequency Bar Chart for Total Seeds, Long Grain Rough Rice, Louisiana, 1986.



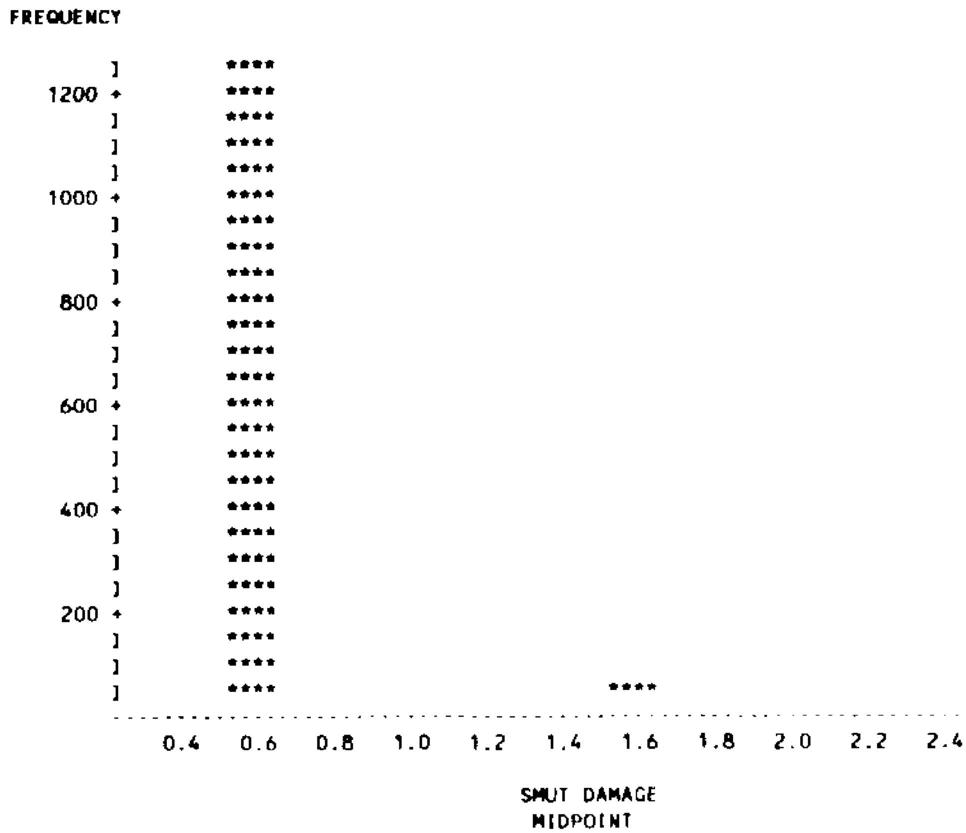
Appendix A Figure 6. Frequency Bar Chart for Heat Damage, Long Grain Rough Rice, Louisiana, 1986.



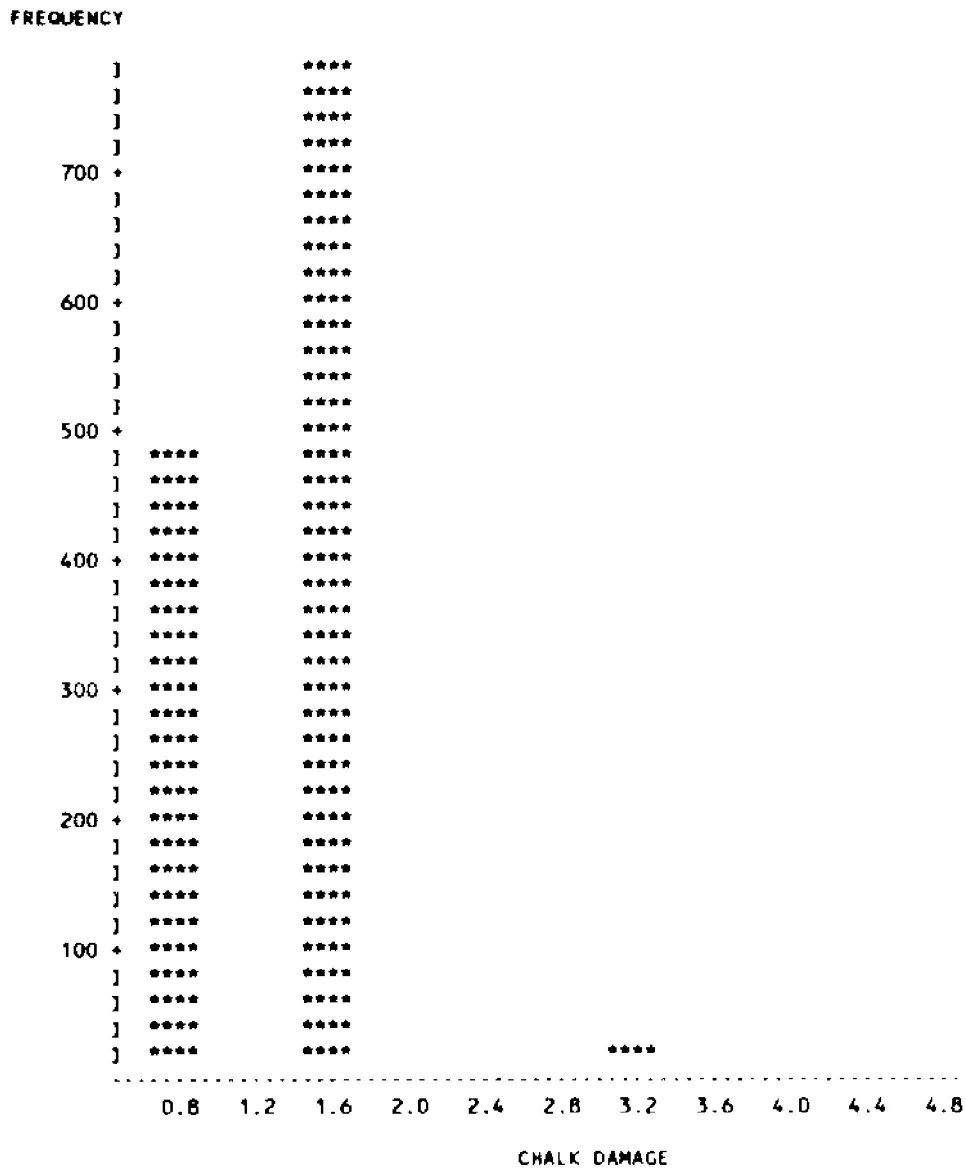
Appendix A Figure 7. Frequency Bar Chart for Red Rice, Long Grain Rough Rice, Louisiana, 1986.



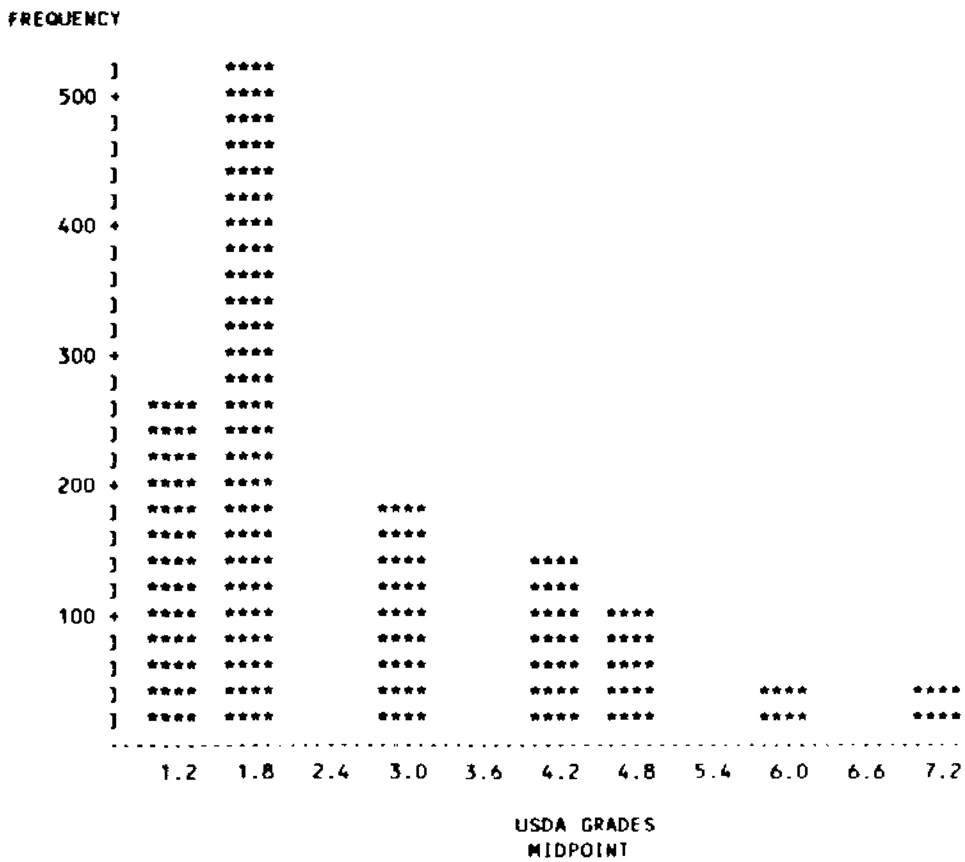
Appendix A Figure 8. Frequency Bar Chart for Peck Damage, Long Grain Rough Rice, Louisiana, 1986.



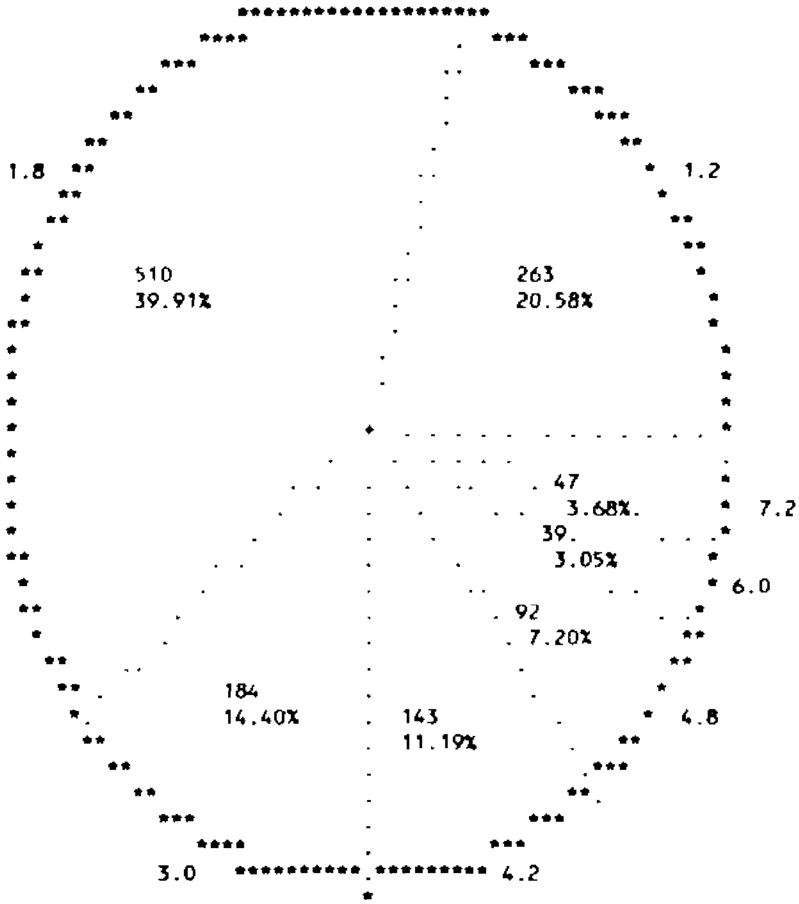
Appendix A Figure 9. Frequency Bar Chart for Smut Damage, Long Grain Rough Rice, Louisiana, 1986.



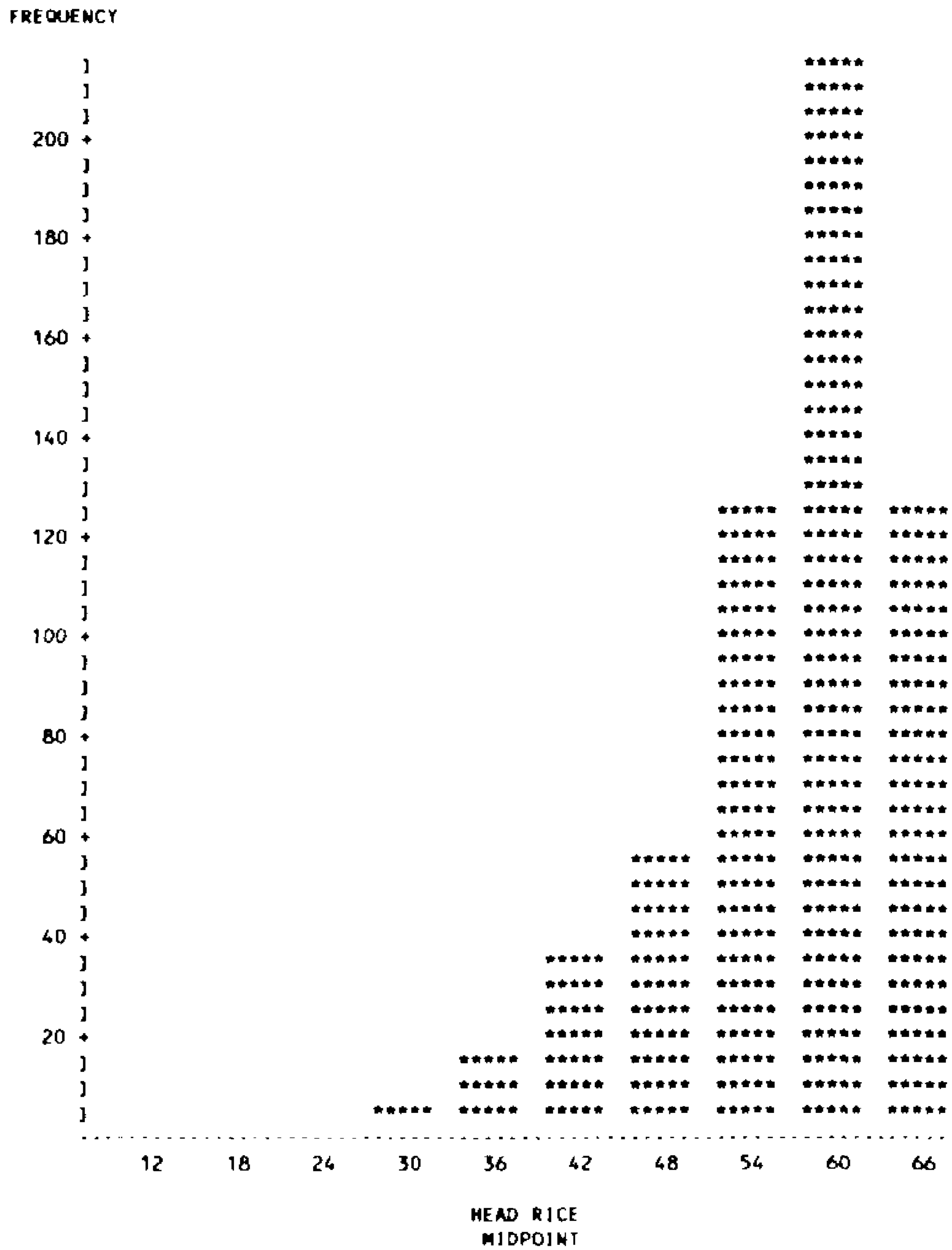
Appendix A Figure 10. Frequency Bar Chart for Chalk Damage, Long Grain Rough Rice, Louisiana, 1986.



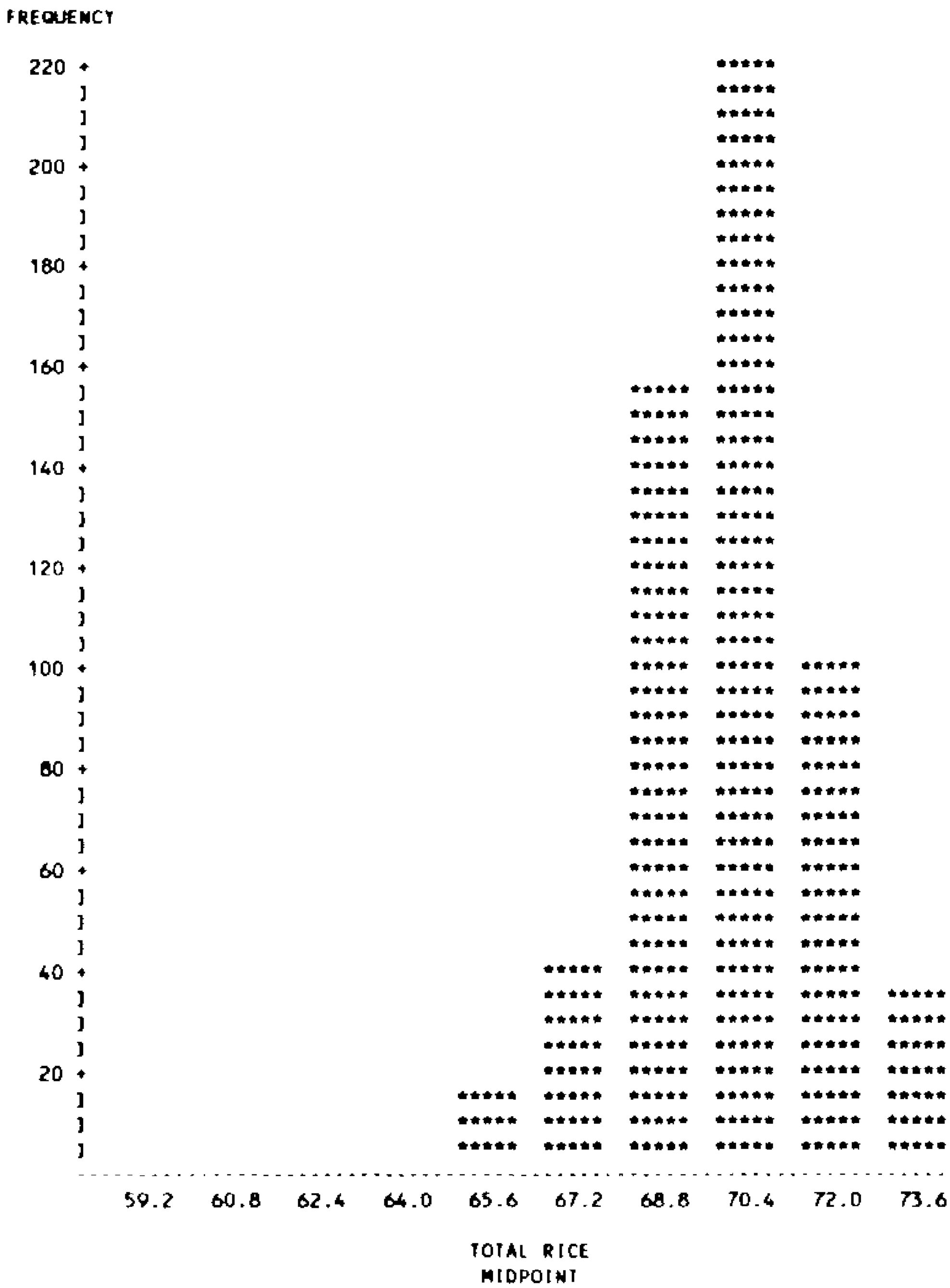
Appendix A Figure 11. Frequency Bar Chart for USDA Grades, Long Grain Rough Rice, Louisiana, 1986.



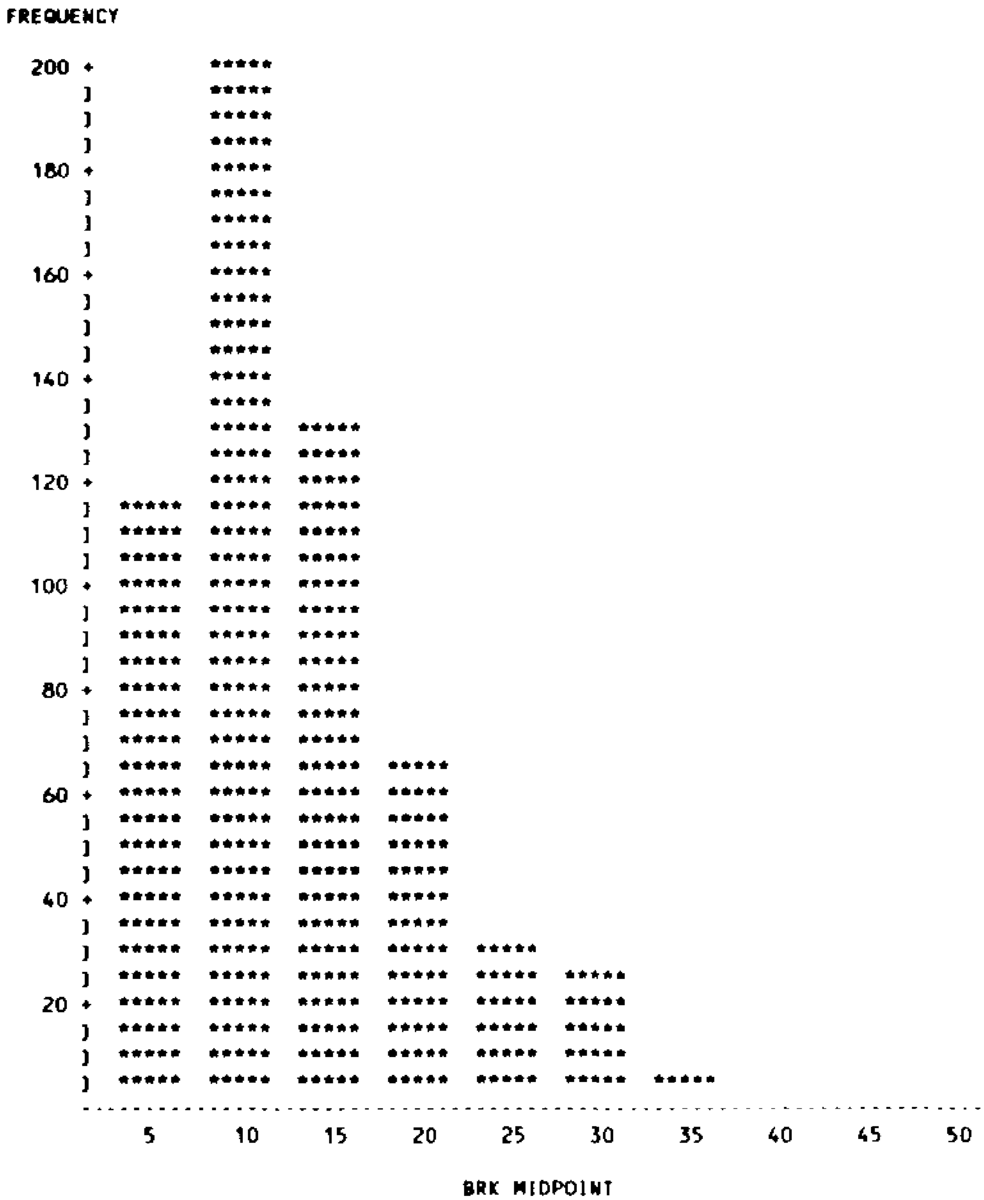
Appendix A Figure 12. Frequency Pie Chart of USDA Grades, Long Grain Rough Rice, Louisiana, 1986.



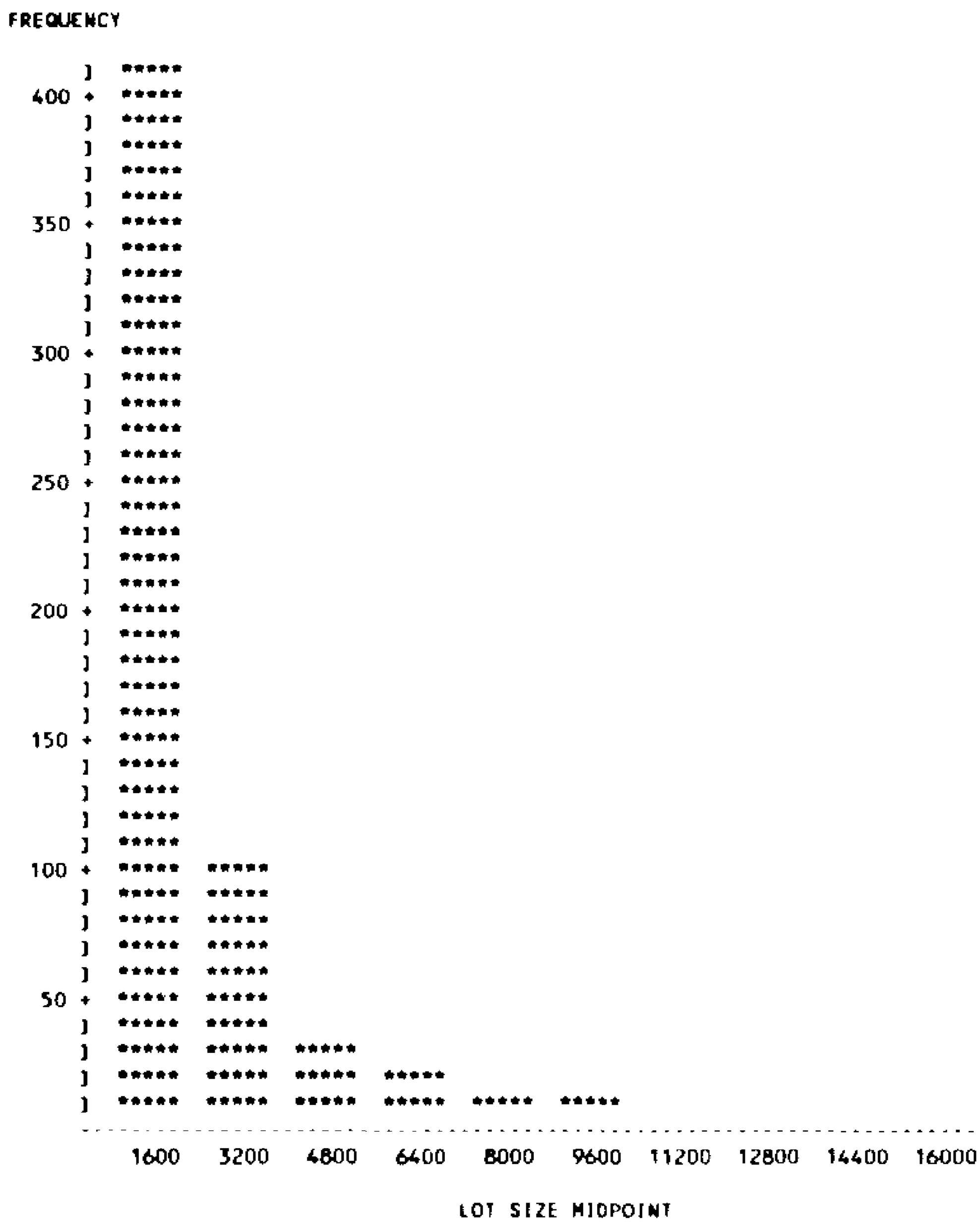
Appendix A Figure 13. Frequency Bar Chart for Head Rice, Medium Grain Rough Rice, Louisiana, 1986.



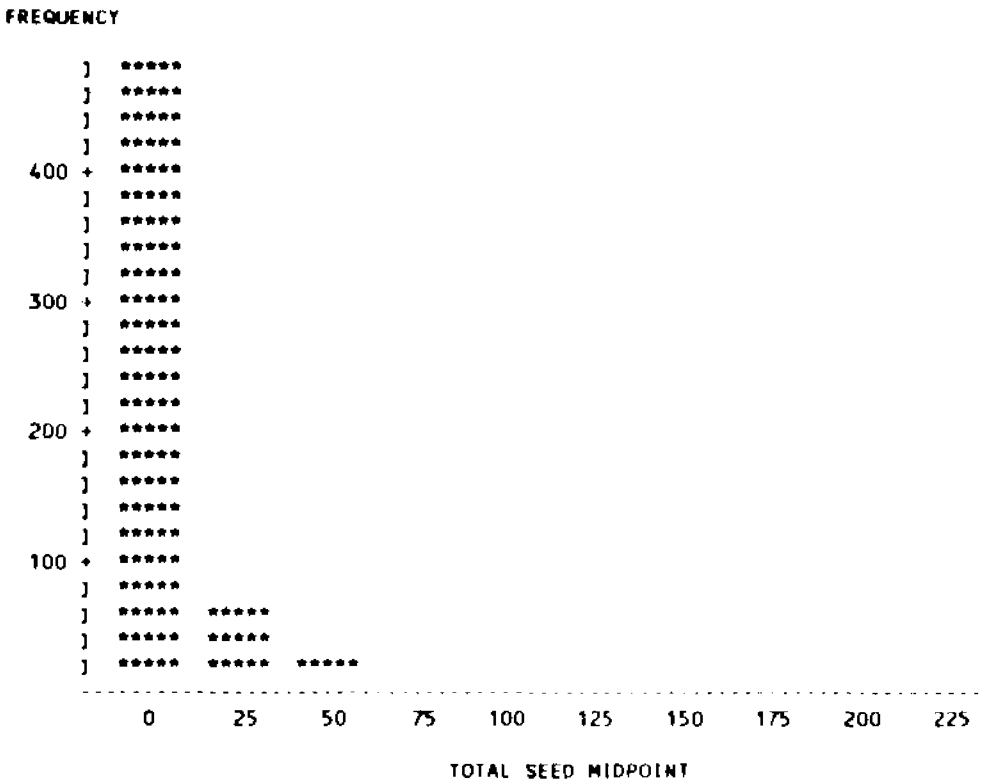
Appendix A Figure 14. Frequency Bar Chart for Total Rice, Medium Grain Rough Rice, Louisiana, 1986.



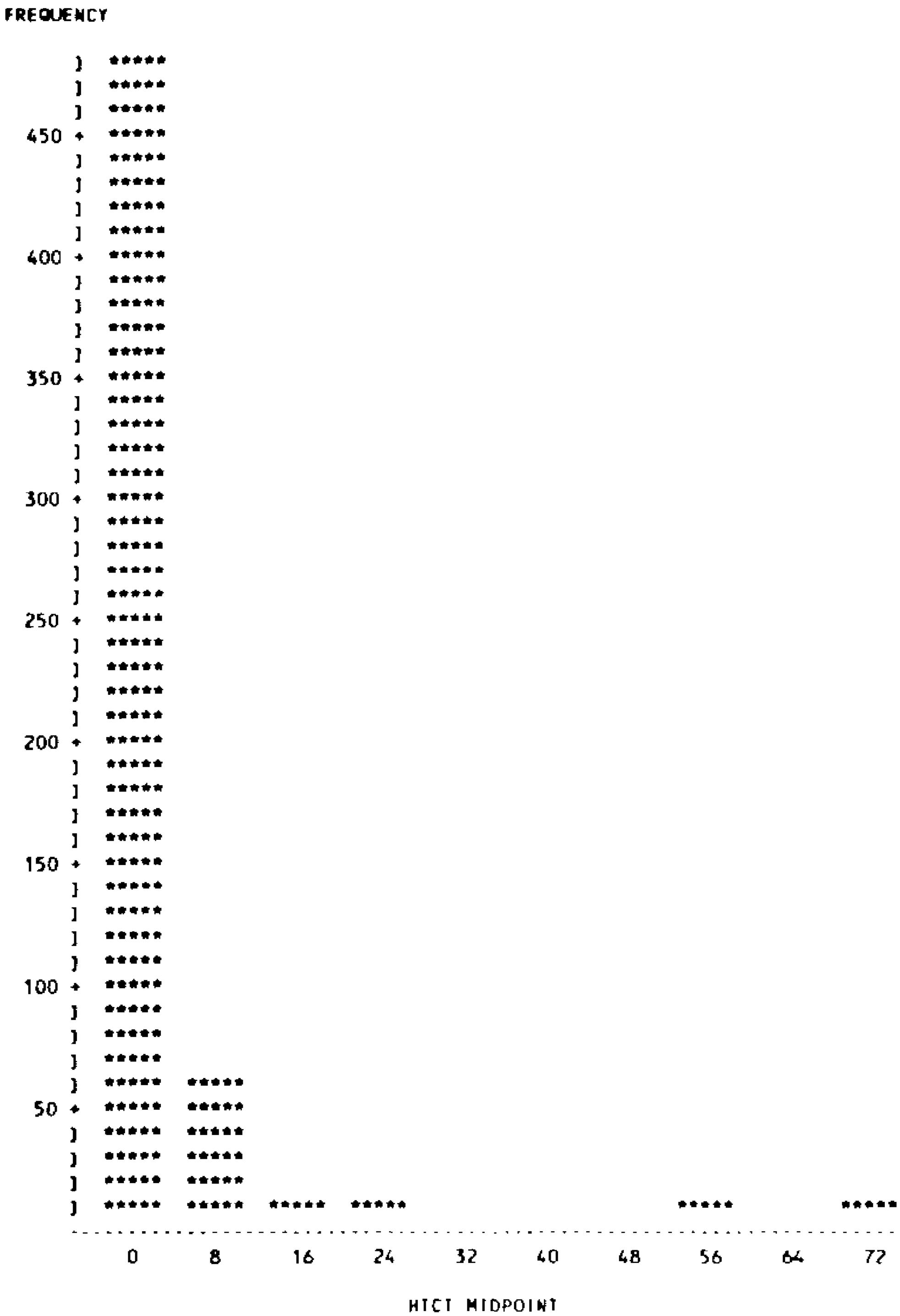
Appendix A Figure 15. Frequency Bar Chart for Broken Kernels, Medium Grain Rough Rice, Louisiana, 1986.



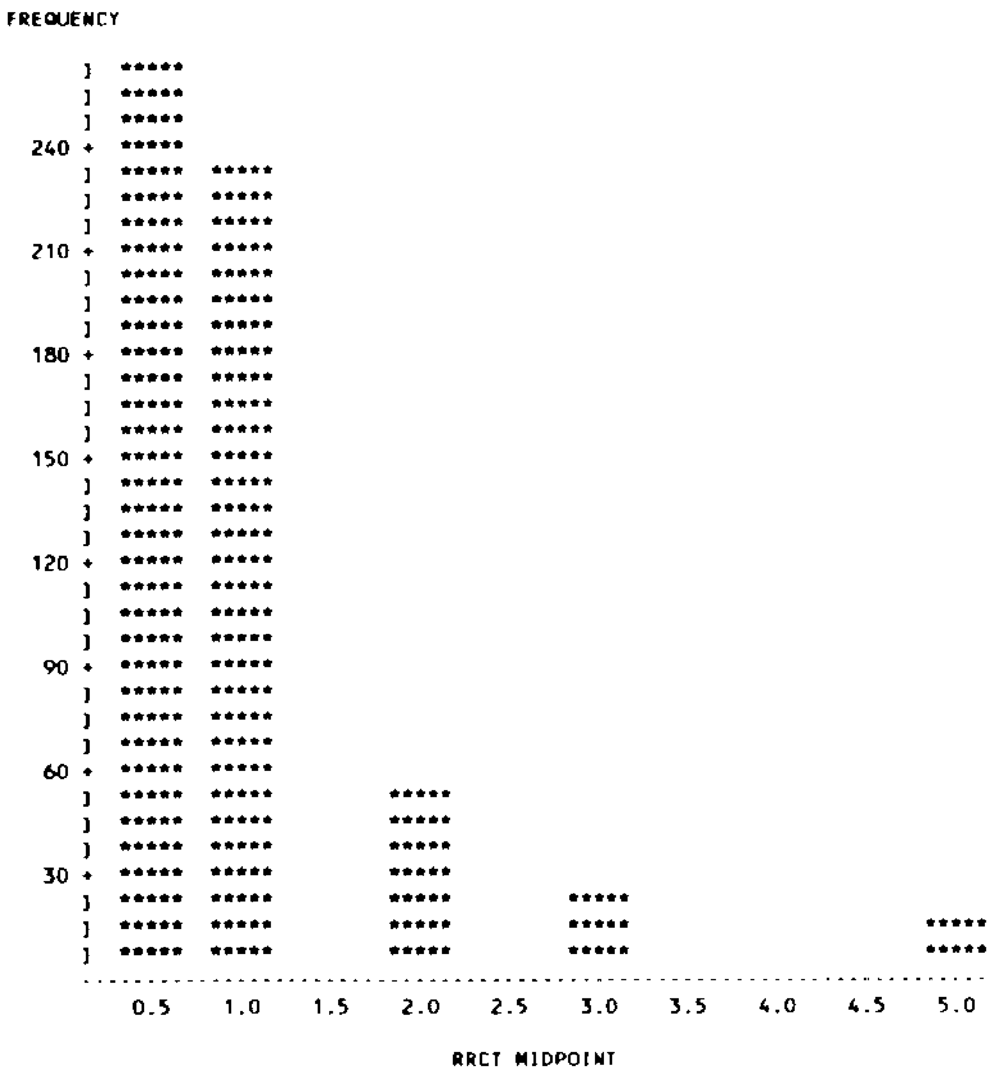
Appendix A Figure 16. Frequency Bar Chart for Lot Size, Medium Grain Rough Rice, Louisiana, 1986.



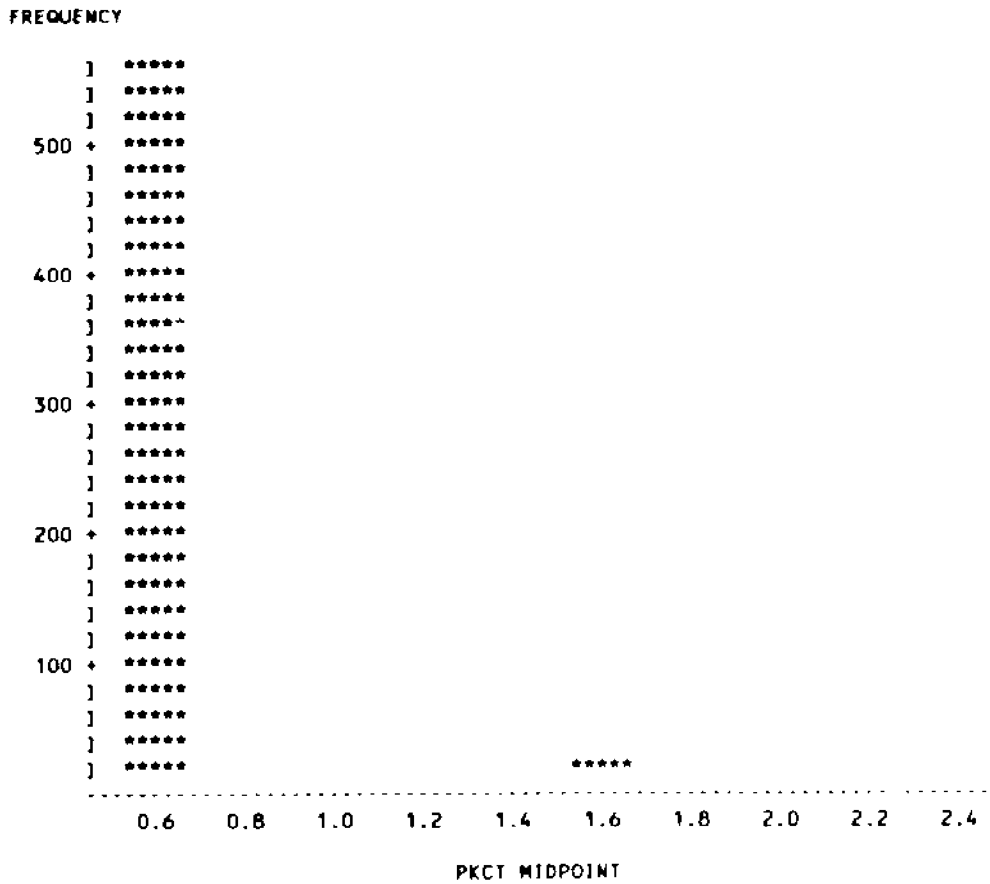
Appendix A Figure 17. Frequency Bar Chart for Total Seed, Medium Grain Rough Rice, Louisiana, 1986.



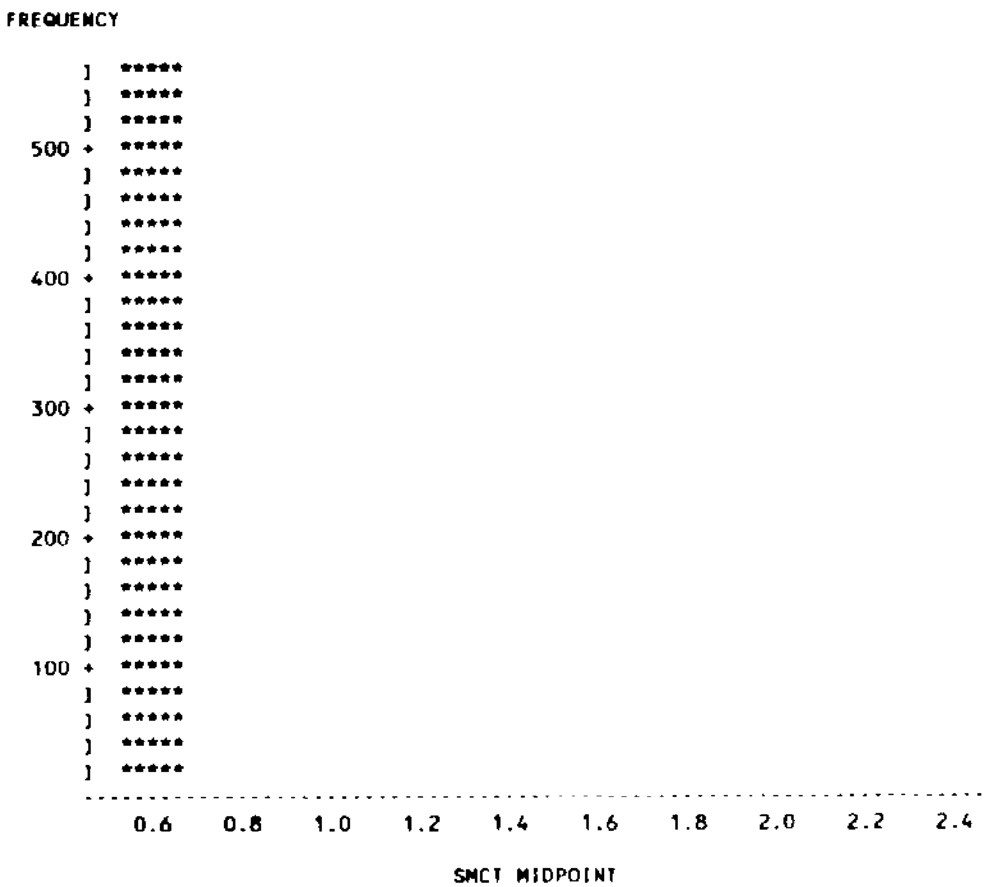
Appendix A Figure 18. Frequency Bar Chart for Heat Damage, Medium Grain Rough Rice, Louisiana, 1986.



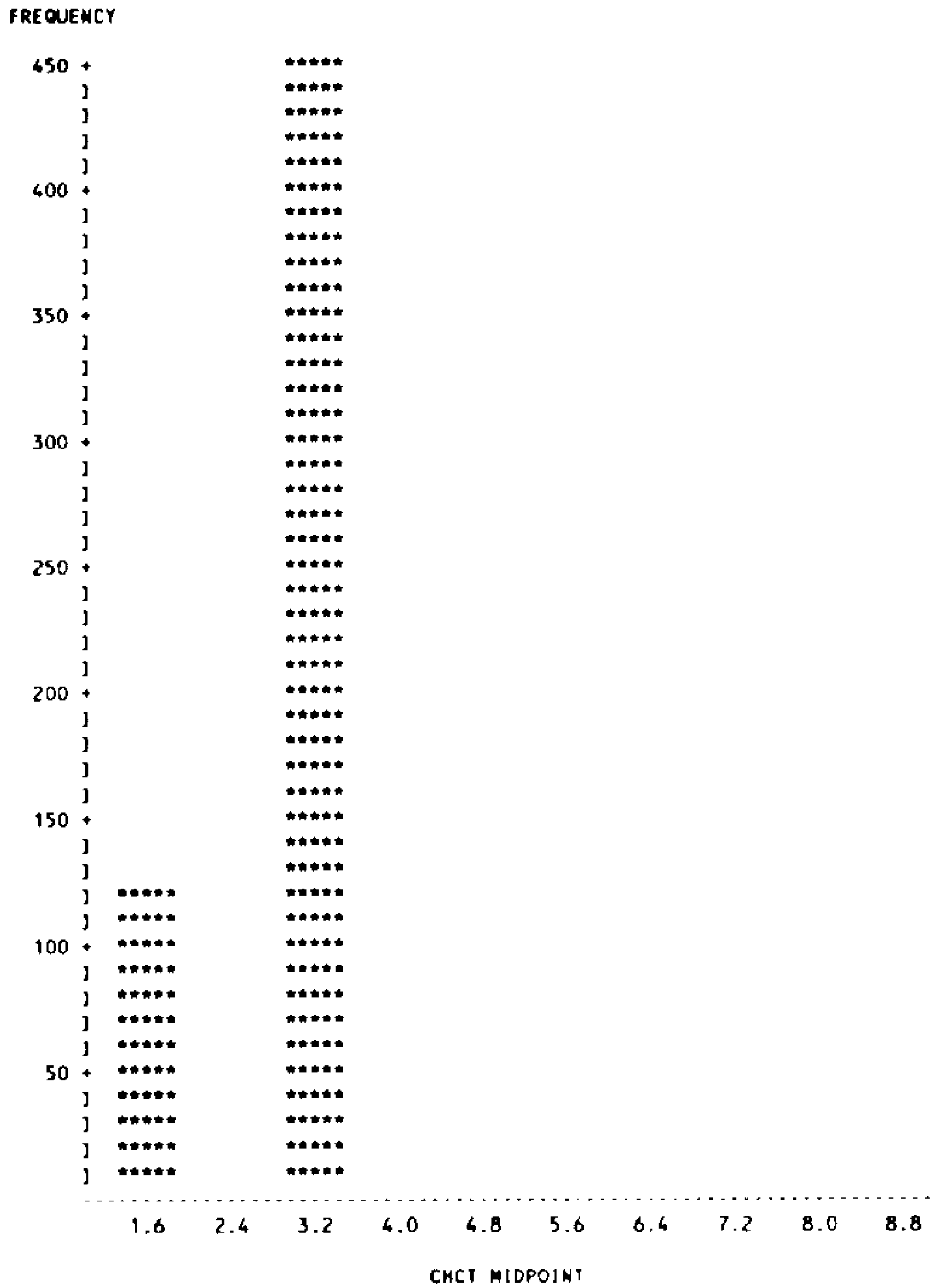
Appendix A Figure 19. Frequency Bar Chart for Red Rice, Medium Grain Rough Rice, Louisiana, 1986.



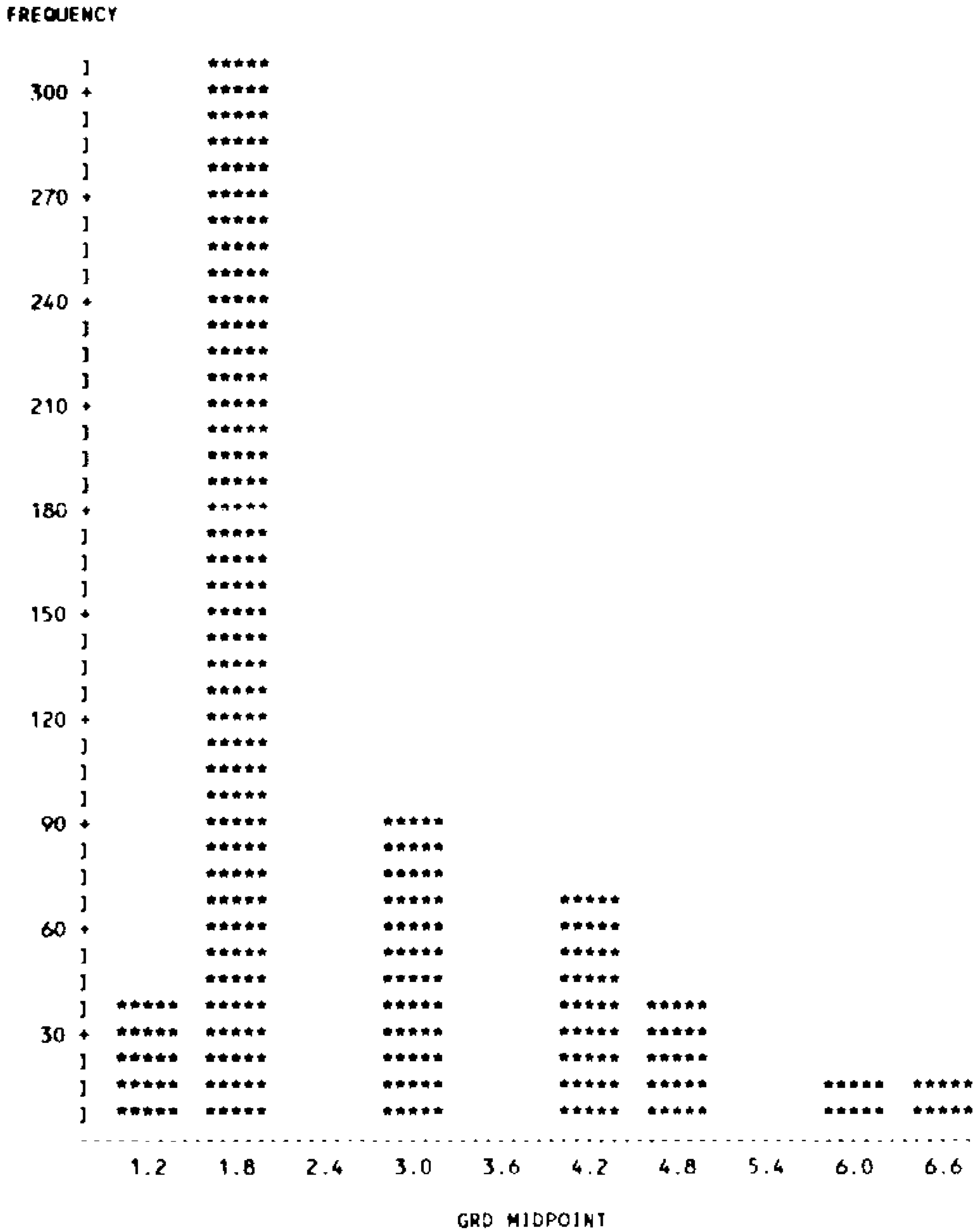
Appendix A Figure 20. Frequency Bar Chart for Peck Damage, Medium Grain Rough Rice, Louisiana, 1986.



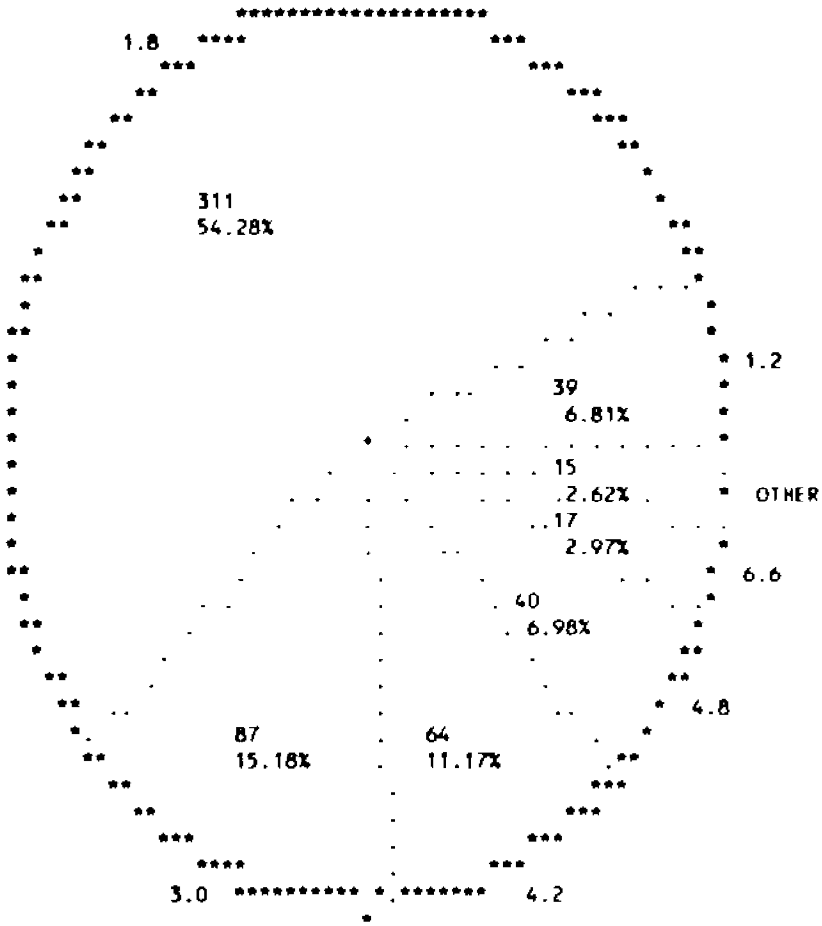
Appendix A Figure 21. Frequency Bar Chart for Smut Damage, Medium Grain Rough Rice, Louisiana, 1986.



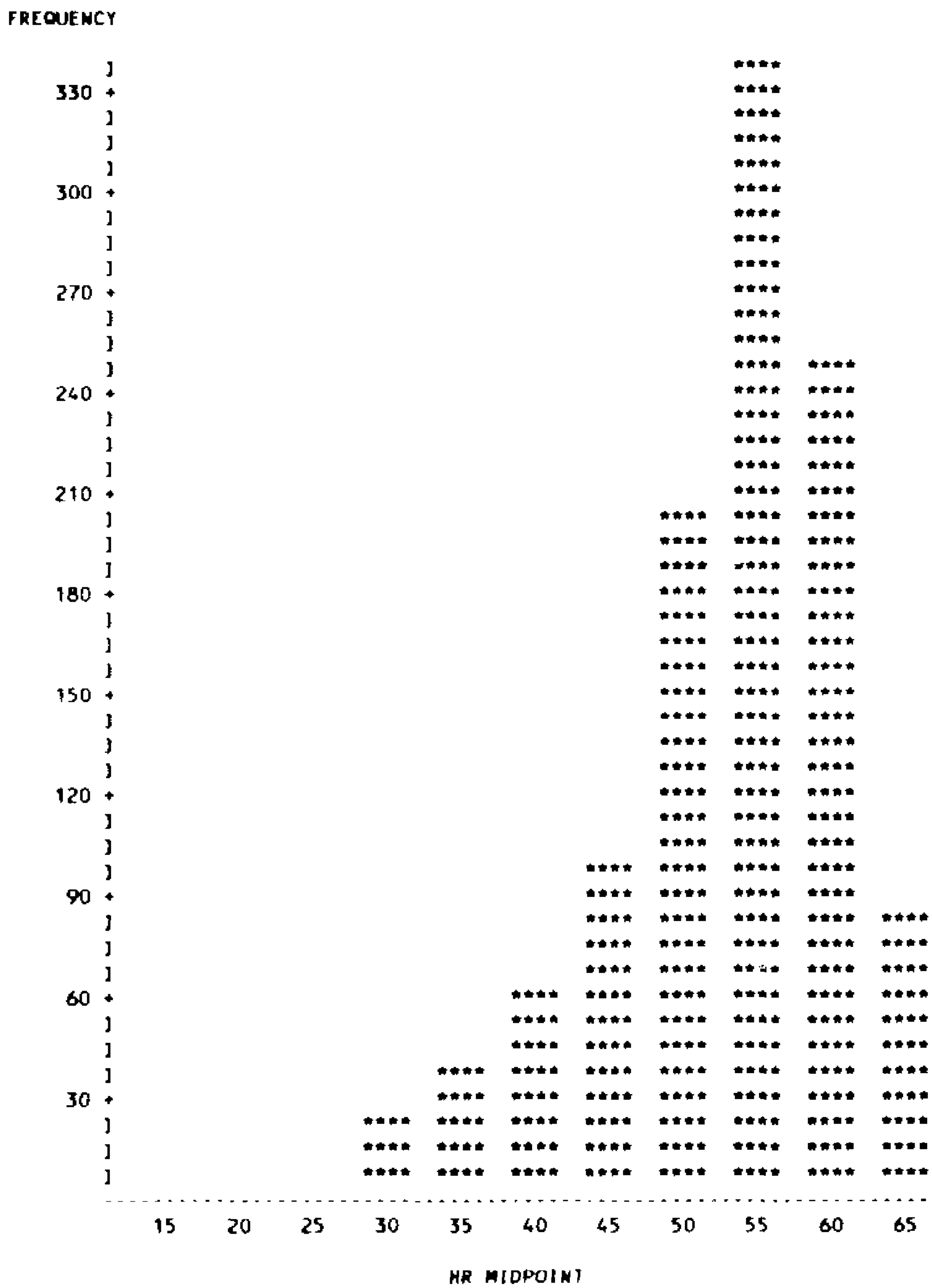
Appendix A Figure 22. Frequency Bar Chart for Chalk Damage, Medium Grain Rough Rice, Louisiana, 1986.



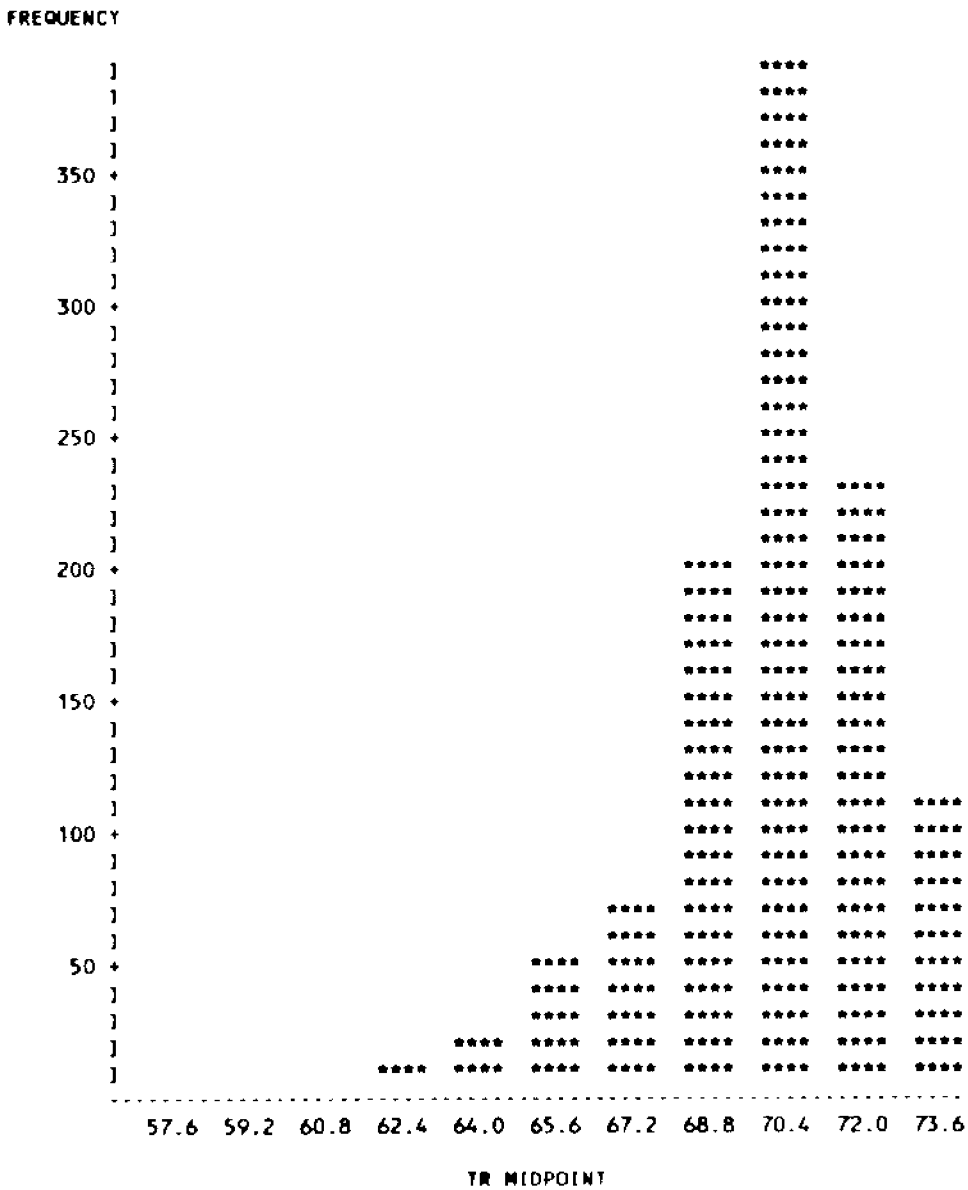
Appendix A Figure 23. Frequency Bar Chart for USDA Grades, Medium Grain Rough Rice, Louisiana, 1986.



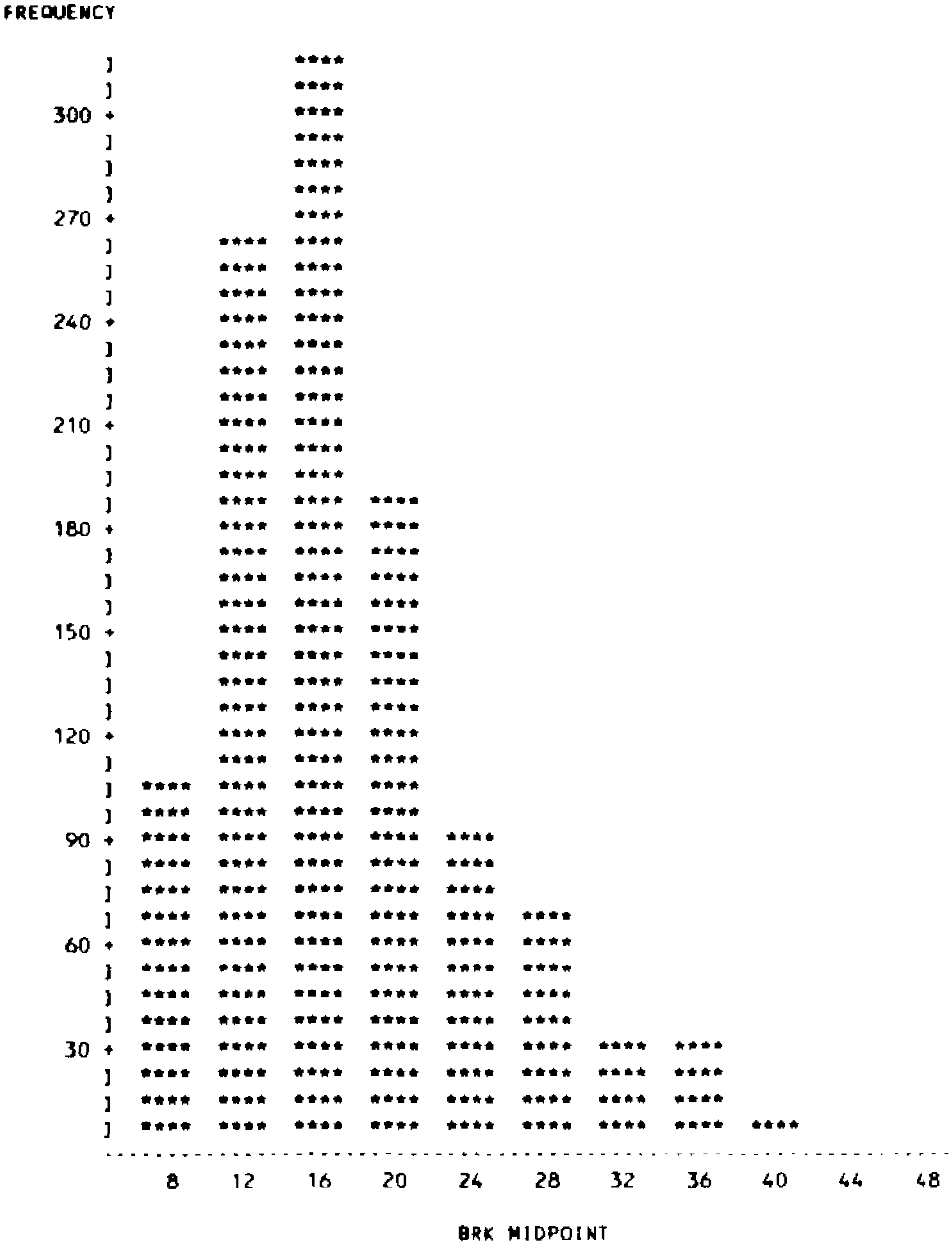
Appendix A Figure 24. Frequency Pie Chart for USDA Grades, Medium Grain Rough Rice, Louisiana, 1986.



Appendix A Figure 25. Frequency Bar Chart for Head Rice, Long Grain Rough Rice, Louisiana, 1987.



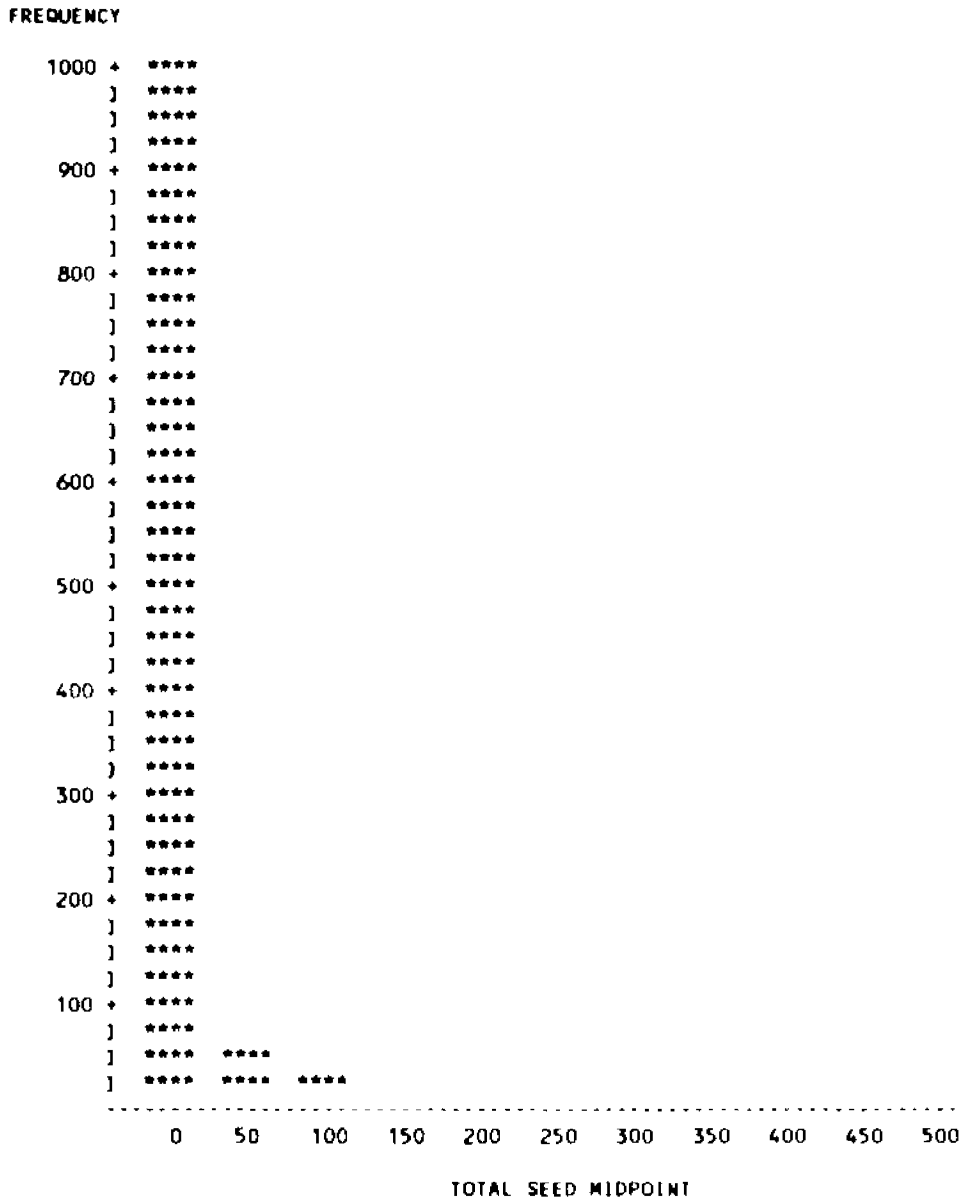
Appendix A Figure 26. Frequency Bar Chart for Total Rice, Long Grain Rough Rice, Louisiana, 1987.



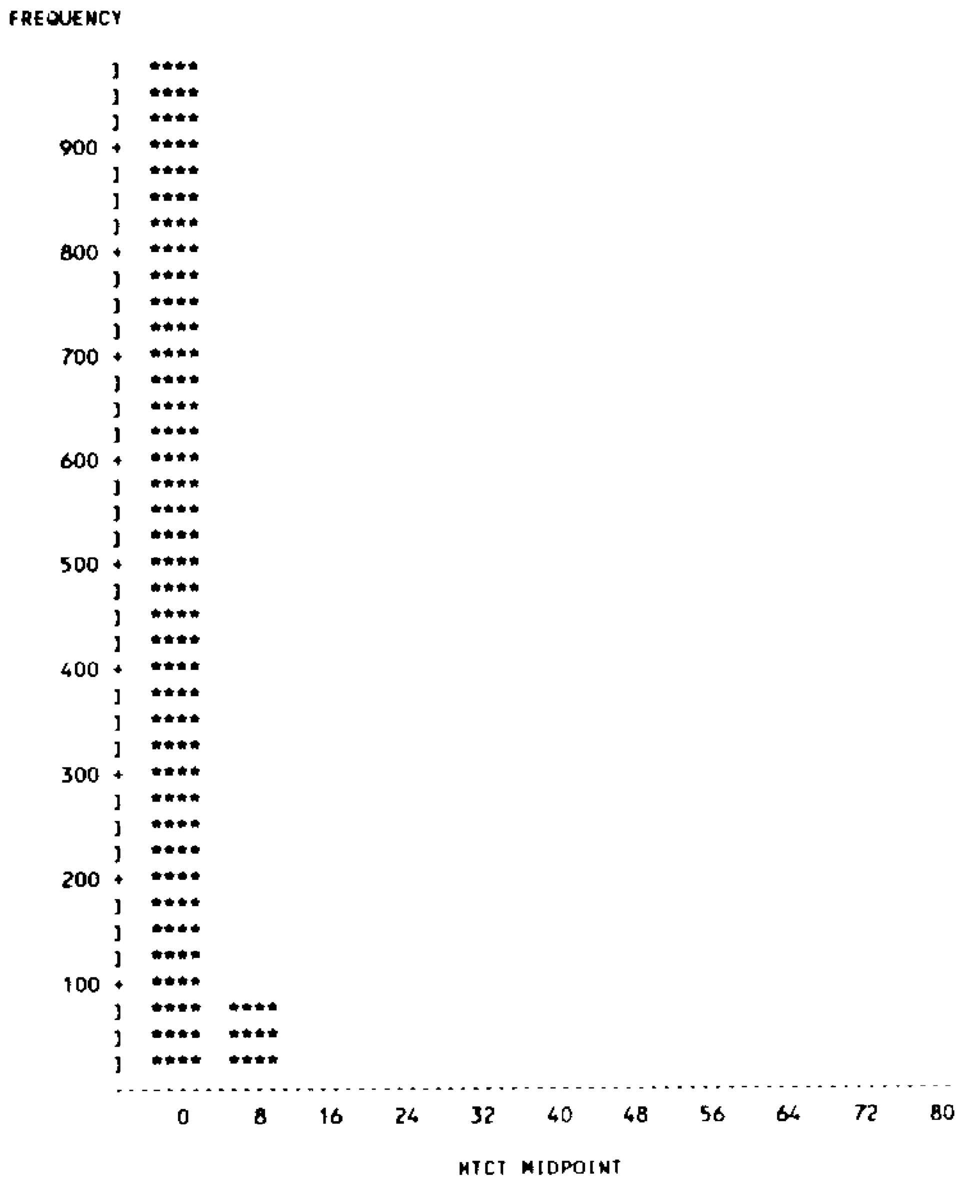
Appendix A Figure 27. Frequency Bar Chart for Broken Kernels, Long Grain Rough Rice, Louisiana, 1987.

```
FREQUENCY

      ]        ****
      ]        ****
  500 +        ****
      ]        ****
      ]        ****
      ]        ****
      ]        ****
  400 +        ****
      ]        ****
      ]        ****
      ]        ****
      ]        ****
  300 +  ****  ****
      ]  ****  ****
      ]  ****  ****
      ]  ****  ****
      ]  ****  ****
  200 +  ****  ****
      ]  ****  ****
      ]  ****  ****  ****
      ]  ****  ****  ****
      ]  ****  ****  ****
  100 +  ****  ****  ****
      ]  ****  ****  ****
      ]  ****  ****  ****  ****
      ]  ****  ****  ****  ****
      ]  ****  ****  ****  ****  ****
      ------------------------------------------------------------------
           0   2000  4000  6000  8000 10000 12000 14000 16000 18000 20000

                              LOT SIZE MIDPOINT
```

Appendix A Figure 28. Frequency Bar Chart for Lot Size, Long Grain Rough Rice, Louisiana, 1987.



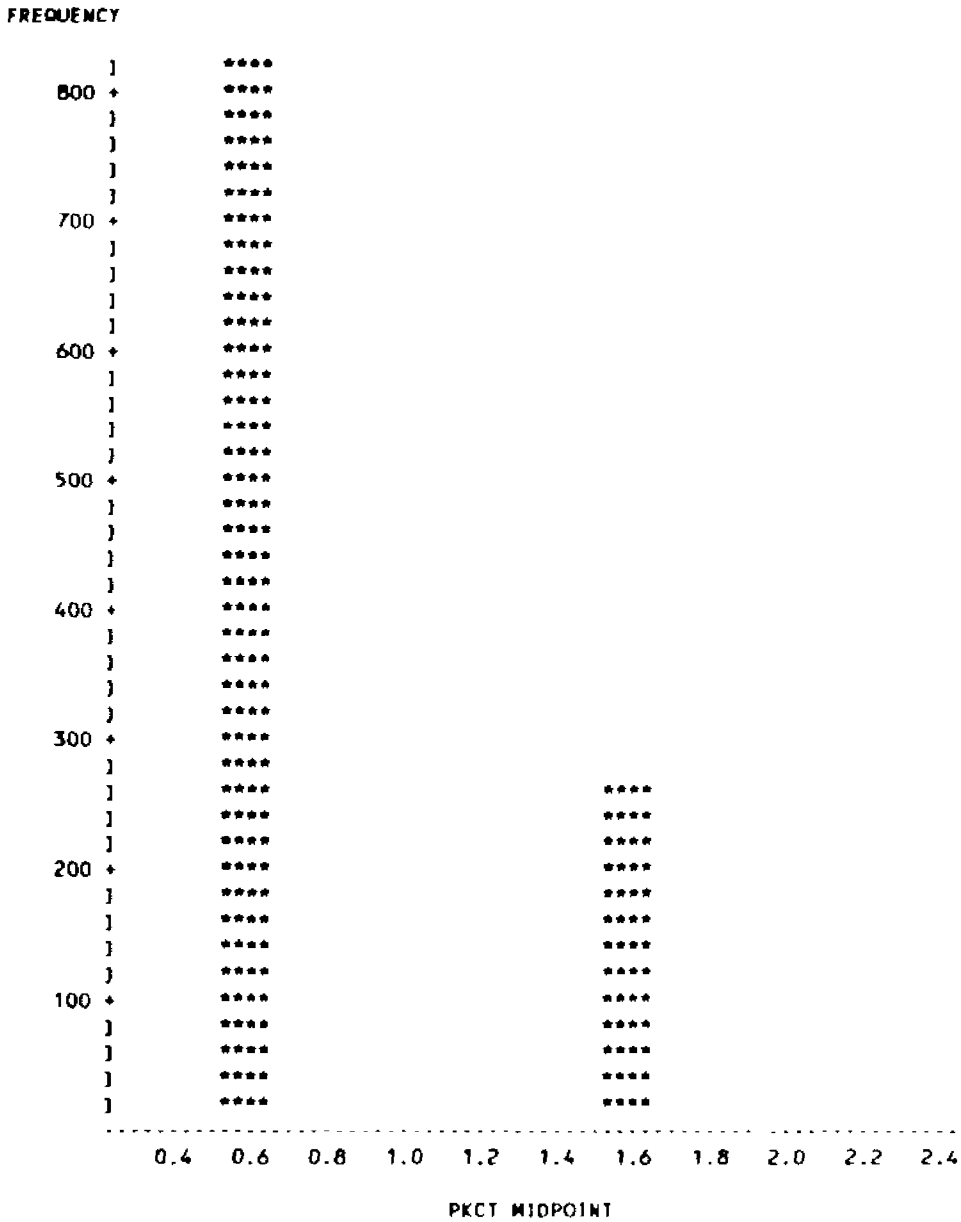
Appendix A Figure 29. Frequency Bar Chart for Total Seeds, Long Grain Rough Rice, Louisiana, 1987.



Appendix A Figure 30. Frequency Bar Chart for Heat Damage, Long Grain Rough Rice, Louisiana, 1987.

```
FREQUENCY

      ]  ****
      ]  ****
      ]  ****
      ]  ****
  500 +  ****
      ]  ****
      ]  ****
      ]  ****
      ]  ****   ****
  400 +  ****   ****
      ]  ****   ****
      ]  ****   ****
      ]  ****   ****
      ]  ****   ****
  300 +  ****   ****
      ]  ****   ****
      ]  ****   ****
      ]  ****   ****
      ]  ****   ****
  200 +  ****   ****
      ]  ****   ****
      ]  ****   ****
      ]  ****   ****
      ]  ****   ****
  100 +  ****   ****
      ]  ****   ****
      ]  ****   ****
      ]  ****   ****
      ]  ****   ****   ****   ****   ****
      ----------------------------------------------------------------------
          0.0    1.6    3.2    4.8    6.4    8.0    9.6   11.2   12.8   14.4   16.0

                                   RRCT MIDPOINT
```

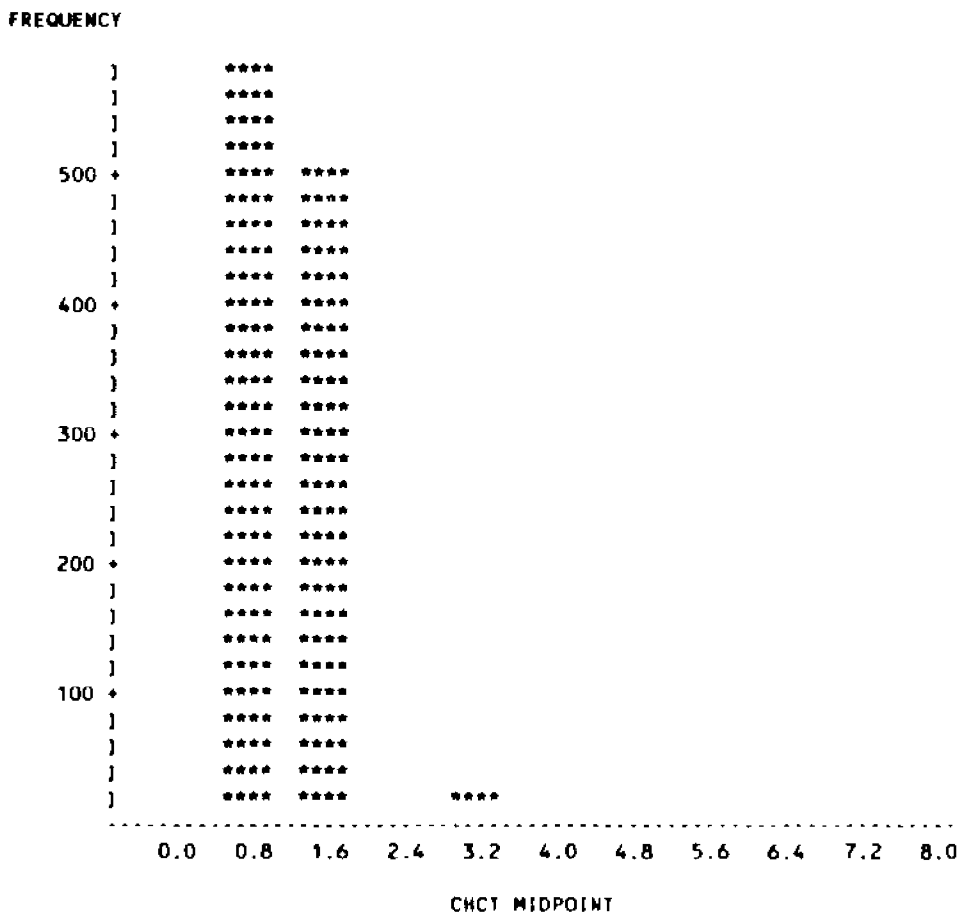
Appendix A Figure 31. Frequency Bar Chart for Red Rice, Long Grain Rough Rice, Louisiana, 1987.



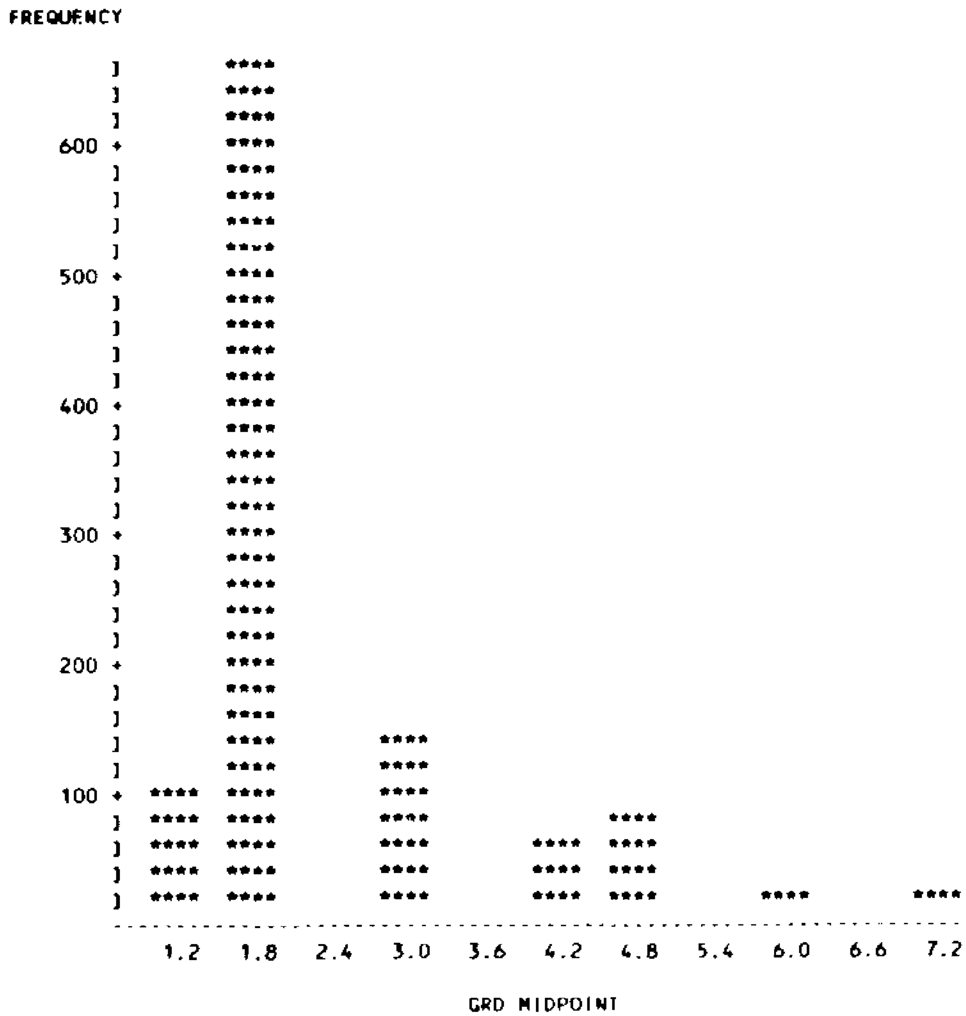
Appendix A Figure 32. Frequency Bar Chart for Peck Damage, Long Grain Rough Rice, Louisiana, 1987.

```
FREQUENCY

      ]  ****
      ]  ****
      ]  ****
 1000 +  ****
      ]  ****
      ]  ****
      ]  ****
  900 +  ****
      ]  ****
      ]  ****
      ]  ****
  800 +  ****
      ]  ****
      ]  ****
      ]  ****
  700 +  ****
      ]  ****
      ]  ****
      ]  ****
  600 +  ****
      ]  ****
      ]  ****
      ]  ****
  500 +  ****
      ]  ****
      ]  ****
      ]  ****
  400 +  ****
      ]  ****
      ]  ****
      ]  ****
  300 +  ****
      ]  ****
      ]  ****
      ]  ****
  200 +  ****
      ]  ****
      ]  ****
      ]  ****
  100 +  ****
      ]  ****
      ]  ****
      ]  ****
      --------------------------------------------------------------------
          0.6   0.9   1.2   1.5   1.8   2.1   2.4   2.7   3.0   3.3   3.6

                              SMCT MIDPOINT
```

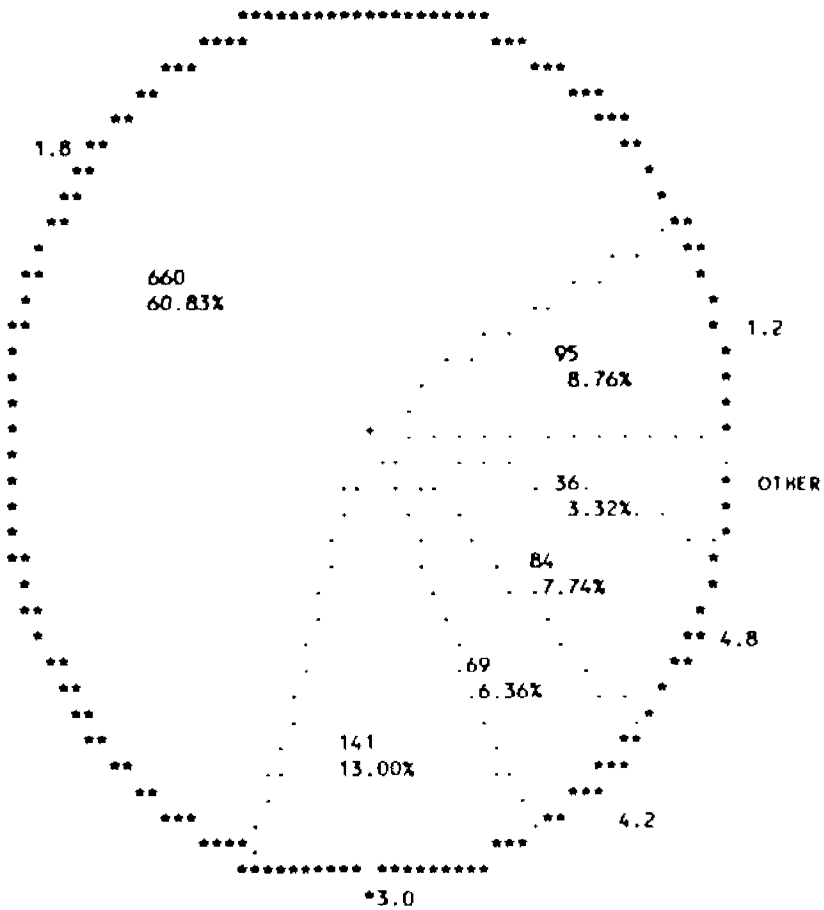
Appendix A Figure 33. Frequency Bar Chart for Smut Damage, Long Grain Rough Rice, Louisiana, 1987.



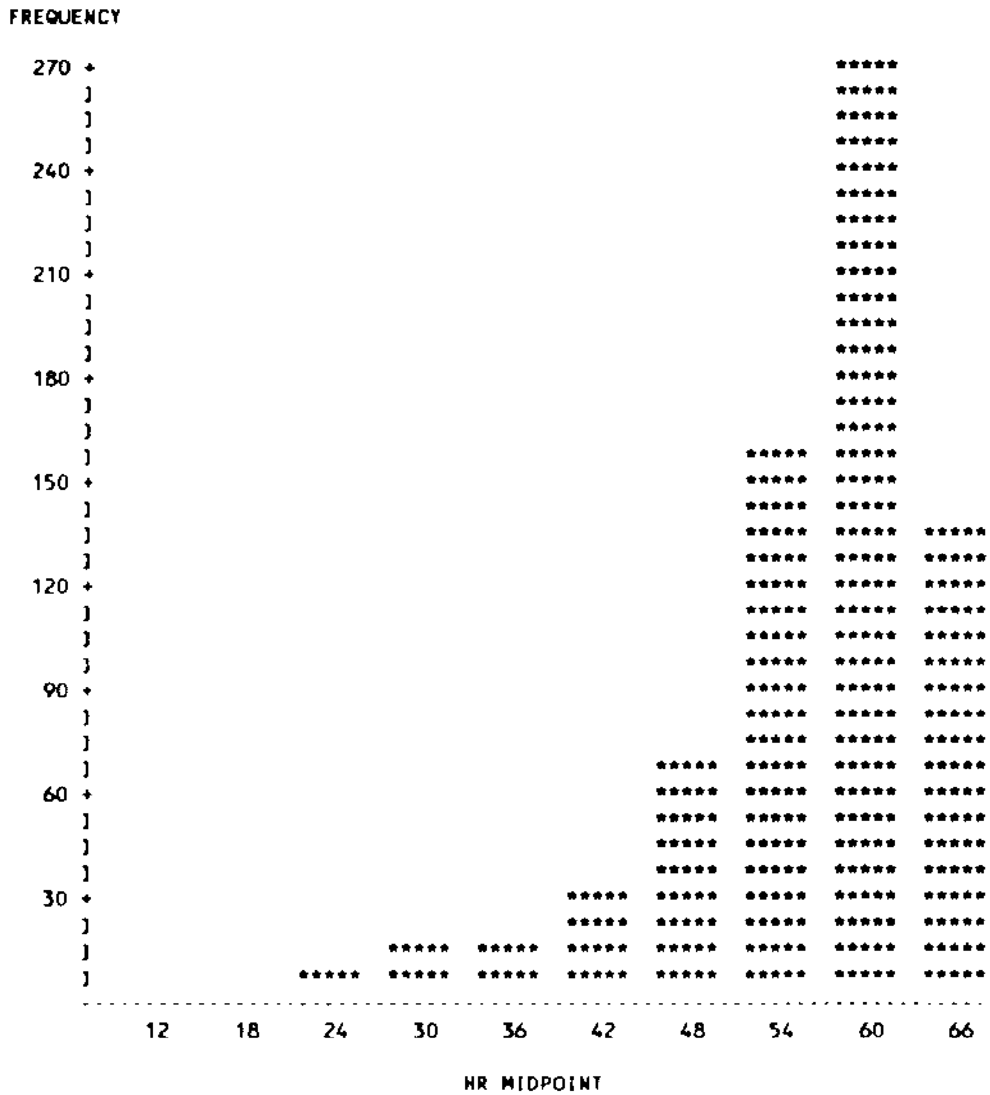
Appendix A Figure 34. Frequency Bar Chart for Chalk Damage, Long Grain Rough Rice, Louisiana, 1987.



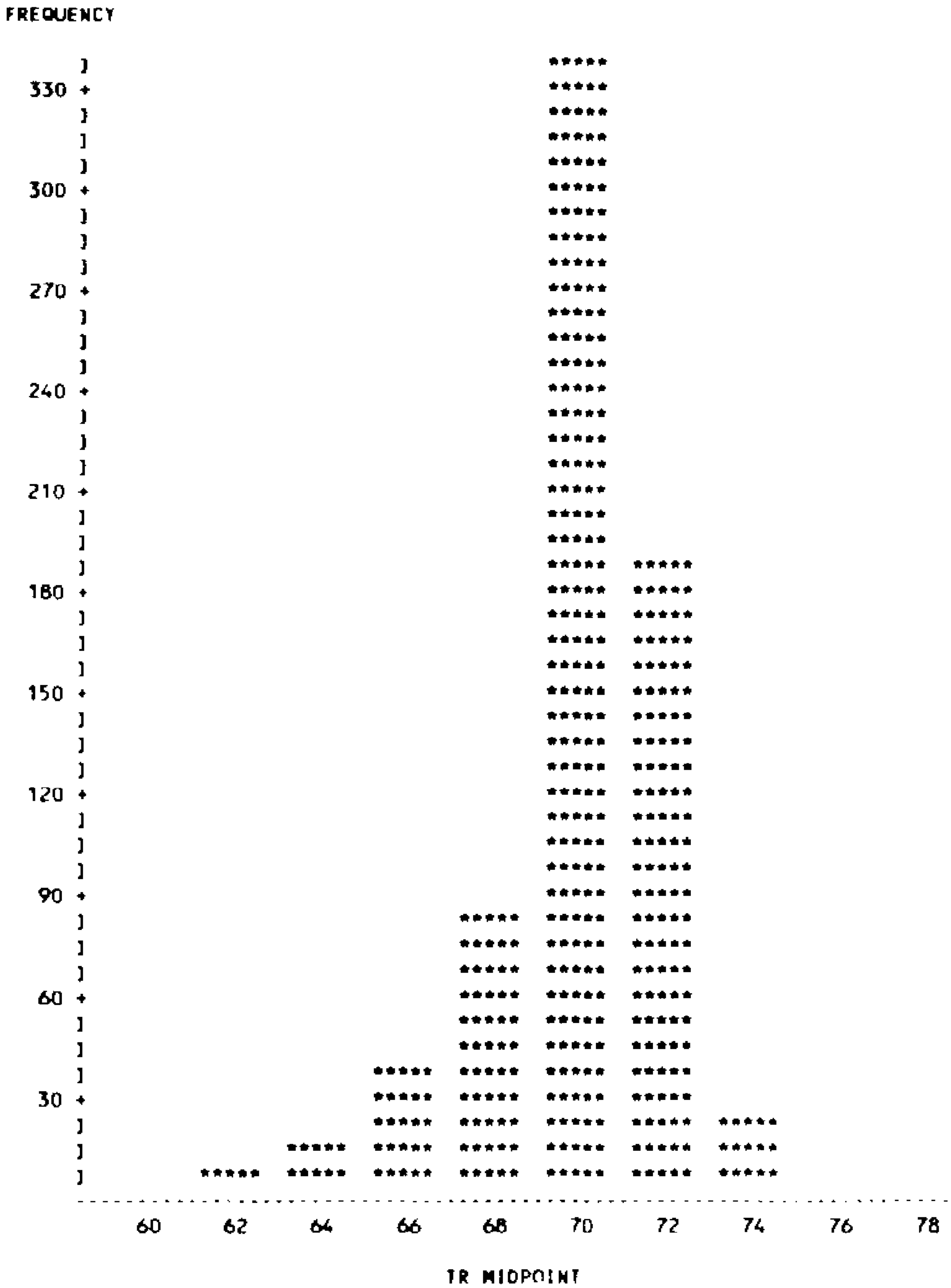
Appendix A Figure 35. Frequency Bar Chart for USDA Grades, Long Grain Rough Rice, Louisiana, 1987.



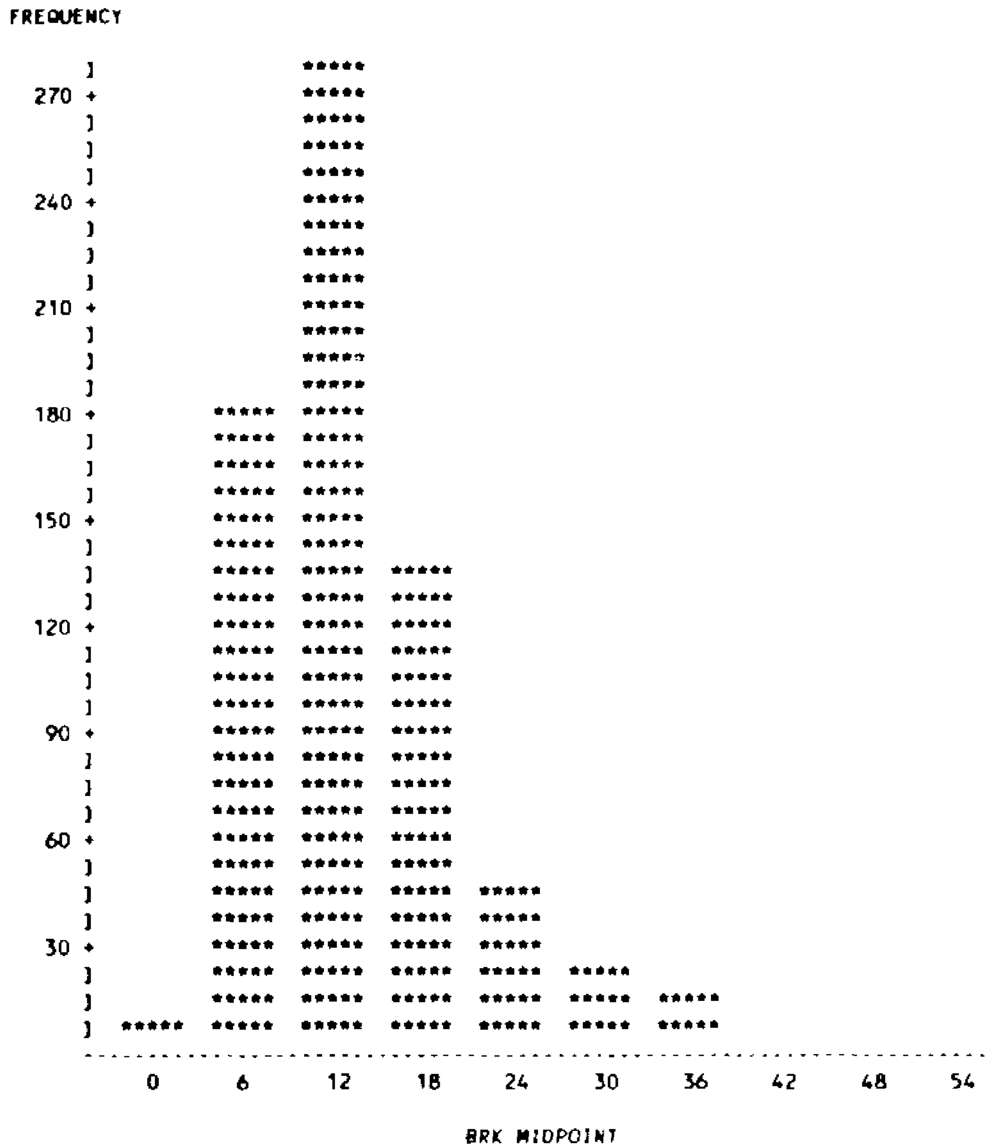
Appendix A Figure 36. Frequency Pie Chart for USDA Grades, Long Grain Rough Rice, Louisiana, 1987.



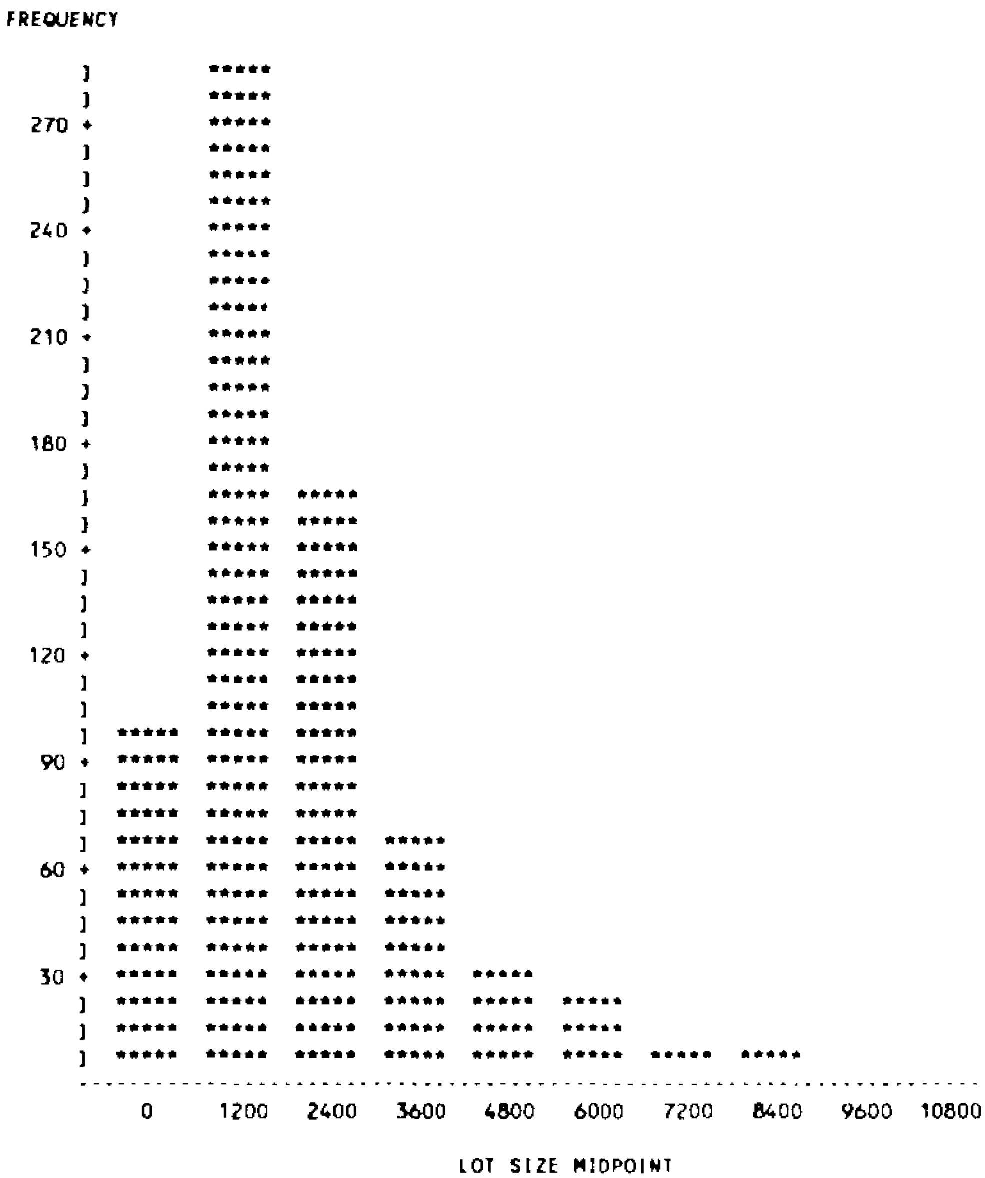
Appendix A Figure 37. Frequency Bar Chart for Head Rice, Medium Grain Rough Rice, Louisiana, 1987.



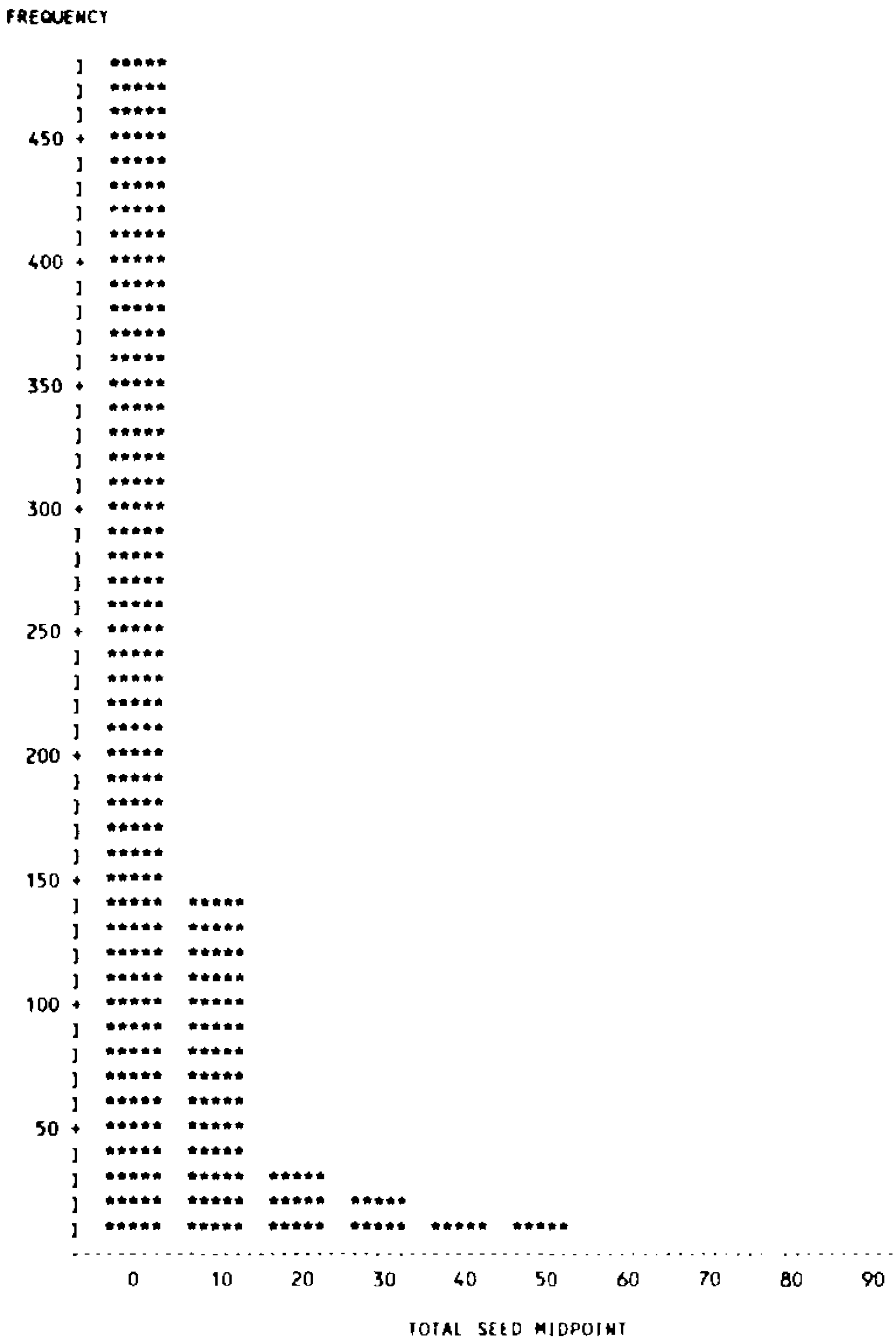
Appendix A Figure 38. Frequency Bar Chart for Total Rice, Medium Grain Rough Rice, Louisiana, 1987.



Appendix A Figure 39. Frequency Bar Chart for Broken Kernels, Medium Grain Rough Rice, Louisiana, 1987.



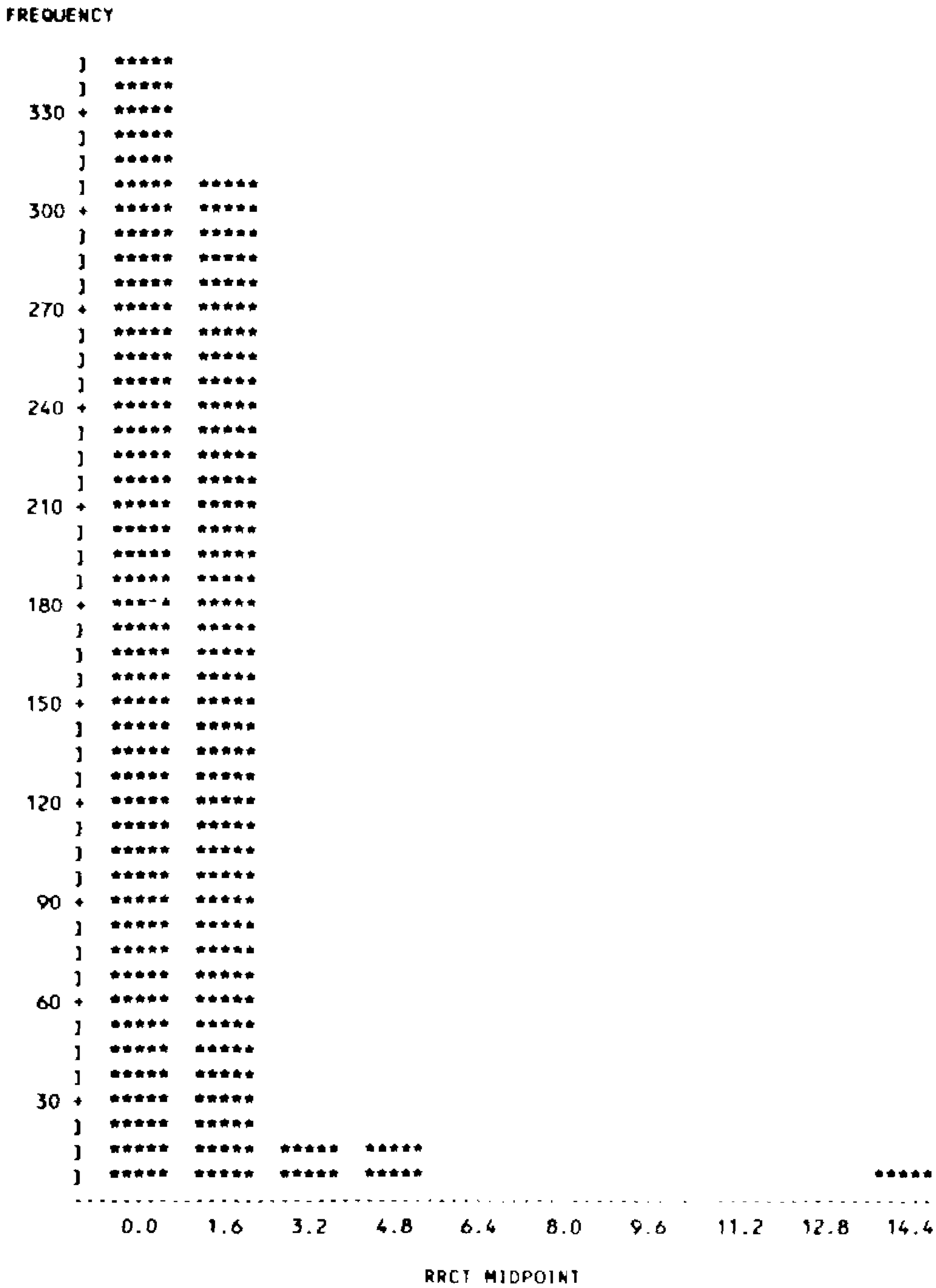
Appendix A Figure 40. Frequency Bar Chart for Lot Size, Medium Grain Rough Rice, Louisiana, 1987.



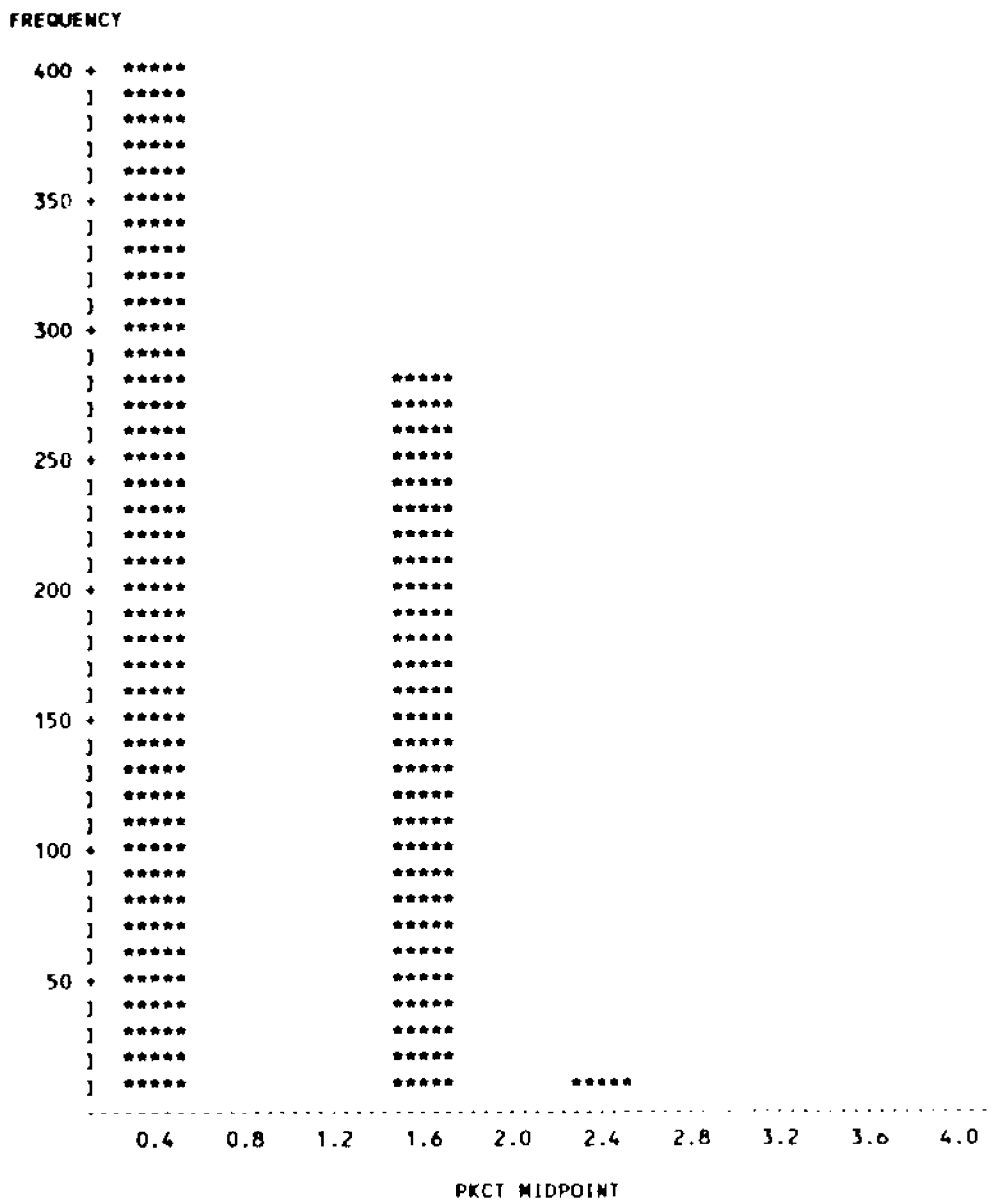
Appendix A Figure 41. Frequency Bar for Total Seed, Medium Grain Rough Rice, Louisiana, 1987.

```
FREQUENCY

    ]  *****
    ]  *****
    ]  *****
    ]  *****
500 +  *****
    ]  *****
    ]  *****
    ]  *****
    ]  *****
400 +  *****
    ]  *****
    ]  *****
    ]  *****
    ]  *****
300 +  *****
    ]  *****
    ]  *****
    ]  *****
    ]  *****
200 +  *****
    ]  *****
    ]  *****
    ]  *****
    ]  *****
100 +  *****  *****
    ]  *****  *****
    ]  *****  *****
    ]  *****  *****
    ]  *****  *****
    ----------------------------------------------------------------------------
        0      8      16     24     32     40     48     56     64     72

                                 HTCT MIDPOINT
```

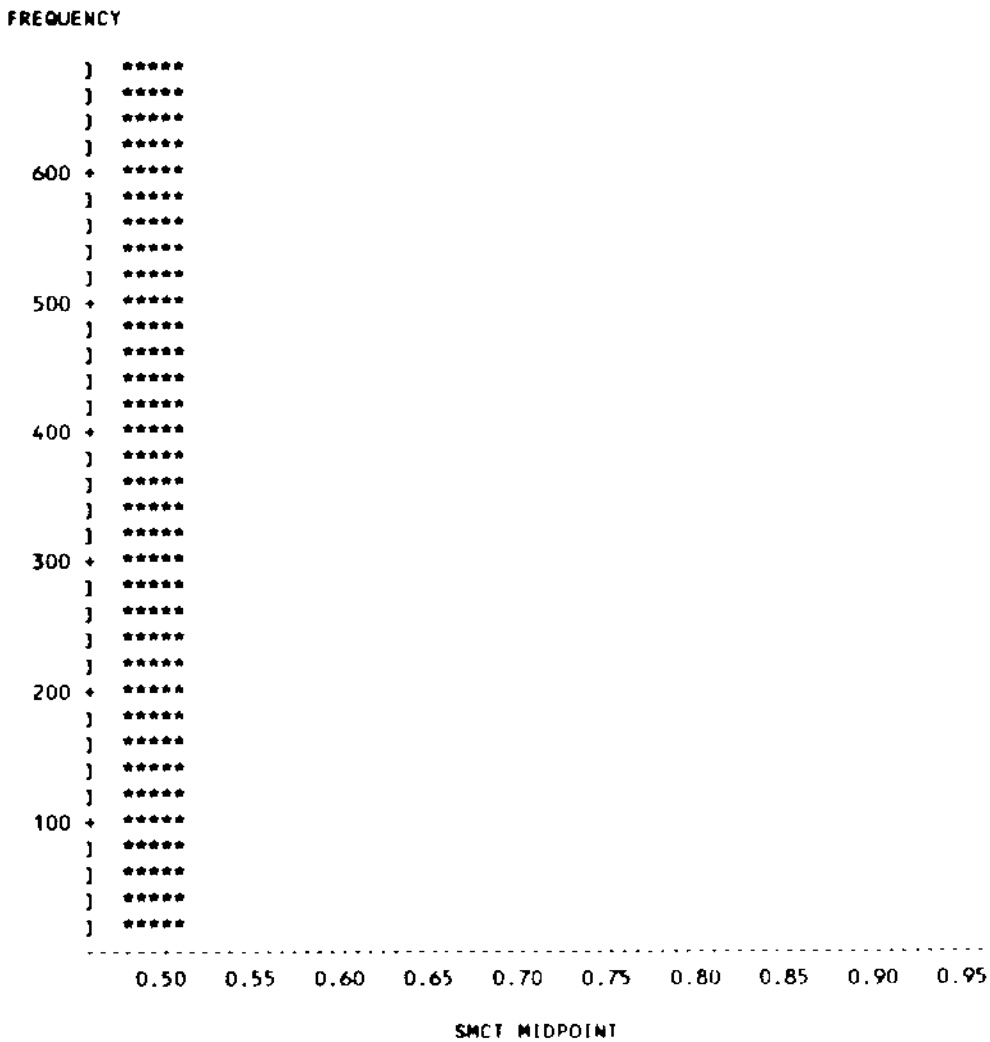
Appendix A Figure 42. Frequency Bar Chart for Heat Damage, Medium Grain Rough Rice, Louisiana, 1987.



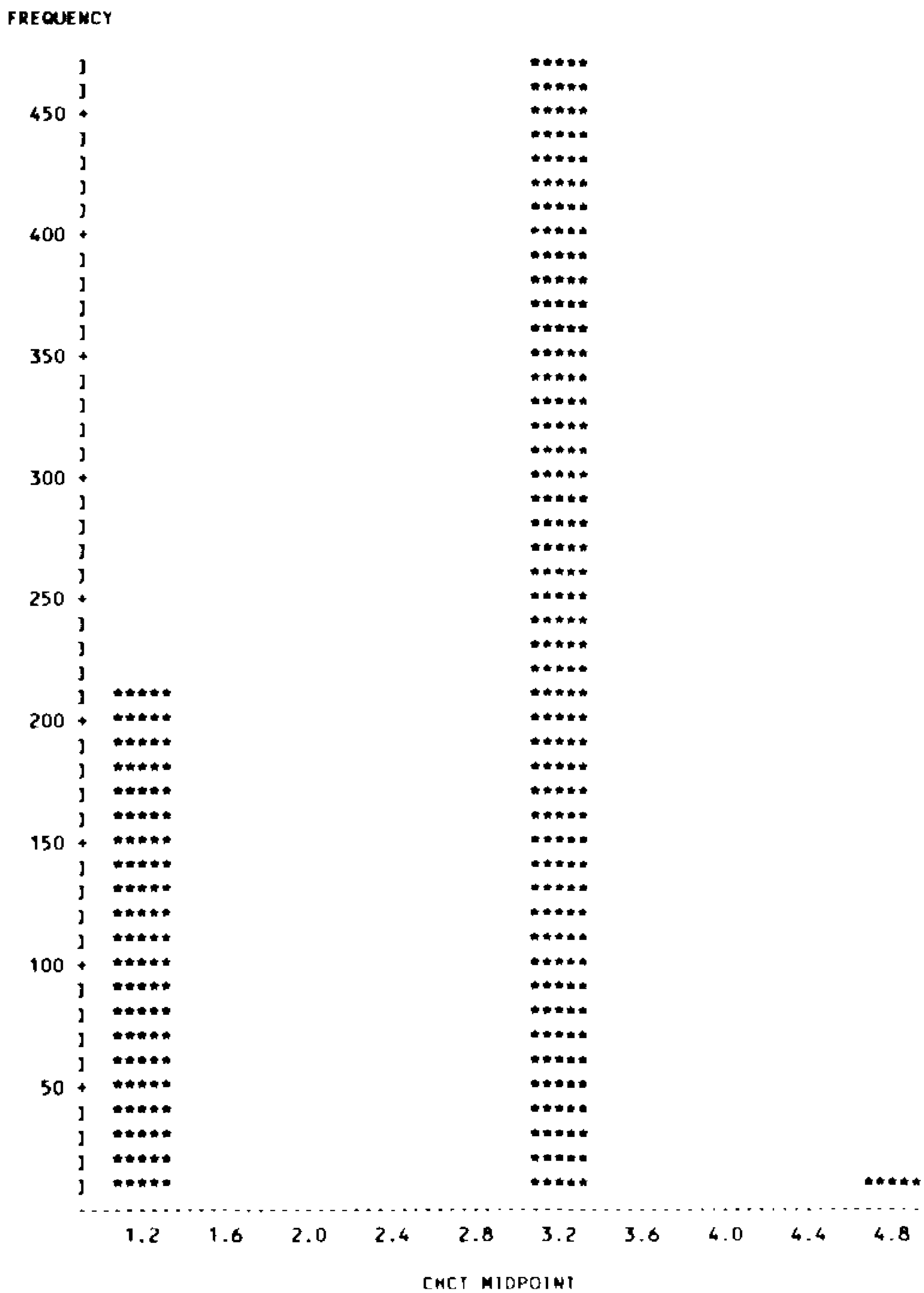
Appendix A Figure 43. Frequency Bar Chart for Red Rice, Medium Grain Rough Rice, Louisiana, 1987.



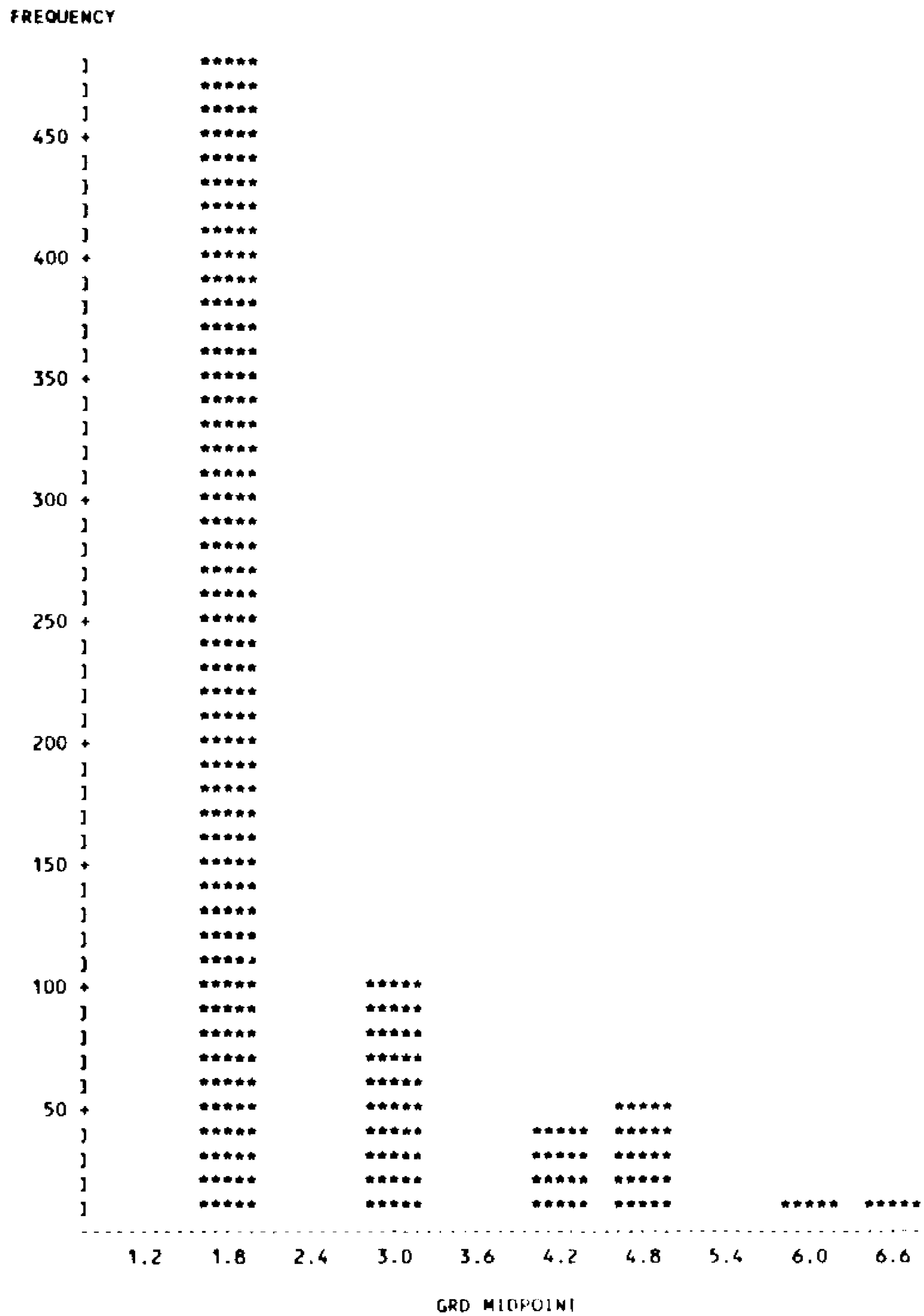
Appendix A Figure 44. Frequency Bar Chart for Peck Damage, Medium Grain Rough Rice, Louisiana, 1987.



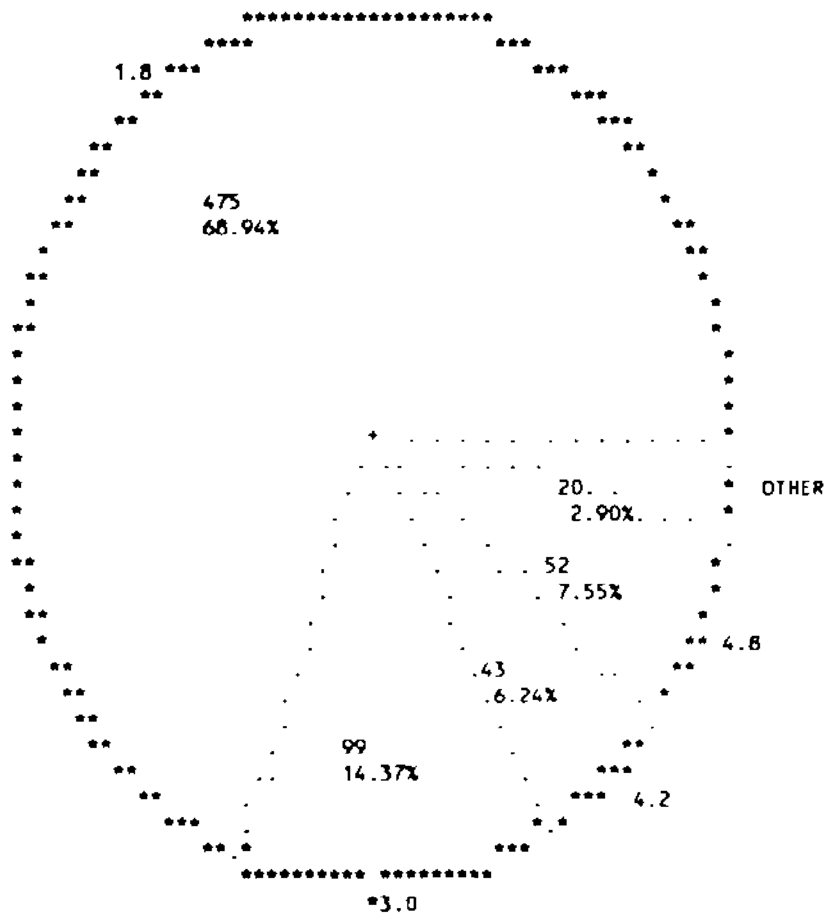
Appendix A Figure 45. Frequency Bar Chart for Smut Damage, Medium Grain Rough Rice, Louisiana, 1987.



Appendix A Figure 46. Frequency Bar Chart for Chalk Damage, Medium Grain Rough Rice, Louisiana, 1987.

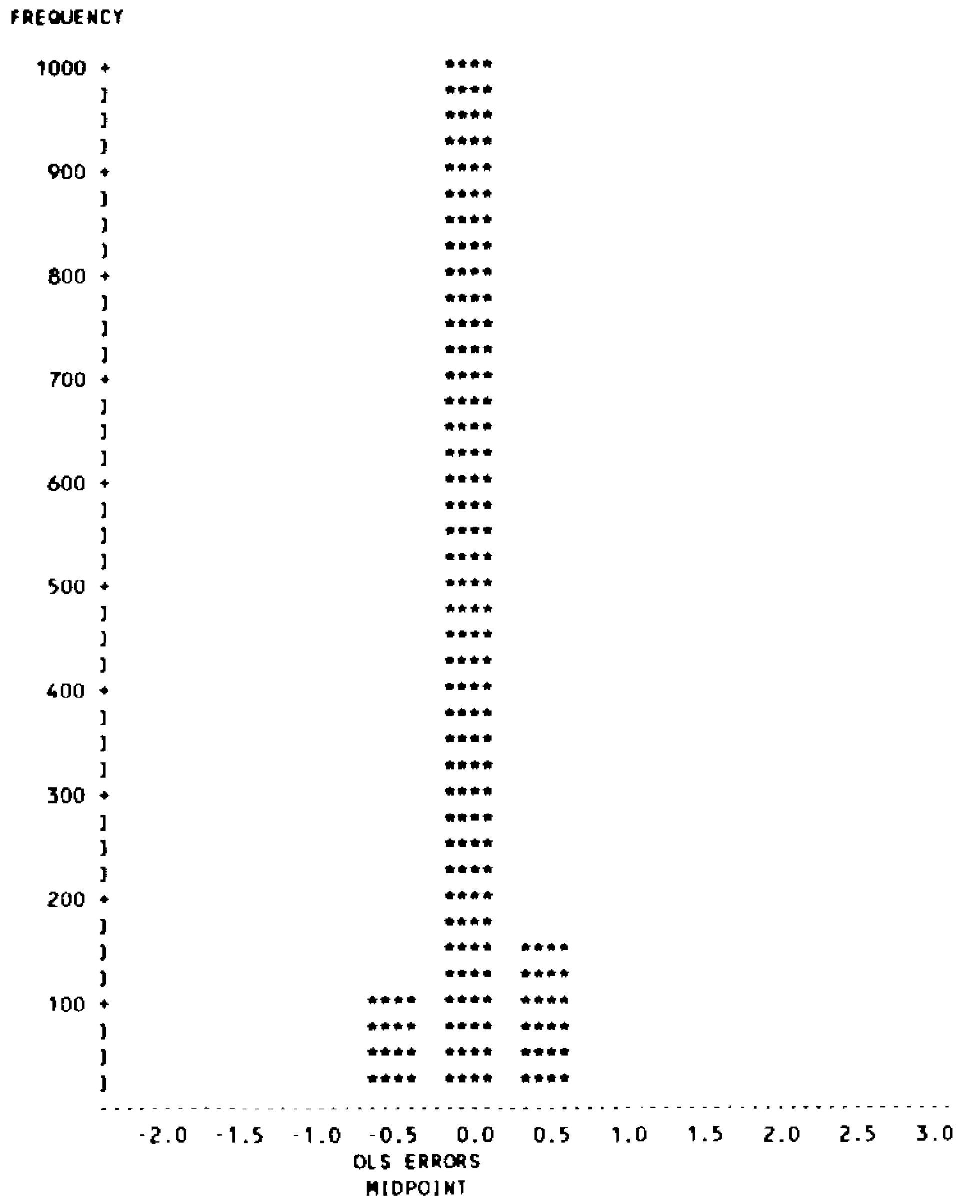


Appendix A Figure 47. Frequency Bar Chart for USDA Grades, Medium Grain Rough Rice, Louisiana, 1987.

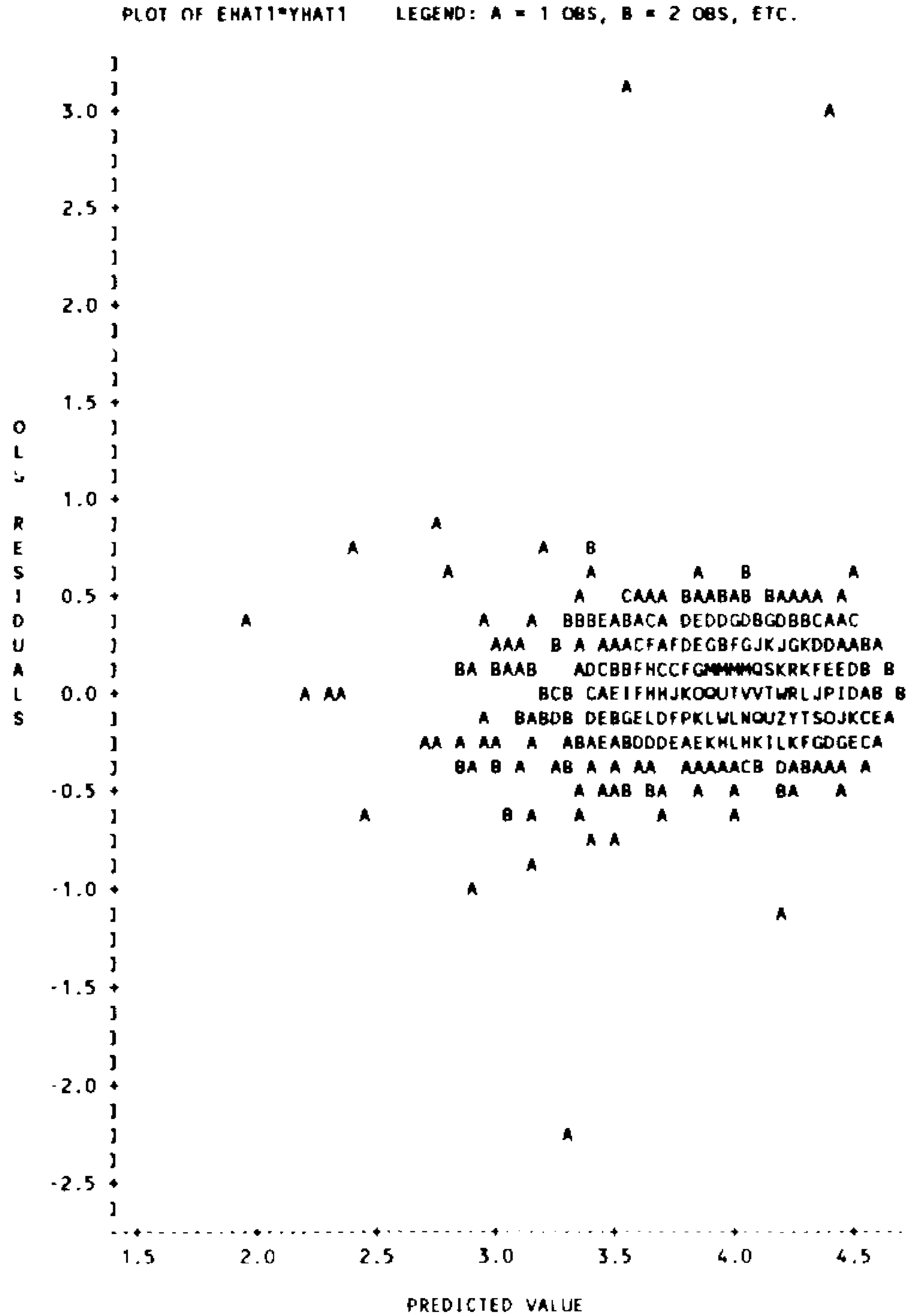


Appendix A Figure 48. Frequency Pie Chart for USDA Grades, Medium Grain rough Rice, Louisiana, 1987.

APPENDIX B
ERROR DIAGNOSTICS FOR THE HEDONIC MODELS



Appendix B Figure 1. Frequency Bar Chart of OLS Errors, Long Grain Rough Rice, 1986.



Appendix B Figure 2. Plot of OLS Errors Against Predicted Values of Bid Price, Long Grain Rough Rice, 1986.

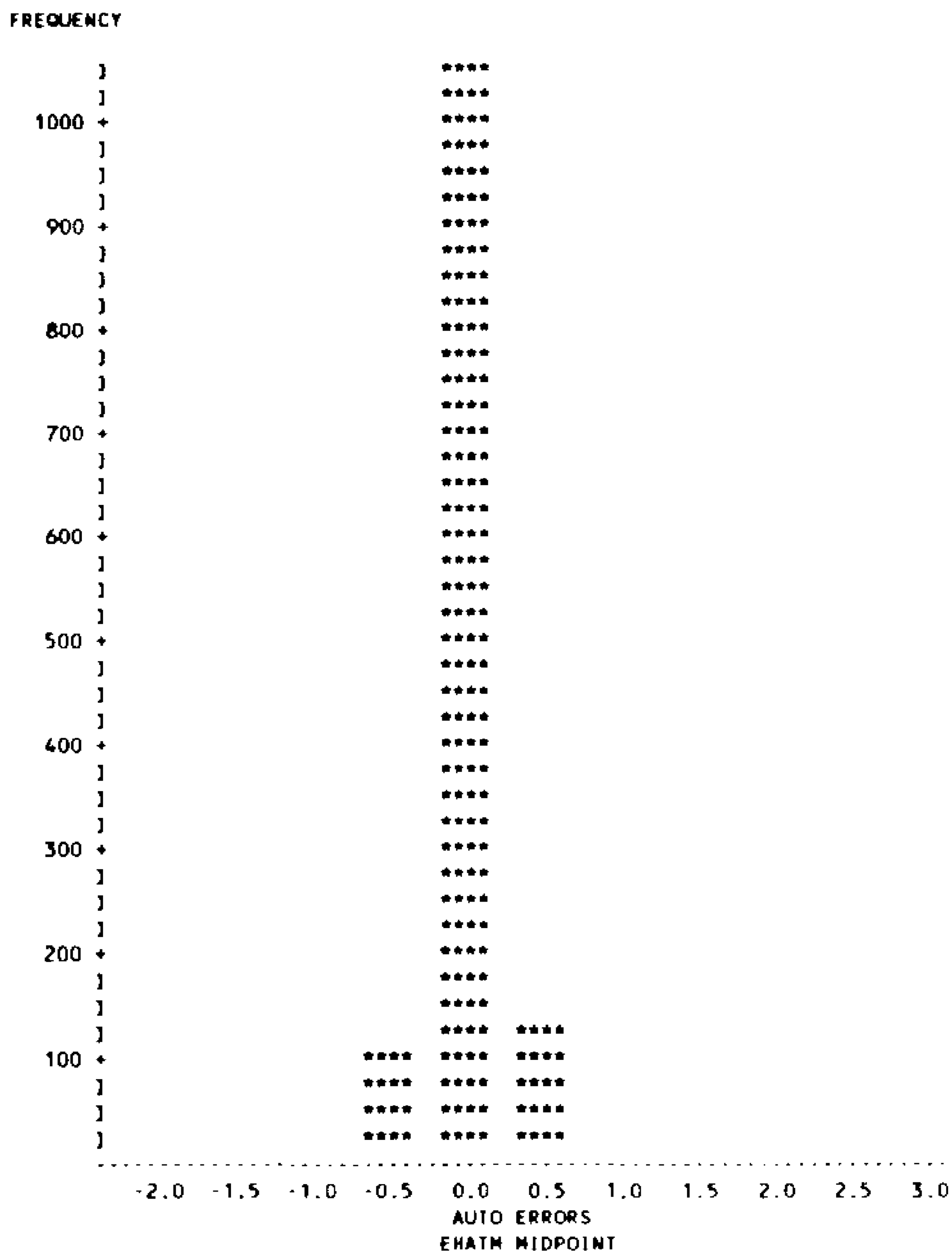
```
                        ARIMA PROCEDURE
                          OLS ERRORS
                   NAME OF VARIABLE        =      EHAT1
                   MEAN OF WORKING SERIES= 1.302E-13
                   STANDARD DEVIATION      =  0.257137
                   NUMBER OF OBSERVATIONS=       1278

                       AUTOCORRELATIONS
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0  0.0661197     1.00000  ]                    ]********************]
  1  0.0193656     0.29289  ]                   .]******              ]
  2  0.0175883     0.26601  ]                   .]*****               ]
  3  0.0138836     0.20998  ]                   .]****                ]
  4  0.0133143     0.20137  ]                   .]****                ]
  5  0.0101254     0.15314  ]                   .]***                 ]
  6 0.00972384     0.14706  ]                   .]***                 ]
  7  0.0123395     0.18662  ]                   .]****                ]
  8 0.00988185     0.14945  ]                   .]***                 ]
  9 0.00784757     0.11869  ]                   .]**                  ]
 10 0.00927838     0.14033  ]                   .]***                 ]
 11 0.00802012     0.12130  ]                   .]**                  ]
 12 0.00428786     0.06485  ]                   .]*                   ]
 13 0.00470345     0.07114  ]                   .]*                   ]
 14 0.00658707     0.09962  ]                  . ]**                  ]
 15 0.00375161     0.05674  ]                  . ]*.                  ]
 16 0.00669323     0.10123  ]                  . ]**                  ]
 17 0.00406793     0.06152  ]                  . ]*.                  ]
 18 0.00321236     0.04858  ]                  . ]*.                  ]
 19  0.0044957     0.06799  ]                  . ]*.                  ]
 20  0.0043843     0.06631  ]                  . ]*.                  ]
 21 0.00367315     0.05555  ]                  . ]*.                  ]
 22 0.00355133     0.05371  ]                  . ]*.                  ]
 23  0.0065908     0.09968  ]                  . ]**                  ]
 24 0.00419486     0.06344  ]                  . ]*.                  ]
                           '.' MARKS TWO STANDARD ERRORS

                     PARTIAL AUTOCORRELATIONS
           LAG CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
             1     0.29289  ]                   .]******              ]
             2     0.19714  ]                   .]****                ]
             3     0.10207  ]                   .]**                  ]
             4     0.09231  ]                   .]**                  ]
             5     0.03460  ]                   .]*                   ]
             6     0.04190  ]                   .]*                   ]
             7     0.09705  ]                   .]**                  ]
             8     0.03477  ]                   .]*                   ]
             9     0.00280  ]                   .].                   ]
            10     0.04633  ]                   .]*                   ]
            11     0.01938  ]                   .].                   ]
            12    -0.03908  ]                   *].                   ]
            13    -0.00202  ]                   .].                   ]
            14     0.03792  ]                   .]*                   ]
            15    -0.01909  ]                   .].                   ]
            16     0.05234  ]                   .]*                   ]
            17    -0.01251  ]                   .].                   ]
            18    -0.02190  ]                   .].                   ]
            19     0.03161  ]                   .]*                   ]
            20     0.01787  ]                   .].                   ]
            21    -0.00261  ]                   .].                   ]
            22     0.01096  ]                   .].                   ]
            23     0.05993  ]                   .]*                   ]
            24    -0.00523  ]                   .].                   ]
```

Appendix B Figure 3. Autocorrelations, Partial Correlations and Check for White Noise, OLS Errors, Long Grain Rough Rice, 1986. (Continued)

AUTOCORRELATION CHECK FOR WHITE NOISE

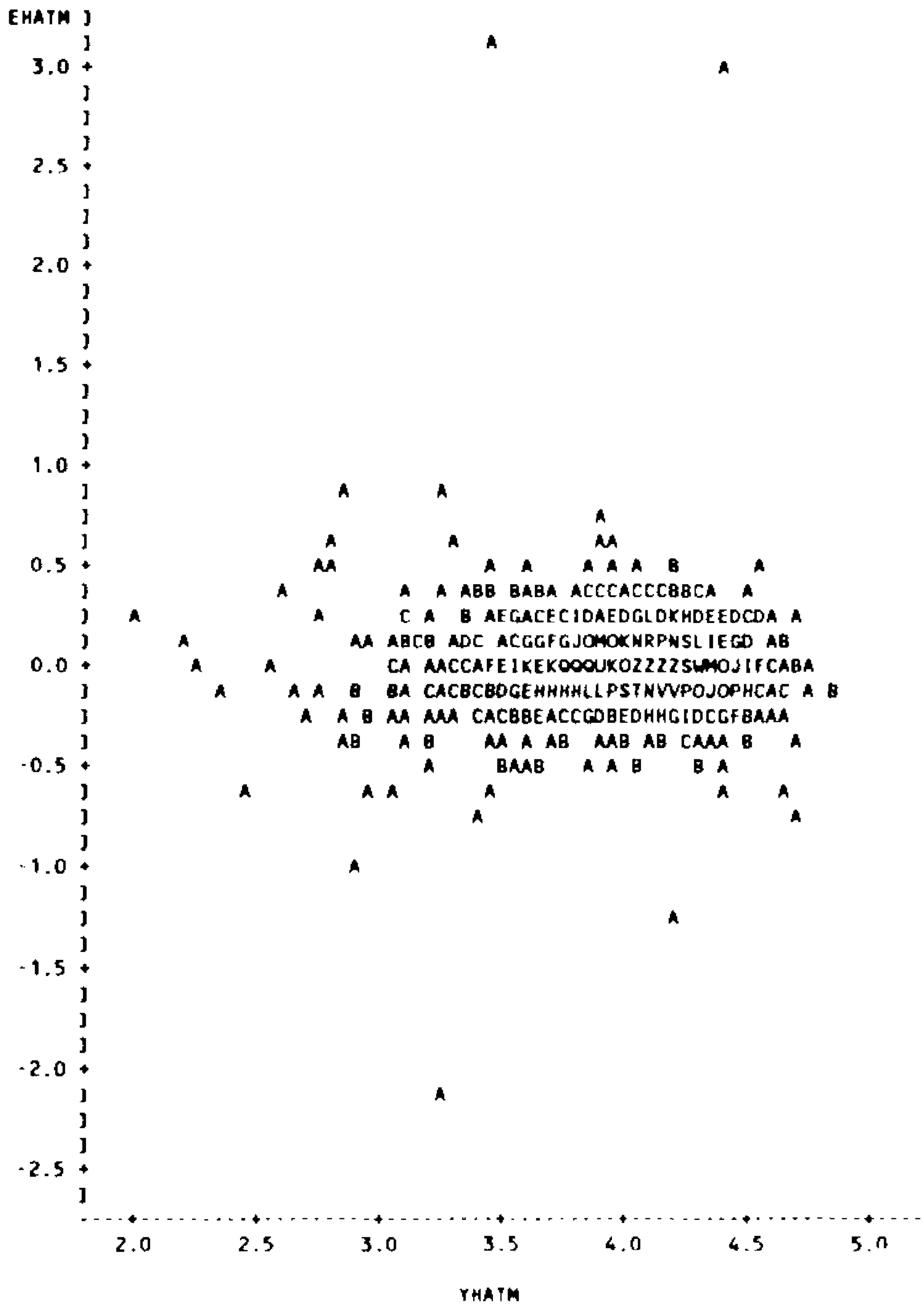
TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	367.19	6	0.000	0.293	0.266	0.210	0.201	0.153	0.147
12	508.78	12	0.000	0.187	0.149	0.119	0.140	0.121	0.065
18	553.59	18	0.000	0.071	0.100	0.057	0.101	0.062	0.049
24	591.29	24	0.000	0.068	0.066	0.056	0.054	0.100	0.063

Appendix B Figure 3. (Continued).



Appendix B Figure 4. Frequency Bar Chart of Autoregressive Errors, Long Grain Rough Rice, 1986.

PLOT OF EHATM*YHATM   LEGEND: A = 1 OBS, B = 2 OBS, ETC.



NOTE: 29 OBS HIDDEN

Appendix B Figure 5. Plot of Autoregressive Errors Against Predicted Values of Bid Price, Long Grain Rough Rice, 1986.

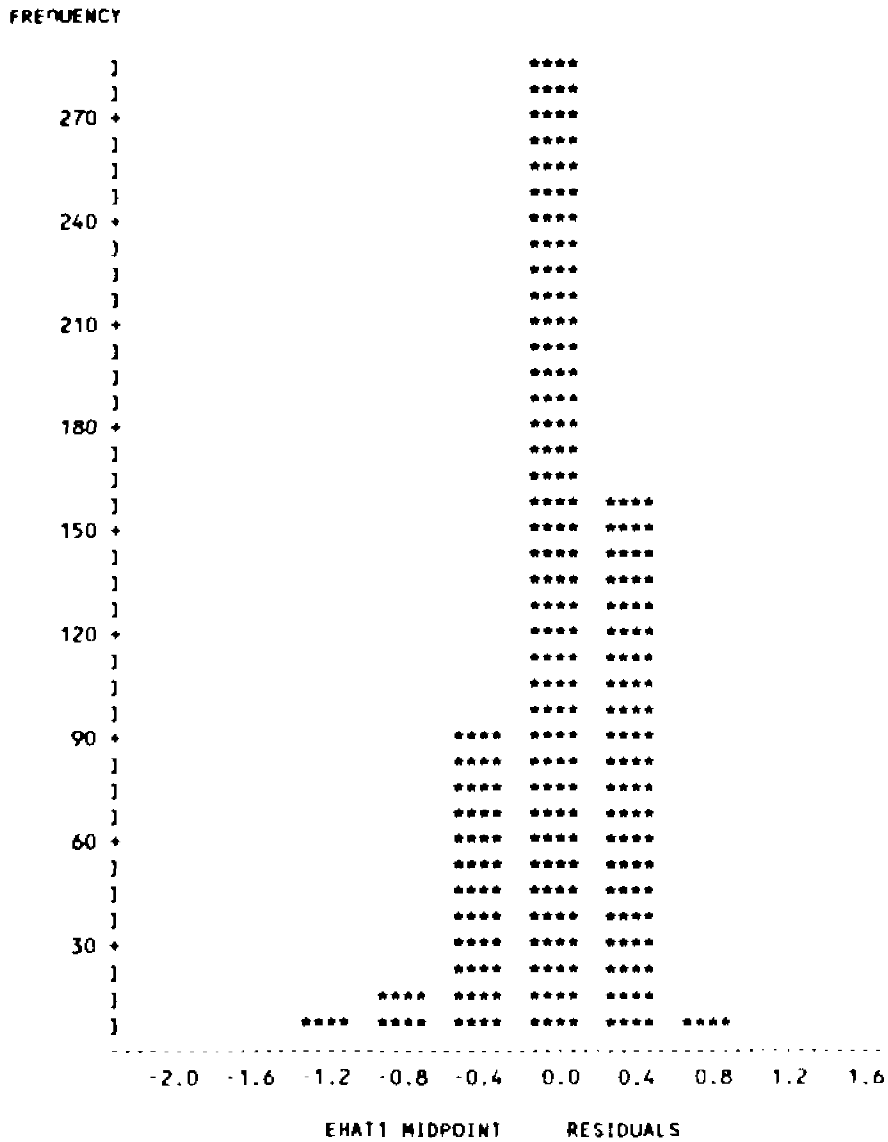
```
                         ARIMA PROCEDURE

                 NAME OF VARIABLE        =      EHATM
                 MEAN OF WORKING SERIES=.000093889
                 STANDARD DEVIATION      =  0.236582
                 NUMBER OF OBSERVATIONS=       1278

                        AUTOCORRELATIONS
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0  0.0559708     1.00000  ]                   ]********************]
  1 -.00023885    -0.00427  ]                  .].                   ]
  2 -3.255E-05    -0.00058  ]                  .].                   ]
  3 -.00033881    -0.00605  ]                  .].                   ]
  4 -0.0005035    -0.00900  ]                  .].                   ]
  5 .000485894     0.00868  ]                  .].                   ]
  6 .000845105     0.01510  ]                  .].                   ]
  7 -.00089618    -0.01601  ]                  .].                   ]
  8 0.00182553     0.03262  ]                  .]*                   ]
  9 -.00029705    -0.00531  ]                  .].                   ]
 10 0.00310581     0.05549  ]                  .]*                   ]
 11 0.00221509     0.03958  ]                  .]*                   ]
 12 -.00186454    -0.03331  ]                  *].                   ]
 13  -0.000181    -0.00323  ]                  .].                   ]
 14 0.00211396     0.03777  ]                  .]*                   ]
 15 -.00090637    -0.01619  ]                  .].                   ]
 16 0.00262305     0.04686  ]                  .]*                   ]
 17 -0.0001635    -0.00292  ]                  .].                   ]
 18 -.00103437    -0.01848  ]                  .].                   ]
 19 0.00157678     0.02817  ]                  .]*                   ]
 20 .000925429     0.01653  ]                  .].                   ]
 21 -0.0002822    -0.00504  ]                  .].                   ]
 22 .000122668     0.00219  ]                  .].                   ]
 23 0.00324109     0.05791  ]                  .]*                   ]
 24 0.00104619     0.01869  ]                  .].                   ]
                            '.' MARKS TWO STANDARD ERRORS

                      PARTIAL AUTOCORRELATIONS
           LAG CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
             1    -0.00427  ]                  .].                   ]
             2    -0.00060  ]                  .].                   ]
             3    -0.00606  ]                  .].                   ]
             4    -0.00905  ]                  .].                   ]
             5     0.00860  ]                  .].                   ]
             6     0.01513  ]                  .].                   ]
             7    -0.01599  ]                  .].                   ]
             8     0.03254  ]                  .]*                   ]
             9    -0.00474  ]                  .].                   ]
            10     0.05559  ]                  .]*                   ]
            11     0.03999  ]                  .]*                   ]
            12    -0.03242  ]                  *].                   ]
            13    -0.00289  ]                  .].                   ]
            14     0.03828  ]                  .]*                   ]
            15    -0.01550  ]                  .].                   ]
            16     0.04298  ]                  .]*                   ]
            17    -0.00076  ]                  .].                   ]
            18    -0.01964  ]                  .].                   ]
            19     0.02531  ]                  .]*                   ]
            20     0.01607  ]                  .].                   ]
            21    -0.00908  ]                  .].                   ]
            22     0.00037  ]                  .].                   ]
            23     0.06530  ]                  .]*                   ]
```

Appendix B Figure 6. Autocorrelations, Partial Correlations and Check for White Noise, Autoregressive Errors,Long Grain Rough Rice, 1986. (Continued)

AUTOCORRELATION CHECK FOR WHITE NOISE

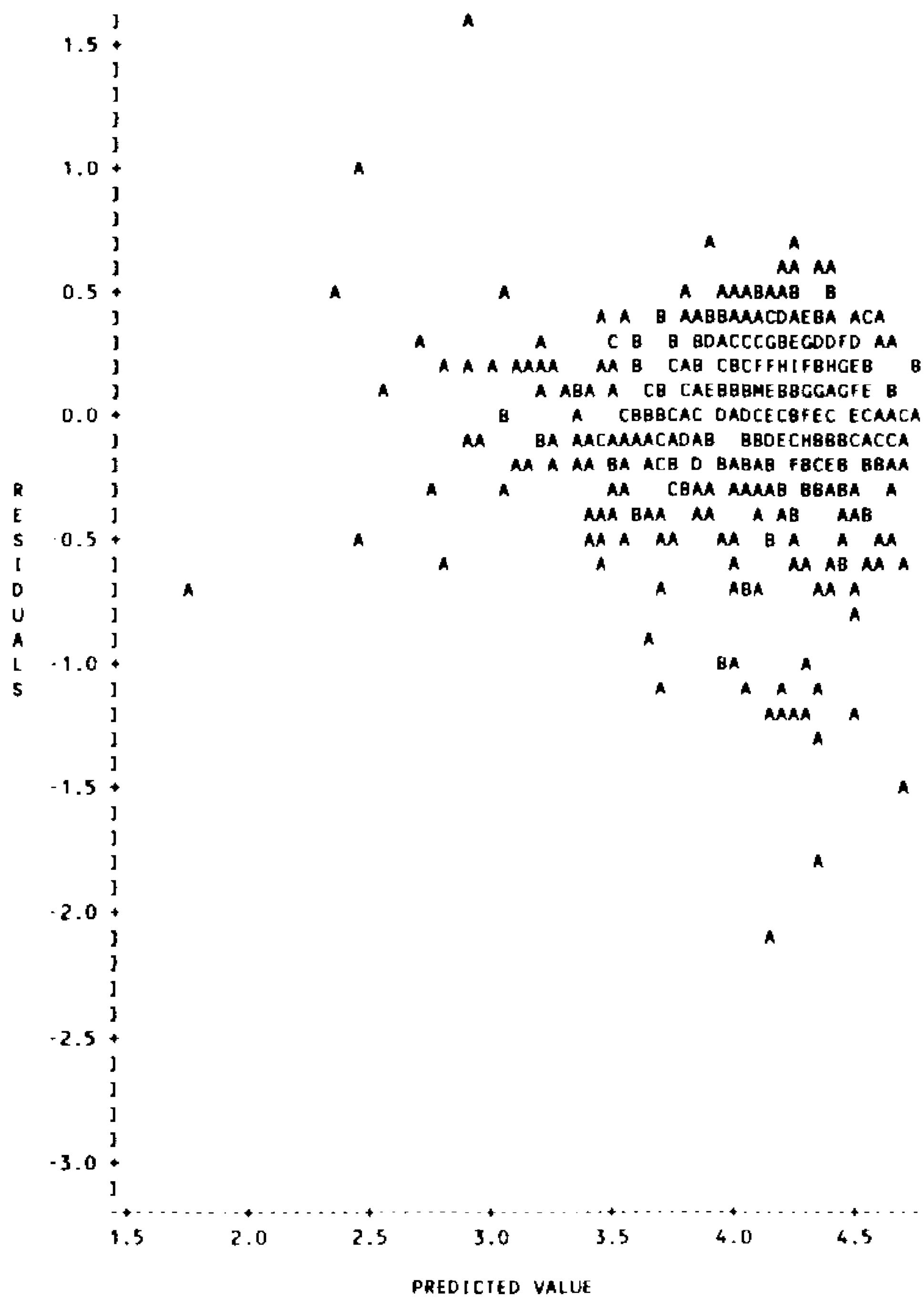
TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	0.56	6	0.997	-0.004	-0.001	-0.006	-0.009	0.009	0.C15
12	9.73	12	0.640	-0.016	0.033	-0.005	0.055	0.040	-0.033
18	15.23	18	0.646	-0.003	0.038	-0.016	0.047	-0.003	-0.018
24	21.48	24	0.610	0.028	0.017	-0.005	0.002	0.058	0.019

Appendix B Figure 6. (Continued).



Appendix B Figure 7. Frequency Bar Chart of OLS Errors, Medium Grain Rough Rice, 1986.

PLOT OF EHAT1*YHAT1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.



Appendix B Figure 8. Plot of OLS Errors Against Predicted Values of Bid Price, Medium Grain 1986.

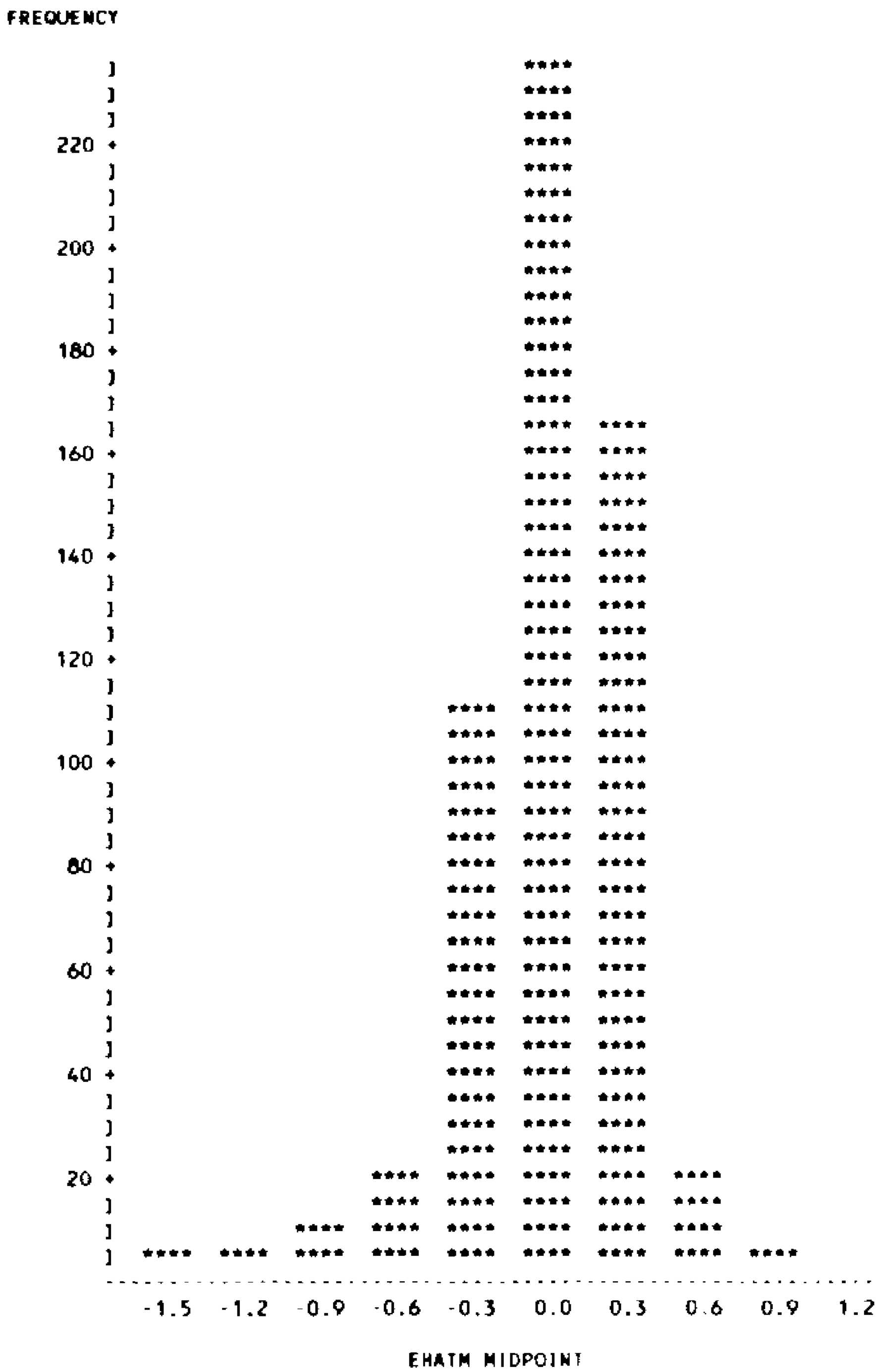
```
                         ARIMA PROCEDURE

                    NAME OF VARIABLE       =     EHAT1
                    MEAN OF WORKING SERIES= 3.322E-14
                    STANDARD DEVIATION     =  0.357712
                    NUMBER OF OBSERVATIONS=        573

                          AUTOCORRELATIONS
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0   0.127958     1.00000  ]                    ]********************]
  1  0.0452023     0.35326  ]                  . ]*******             ]
  2  0.0296283     0.23155  ]                  . ]*****               ]
  3  0.0265173     0.20723  ]                  . ]****                ]
  4   0.031678     0.24757  ]                  . ]*****               ]
  5  0.0236365     0.18472  ]                  . ]****                ]
  6  0.0085821     0.06707  ]                  . ]*.                  ]
  7 0.00968242     0.07567  ]                  . ]**                  ]
  8 0.00522628     0.04084  ]                  . ]*.                  ]
  9  0.0129898     0.10152  ]                  . ]**                  ]
 10  0.0117568     0.09188  ]                  . ]**                  ]
 11 0.00729467     0.05701  ]                  . ]*.                  ]
 12  0.0043449     0.03396  ]                  . ]*.                  ]
 13  0.0100567     0.07859  ]                  . ]**                  ]
 14 0.00745159     0.05823  ]                  . ]*.                  ]
 15 0.00374008     0.02923  ]                  . ]*.                  ]
 16 0.00177787     0.01389  ]                  . ] .                  ]
 17 0.00200269     0.01565  ]                  . ] .                  ]
 18 0.00307142     0.02400  ]                  . ] .                  ]
 19 -.00105298    -0.00823  ]                  . ] .                  ]
 20 .000535001     0.00418  ]                  . ] .                  ]
 21 0.00227594     0.01779  ]                  . ] .                  ]
 22 -.00076959    -0.00601  ]                  . ] .                  ]
 23 -.00246939    -0.01930  ]                  . ] .                  ]
 24  0.0020002     0.01563  ]                  . ] .                  ]
                        '.' MARKS TWO STANDARD ERRORS

                      PARTIAL AUTOCORRELATIONS
           LAG CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
             1     0.35326  ]                  . ]*******             ]
             2     0.12198  ]                  . ]**                  ]
             3     0.10708  ]                  . ]**                  ]
             4     0.14973  ]                  . ]***                 ]
             5     0.03854  ]                  . ]*.                  ]
             6    -0.07214  ]                  .*] .                  ]
             7     0.00956  ]                  . ] .                  ]
             8    -0.03732  ]                  .*] .                  ]
             9     0.07359  ]                  . ]*.                  ]
            10     0.04799  ]                  . ]*.                  ]
            11     0.00085  ]                  . ] .                  ]
            12    -0.01325  ]                  . ] .                  ]
            13     0.04425  ]                  . ]*.                  ]
            14    -0.01641  ]                  . ] .                  ]
            15    -0.01141  ]                  . ] .                  ]
            16    -0.01064  ]                  . ] .                  ]
            17    -0.00502  ]                  . ] .                  ]
            18     0.00573  ]                  . ] .                  ]
            19    -0.02495  ]                  . ] .                  ]
            20     0.00680  ]                  . ] .                  ]
            21     0.02434  ]                  . ] .                  ]
            22    -0.02691  ]                  .*] .                  ]
            23    -0.02270  ]                  . ] .                  ]
            24     0.03291  ]                  . ]*.                  ]
```

Appendix B Figure 9. Autocorrelations, Partial Correlations and Check for White Noise, OLS Errors, Medium Grain, 1986. (Continued)

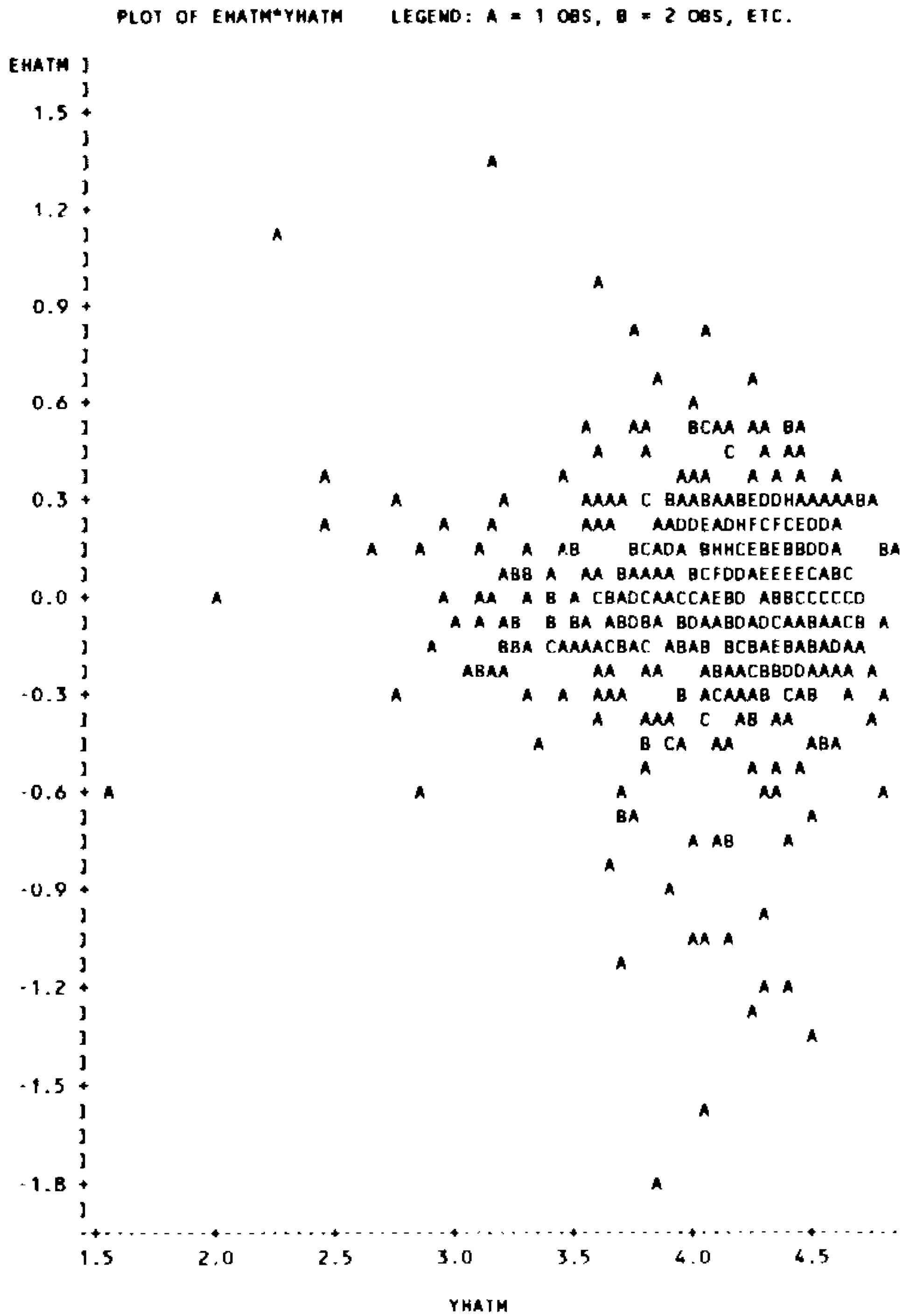
AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	185.54	6	0.000	0.353	0.232	0.207	0.248	0.185	0.067
12	203.39	12	0.000	0.076	0.041	0.102	0.092	0.057	0.034
18	210.12	18	0.000	0.079	0.058	0.029	0.014	0.016	0.024
24	210.76	24	0.000	-0.008	0.004	0.018	-0.006	-0.019	0.016

Appendix B Figure 9. (Continued).



Appendix B Figure 10. Frequency Bar Chart of Autoregressive Errors, Medium Grain, 1986.



Appendix B Figure 11. Plot of Autoregressive Errors Against Predicted Values of Bid Price, Medium Grain Rough Rice, 1986.

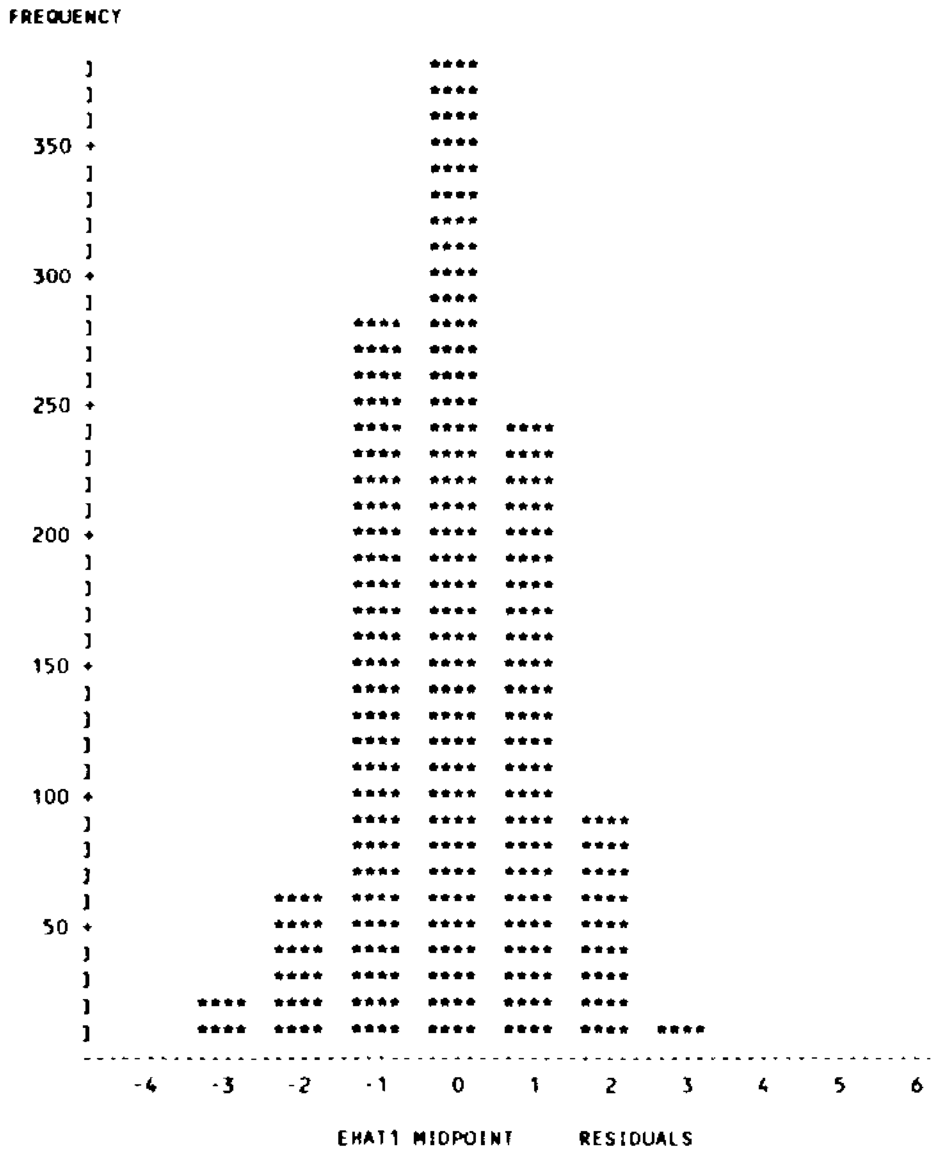
```
                              ARIMA PROCEDURE

                    NAME OF VARIABLE      =     EHATM
                    MEAN OF WORKING SERIES=.000191211
                    STANDARD DEVIATION    =   0.32407
                    NUMBER OF OBSERVATIONS=       573

                             AUTOCORRELATIONS
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0   0.105022     1.00000  ]                    ]********************]
  1 0.00139739     0.01331  ]                  . ] .                  ]
  2 0.00246676     0.02349  ]                  . ] .                  ]
  3 .000918562     0.00875  ]                  . ] .                  ]
  4  0.0022469     0.02139  ]                  . ] .                  ]
  5 0.00102611     0.00977  ]                  . ] .                  ]
  6 -.00751687    -0.07157  ]                  .*] .                  ]
  7 0.00150286     0.01431  ]                  . ] .                  ]
  8 -.00566876    -0.05398  ]                  .*] .                  ]
  9 0.00430176     0.04096  ]                  . ]*.                  ]
 10 0.00509358     0.04850  ]                  . ]*.                  ]
 11 0.00291148     0.02772  ]                  . ]*.                  ]
 12 -.00214981    -0.02047  ]                  . ] .                  ]
 13 0.00618121     0.05886  ]                  . ]*.                  ]
 14 0.00196657     0.01873  ]                  . ] .                  ]
 15 0.00123508     0.01176  ]                  . ] .                  ]
 16 -.00125624    -0.01196  ]                  . ] .                  ]
 17 -.00055741    -0.00531  ]                  . ] .                  ]
 18 0.00248552     0.02367  ]                  . ] .                  ]
 19 -.00350417    -0.03337  ]                  .*] .                  ]
 20 .000134672     0.00128  ]                  . ] .                  ]
 21 0.00270936     0.02580  ]                  . ]*.                  ]
 22 .000524555     0.00499  ]                  . ] .                  ]
 23 -.00115213    -0.01097  ]                  . ] .                  ]
 24 0.00480056     0.04571  ]                  . ]*.                  ]
                           '.' MARKS TWO STANDARD ERRORS

                         PARTIAL AUTOCORRELATIONS
           LAG CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
             1     0.01331  ]                  . ] .                  ]
             2     0.02332  ]                  . ] .                  ]
             3     0.00814  ]                  . ] .                  ]
             4     0.02065  ]                  . ] .                  ]
             5     0.00885  ]                  . ] .                  ]
             6    -0.07294  ]                  .*] .                  ]
             7     0.01549  ]                  . ] .                  ]
             8    -0.05194  ]                  .*] .                  ]
             9     0.04299  ]                  . ]*.                  ]
            10     0.05290  ]                  . ]*.                  ]
            11     0.02643  ]                  . ]*.                  ]
            12    -0.02772  ]                  .*] .                  ]
            13     0.05938  ]                  . ]*.                  ]
            14     0.00630  ]                  . ] .                  ]
            15     0.01494  ]                  . ] .                  ]
            16    -0.01057  ]                  . ] .                  ]
            17    -0.00114  ]                  . ] .                  ]
            18     0.02170  ]                  . ] .                  ]
            19    -0.02684  ]                  .*] .                  ]
            20    -0.00603  ]                  . ] .                  ]
            21     0.03501  ]                  . ]*.                  ]
            22    -0.00002  ]                  . ] .                  ]
            23    -0.01618  ]                  . ] .                  ]
```

Appendix B Figure 1[illegible]. Autocorrelations, Partial Correlations and Check for White Noise, Autoregressive Errors, Medium Grain, 1986. (Continued)

AUTOCORRELATION CHECK FOR WHITE NOISE

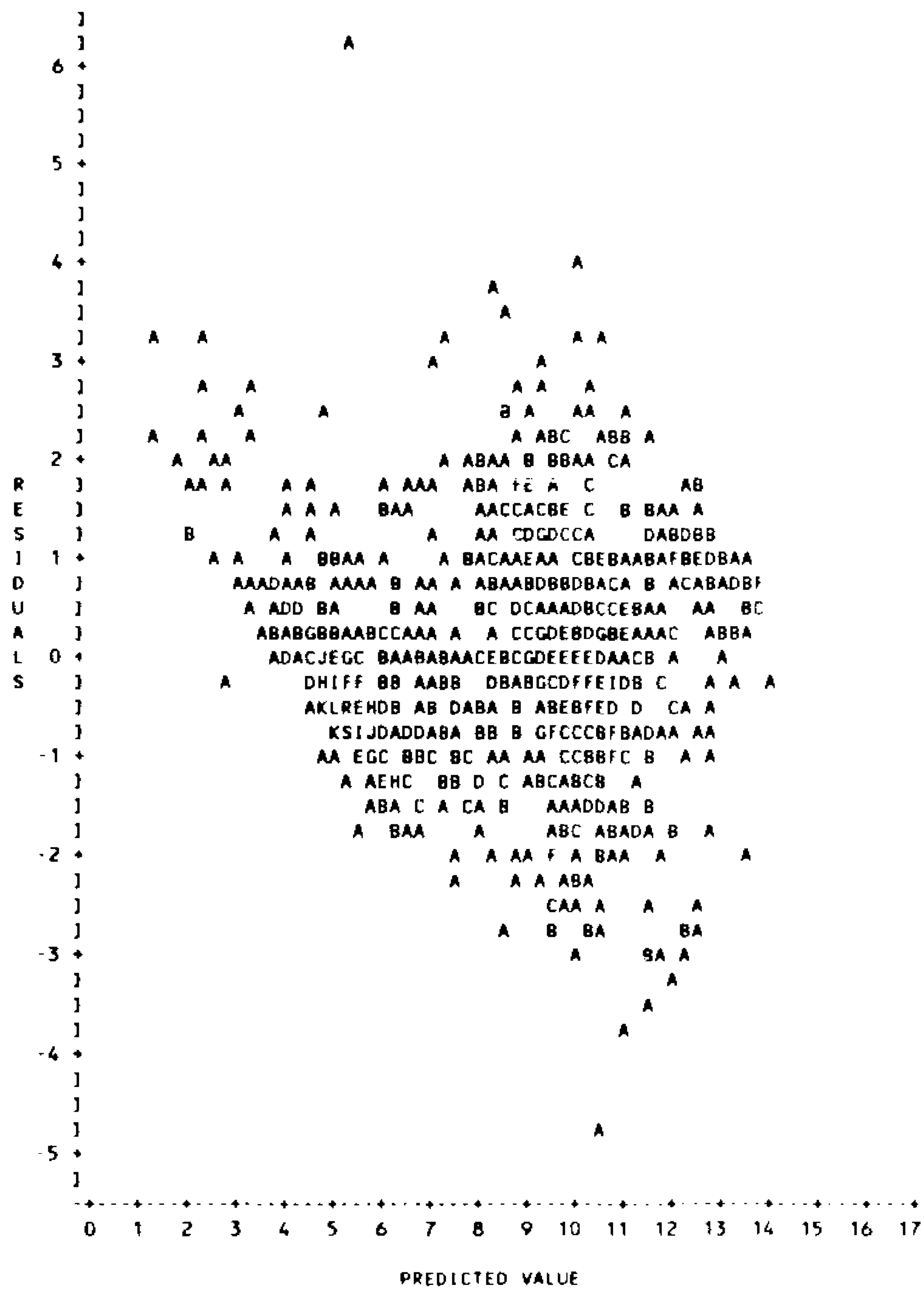
TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	3.76	6	0.709	0.013	0.023	0.009	0.021	0.010	-0.072
12	8.63	12	0.734	0.014	-0.054	0.041	0.049	0.028	-0.020
18	11.39	18	0.877	0.059	0.019	0.012	-0.012	-0.005	0.024
24	13.79	24	0.951	-0.033	0.001	0.026	0.005	-0.011	0.046

Appendix B Figure 12. (Continued).



Appendix B Figure 13. Frequency Bar Chart of OLS Errors, Long Grain, 1987.

PLOT OF EHAT1*YHAT1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.



Appendix B Figure 14. Plot of OLS Errors Against Predicted Values of Bid Price, Long Grain, 1987.

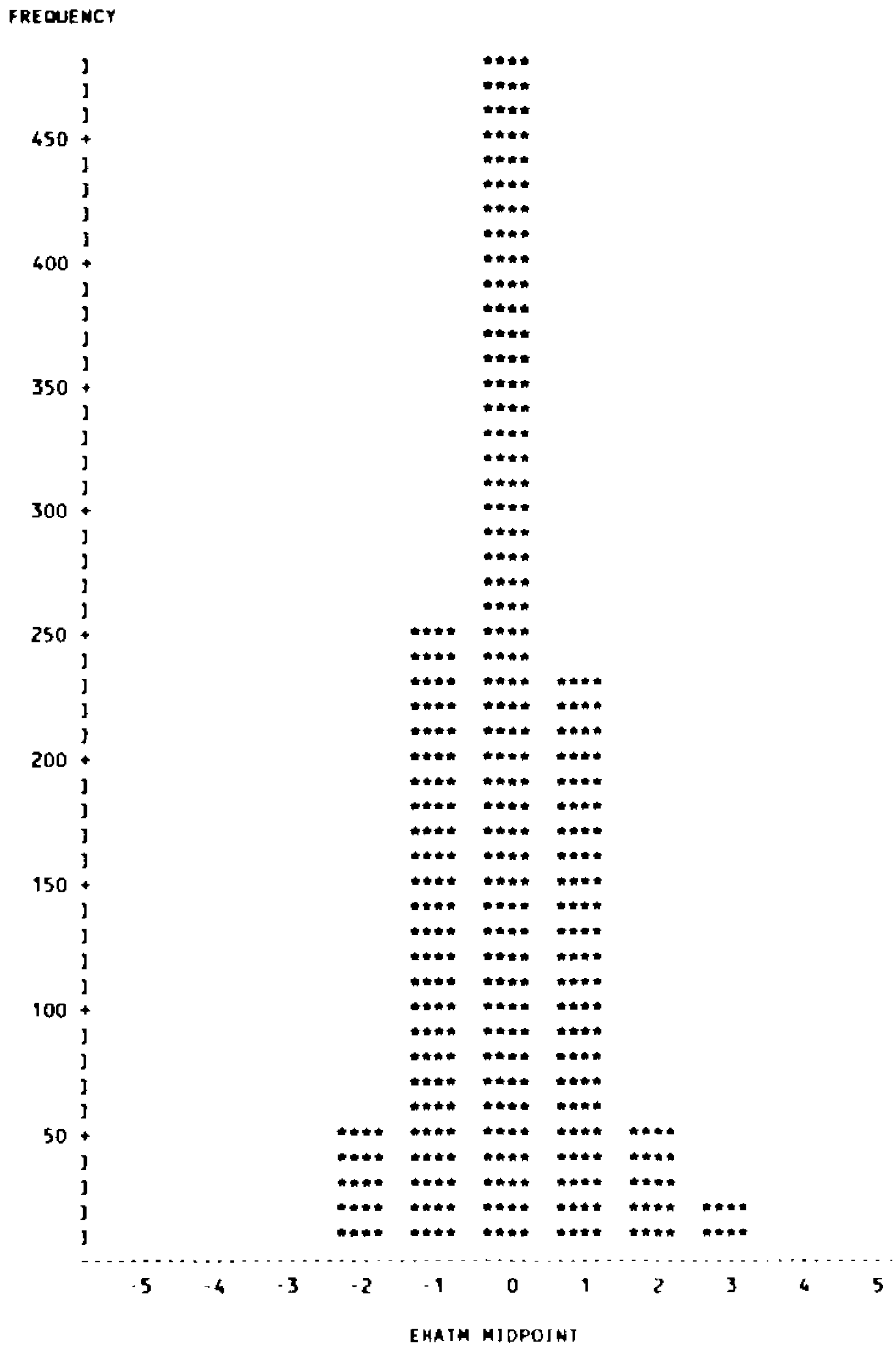
```
                         ARIMA PROCEDURE

                  NAME OF VARIABLE       =      EHAT1
                  MEAN OF WORKING SERIES= 1.978E-13
                  STANDARD DEVIATION    =    1.15843
                  NUMBER OF OBSERVATIONS=       1085

                             AUTOCORRELATIONS
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0    1.34197    1.00000  ]                    ]********************]
  1   0.618436    0.46084  ]                   .]*********           ]
  2   0.431121    0.32126  ]                   .]******              ]
  3    0.39458    0.29403  ]                  . ]******              ]
  4   0.414665    0.30900  ]                  . ]******              ]
  5   0.392848    0.29274  ]                  . ]******              ]
  6   0.334553    0.24930  ]                  . ]*****               ]
  7   0.339138    0.25272  ]                  . ]*****               ]
  8   0.288109    0.21469  ]                  . ]****                ]
  9   0.262524    0.19563  ]                  . ]****                ]
 10   0.249593    0.18599  ]                  . ]****                ]
 11   0.296282    0.22078  ]                  . ]****                ]
 12   0.211128    0.15733  ]                  . ]***                 ]
 13   0.212992    0.15872  ]                  . ]***                 ]
 14     0.2058    0.15336  ]                  . ]***                 ]
 15    0.21322    0.15889  ]                  . ]***                 ]
 16   0.270854    0.20183  ]                  . ]****                ]
 17   0.252437    0.18811  ]                  . ]****                ]
 18   0.259954    0.19371  ]                  . ]****                ]
 19    0.21672    0.16149  ]                  . ]***                 ]
 20   0.200102    0.14911  ]                  . ]***                 ]
 21   0.232899    0.17355  ]                  . ]***                 ]
 22   0.276082    0.20573  ]                  . ]****                ]
 23   0.207827    0.15487  ]                  . ]***                 ]
 24   0.188618    0.14055  ]                  . ]***                 ]
                            '.' MARKS TWO STANDARD ERRORS

                         PARTIAL AUTOCORRELATIONS
          LAG CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
            1    0.46084  ]                   .]*********           ]
            2    0.13824  ]                   .]***                 ]
            3    0.13298  ]                   .]***                 ]
            4    0.14350  ]                   .]***                 ]
            5    0.09242  ]                   .]**                  ]
            6    0.03852  ]                   .]*                   ]
            7    0.07205  ]                   .]*                   ]
            8    0.00753  ]                   .].                   ]
            9    0.01498  ]                   .].                   ]
           10    0.01964  ]                   .].                   ]
           11    0.07526  ]                   .]**                  ]
           12   -0.03993  ]                   *].                   ]
           13    0.02707  ]                   .]*                   ]
           14    0.01075  ]                   .].                   ]
           15    0.02378  ]                   .].                   ]
           16    0.08454  ]                   .]**                  ]
           17    0.03212  ]                   .]*                   ]
           18    0.04226  ]                   .]*                   ]
           19   -0.00241  ]                   .].                   ]
           20   -0.00427  ]                   .].                   ]
           21    0.03916  ]                   .]*                   ]
           22    0.06035  ]                   .]*                   ]
           23   -0.02847  ]                   *].                   ]
           24   -0.00172  ]                   .].                   ]
```

Appendix B Figure 15. Autocorrelations, Partial Correlations and Check for White Noise, OLS Errors, Long Grain, 1987. (Continued)

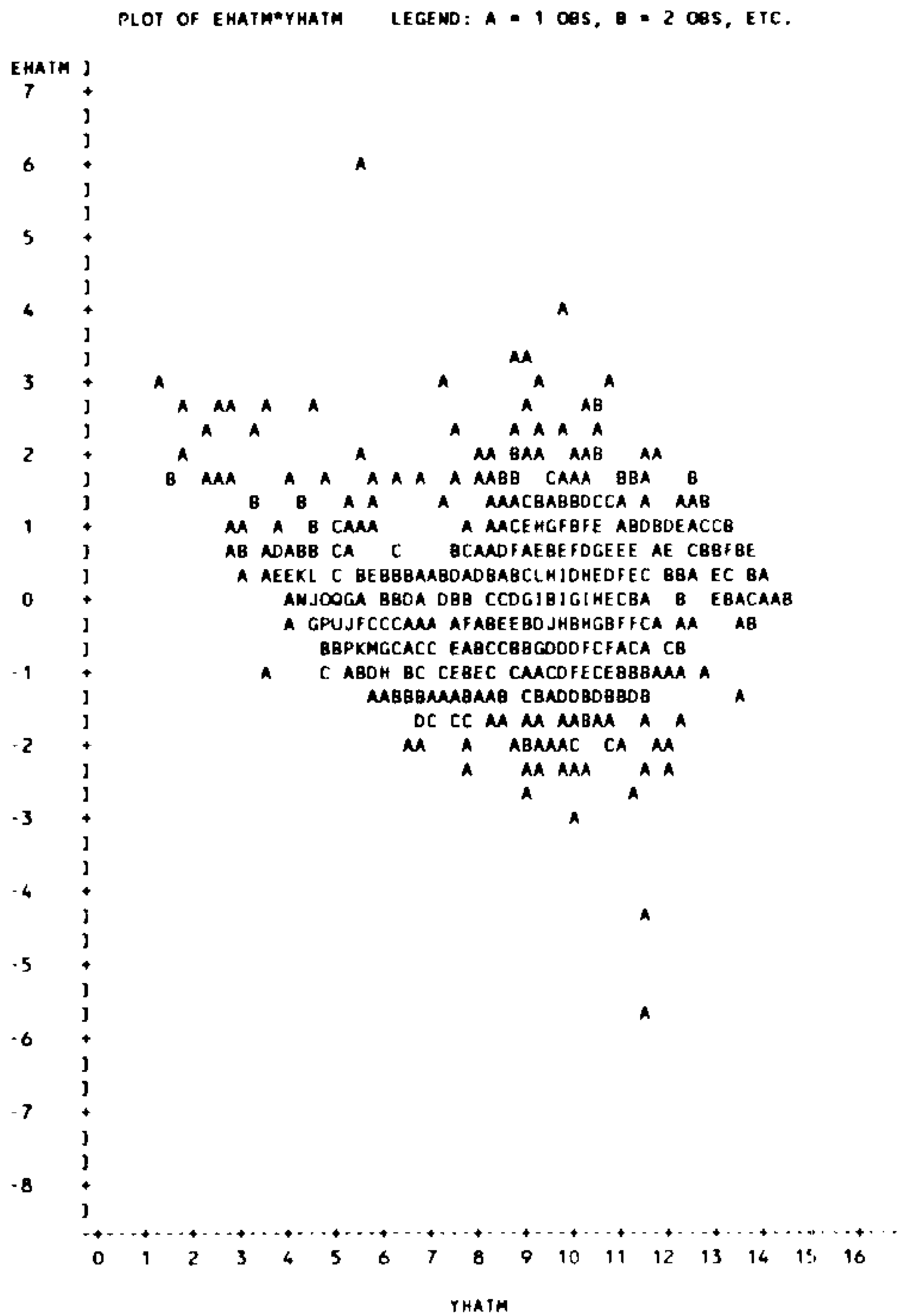
AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	703.39	6	0.000	0.461	0.321	0.294	0.309	0.293	0.249
12	984.37	12	0.000	0.253	0.215	0.196	0.186	0.221	0.157
18	1191.30	18	0.000	0.159	0.153	0.159	0.202	0.188	0.194
24	1373.72	24	0.000	0.161	0.149	0.174	0.206	0.155	0.141

Appendix B Figure 15. (Continued).



Appendix B Figure 16. Frequency Bar Chart of Autoregressive Errors, Long Grain 1987.



Appendix B Figure 17. Plot of Autoregressive Errors Against Predicted Values of Bid Price, Long Grain, 1987.

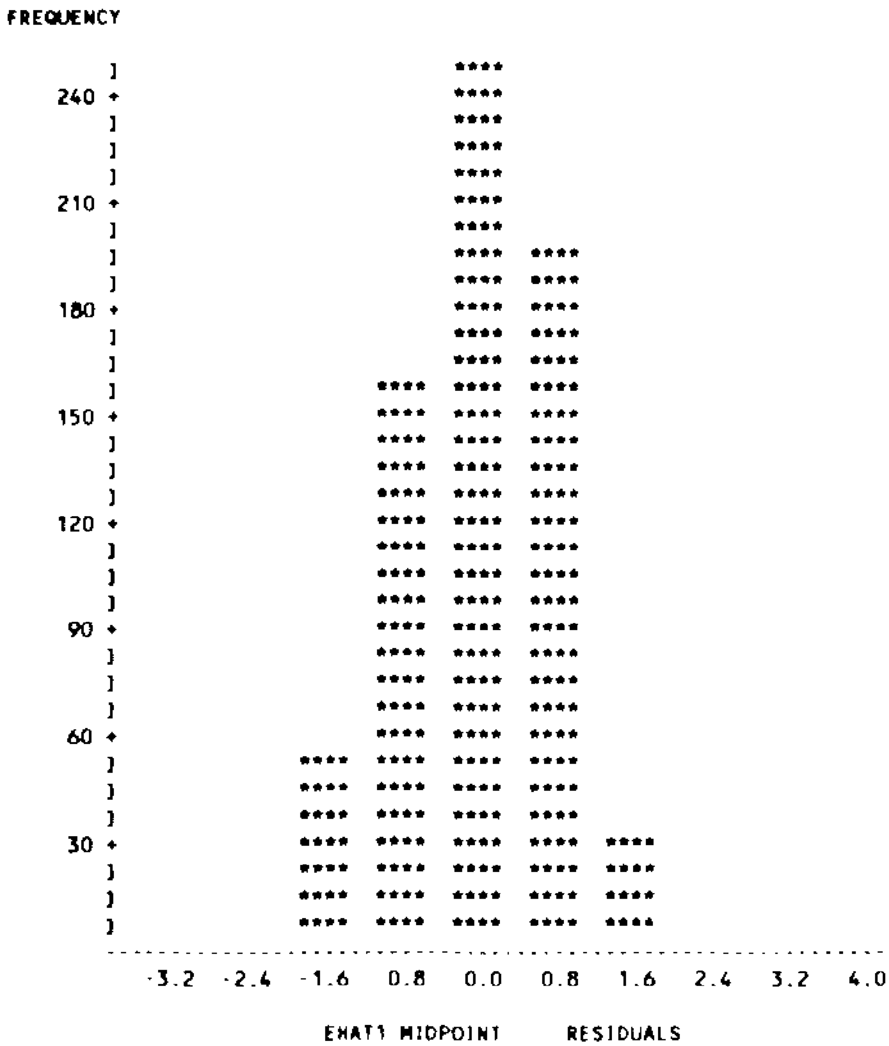
```
                    ARIMA PROCEDURE

             NAME OF VARIABLE      =     EHATM
             MEAN OF WORKING SERIES=0.00201612
             STANDARD DEVIATION    =  0.982963
             NUMBER OF OBSERVATIONS=      1085

                                AUTOCORRELATIONS
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0   0.966216    1.00000   ]                   ]********************]
  1 0.00874073    0.00905   ]                  .].                   ]
  2 -.00689954   -0.00714   ]                  .].                   ]
  3 -0.0101803   -0.01054   ]                  .].                   ]
  4 -.00509124   -0.00527   ]                  .].                   ]
  5 -0.0164518   -0.01703   ]                  .].                   ]
  6 -0.0086101   -0.00891   ]                  .].                   ]
  7   0.054996    0.05692   ]                  .]*                   ]
  8  0.0176845    0.01830   ]                  .].                   ]
  9 0.00904847    0.00936   ]                  .].                   ]
 10 -.00669439   -0.00693   ]                  .].                   ]
 11  0.0789066    0.08167   ]                  .]**                  ]
 12 -0.0296267   -0.03066   ]                  *].                   ]
 13 0.00461586    0.00478   ]                  .].                   ]
 14 0.00811487    0.00840   ]                  .].                   ]
 15  0.0105167    0.01088   ]                  .].                   ]
 16  0.0750284    0.07765   ]                  .]**                  ]
 17  0.0260412    0.02695   ]                  .]*                   ]
 18  0.0481973    0.04988   ]                  .]*                   ]
 19  0.0237322    0.02456   ]                  .].                   ]
 20 -.00522946   -0.00541   ]                  .].                   ]
 21  0.0366278    0.03791   ]                  .]*                   ]
 22  0.0900112    0.09316   ]                  .]**                  ]
 23  0.0106723    0.01105   ]                  .].                   ]
 24 0.00883787    0.00915   ]                  .].                   ]
                            '.' MARKS TWO STANDARD ERRORS

                          PARTIAL AUTOCORRELATIONS
           LAG CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
             1    0.00905   ]                  .].                   ]
             2   -0.00722   ]                  .].                   ]
             3   -0.01041   ]                  .].                   ]
             4   -0.00513   ]                  .].                   ]
             5   -0.01709   ]                  .].                   ]
             6   -0.00879   ]                  .].                   ]
             7    0.05676   ]                  .]*                   ]
             8    0.01683   ]                  .].                   ]
             9    0.00951   ]                  .].                   ]
            10   -0.00607   ]                  .].                   ]
            11    0.08285   ]                  .]**                  ]
            12   -0.03030   ]                  *].                   ]
            13    0.00821   ]                  .].                   ]
            14    0.00692   ]                  .].                   ]
            15    0.00934   ]                  .].                   ]
            16    0.07928   ]                  .]**                  ]
            17    0.02708   ]                  .]*                   ]
            18    0.04234   ]                  .]*                   ]
            19    0.02780   ]                  .]*                   ]
            20   -0.00384   ]                  .].                   ]
            21    0.04460   ]                  .]*                   ]
            22    0.08970   ]                  .]**                  ]
            23    0.01011   ]                  .].                   ]
            24    0.00723   ]                  .].                   ]
```

Appendix A Figure 18. Autocorrelations, Partial Correlations and Check for White Noise, Autoregressive Errors, Long Grain, 1987. (Continued)

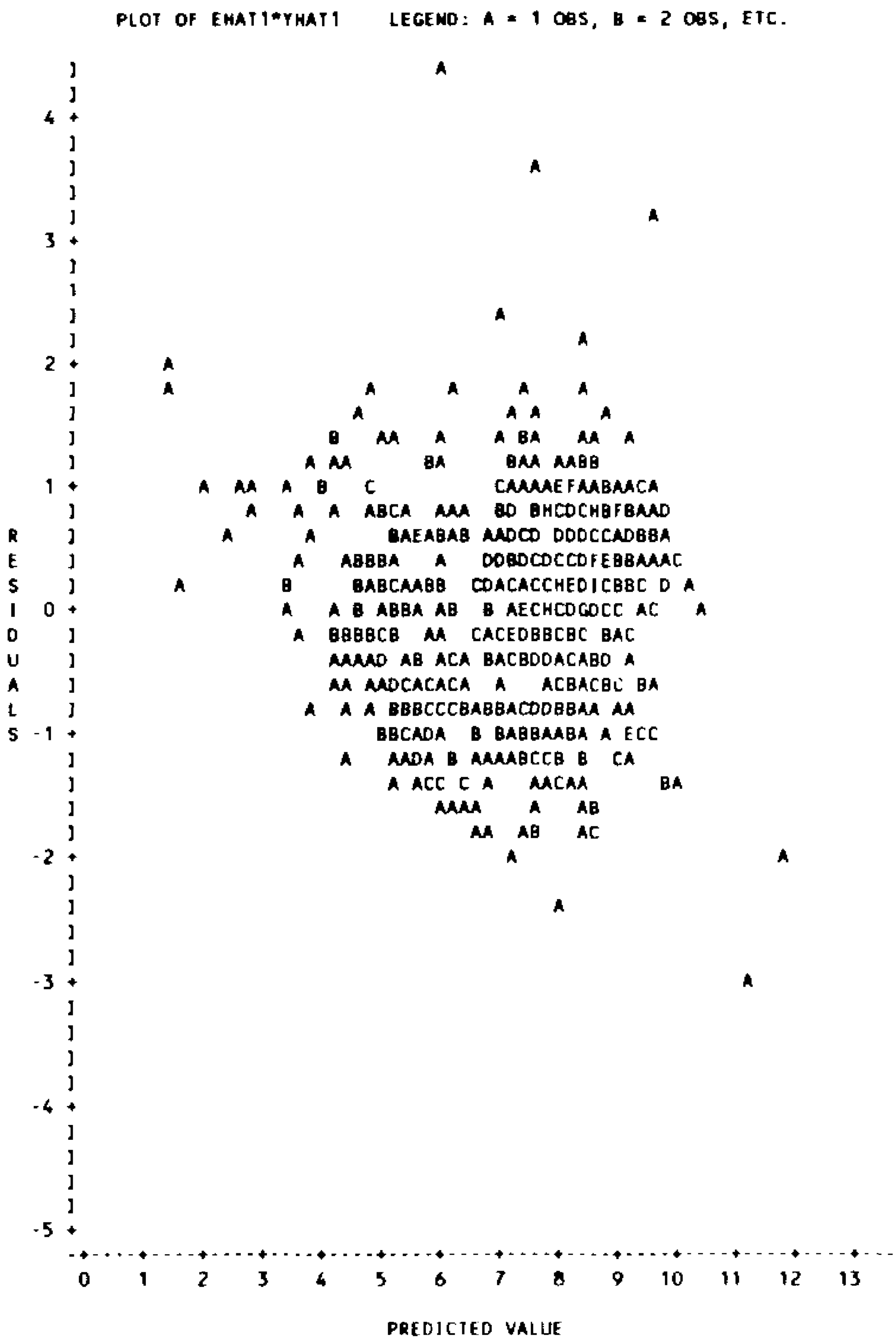
AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	0.70	6	0.995	0.009	-0.007	-0.011	-0.005	-0.017	-0.009
12	13.12	12	0.361	0.057	0.018	0.009	-0.007	0.082	-0.031
18	23.55	18	0.170	0.005	0.008	0.011	0.078	0.027	0.050
24	35.71	24	0.059	0.025	-0.005	0.038	0.093	0.011	0.009

Appendix B Figure 18. (Continued).



Appendix B Figure 19. Frequency Bar of OLS Errors, Medium Grain, 1987.



Appendix B Figure 20. Plot of OLS Errors Against Predicted Values of Bid Price, Medium Grain, 1987.

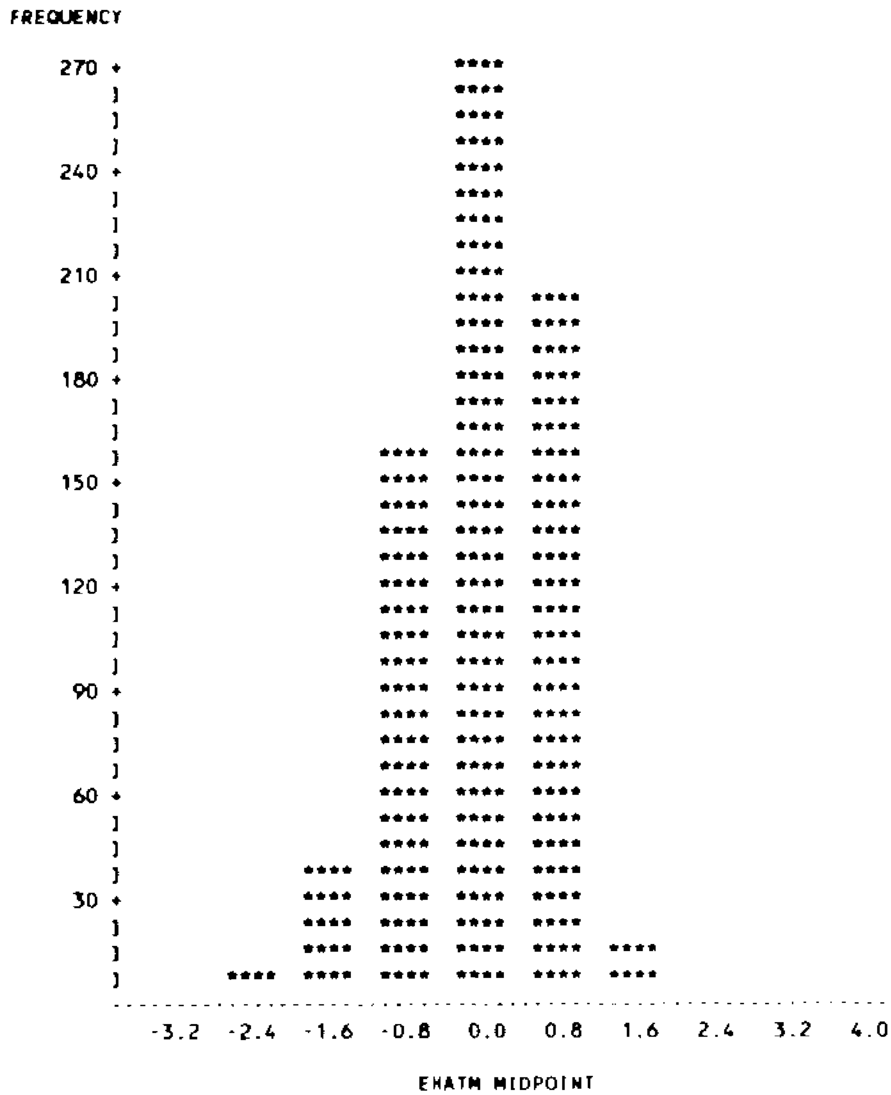
```
                         ARIMA PROCEDURE

                   NAME OF VARIABLE       =     EHAT1
                   MEAN OF WORKING SERIES= 7.678E-14
                   STANDARD DEVIATION     =  0.842226
                   NUMBER OF OBSERVATIONS=       689

                        AUTOCORRELATIONS
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0   0.709345     1.00000 ]                    ]********************]
  1   0.220167     0.31038 ]                  . ]******              ]
  2   0.160582     0.22638 ]                  . ]*****               ]
  3   0.171401     0.24163 ]                  . ]*****               ]
  4   0.159729     0.22518 ]                  . ]*****               ]
  5   0.128237     0.18078 ]                  . ]****                ]
  6    0.14738     0.20777 ]                  . ]****                ]
  7   0.138604     0.19540 ]                  . ]****                ]
  8   0.142595     0.20102 ]                  . ]****                ]
  9   0.111533     0.15723 ]                  . ]***                 ]
 10   0.114652     0.16163 ]                  . ]***                 ]
 11   0.125238     0.17655 ]                  . ]****                ]
 12   0.127656     0.17996 ]                  . ]****                ]
 13   0.104363     0.14713 ]                  . ]***                 ]
 14   0.115419     0.16271 ]                  . ]***                 ]
 15   0.124858     0.17602 ]                  . ]****                ]
 16  0.0832565     0.11737 ]                  . ]**                  ]
 17  0.0799812     0.11275 ]                  . ]**                  ]
 18   0.124378     0.17534 ]                  . ]****                ]
 19   0.118339     0.16683 ]                  . ]***                 ]
 20  0.0674814     0.09513 ]                  . ]**                  ]
 21  0.0740073     0.10433 ]                  . ]**                  ]
 22  0.0181561     0.02560 ]                  . ]*.                  ]
 23  0.0281027     0.03962 ]                  . ]*.                  ]
 24  0.0481116     0.06783 ]                  . ]*.                  ]
                            '.' MARKS TWO STANDARD ERRORS

                      PARTIAL AUTOCORRELATIONS
           LAG CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
             1     0.31038 ]                  . ]******              ]
             2     0.14391 ]                  . ]***                 ]
             3     0.15460 ]                  . ]***                 ]
             4     0.11008 ]                  . ]**                  ]
             5     0.05224 ]                  . ]*.                  ]
             6     0.09470 ]                  . ]**                  ]
             7     0.06350 ]                  . ]*.                  ]
             8     0.07439 ]                  . ]*.                  ]
             9     0.01315 ]                  . ] .                  ]
            10     0.03417 ]                  . ]*.                  ]
            11     0.05233 ]                  . ]*.                  ]
            12     0.05177 ]                  . ]*.                  ]
            13     0.01132 ]                  . ] .                  ]
            14     0.03688 ]                  . ]*.                  ]
            15     0.04906 ]                  . ]*.                  ]
            16    -0.02519 ]                  .*] .                  ]
            17    -0.00444 ]                  . ] .                  ]
            18     0.06997 ]                  . ]*.                  ]
            19     0.04209 ]                  . ]*.                  ]
            20    -0.04113 ]                  .*] .                  ]
            21    -0.00789 ]                  . ] .                  ]
            22    -0.10389 ]                  **] .                  ]
            23    -0.03397 ]                  .*] .                  ]
            24     0.00745 ]                  . ] .                  ]
```

Appendix B Figure 21. Autocorrelations, Partial Correlations and Check for White Noise, OLS Errors, Medium Grain, 1987. (Continued)

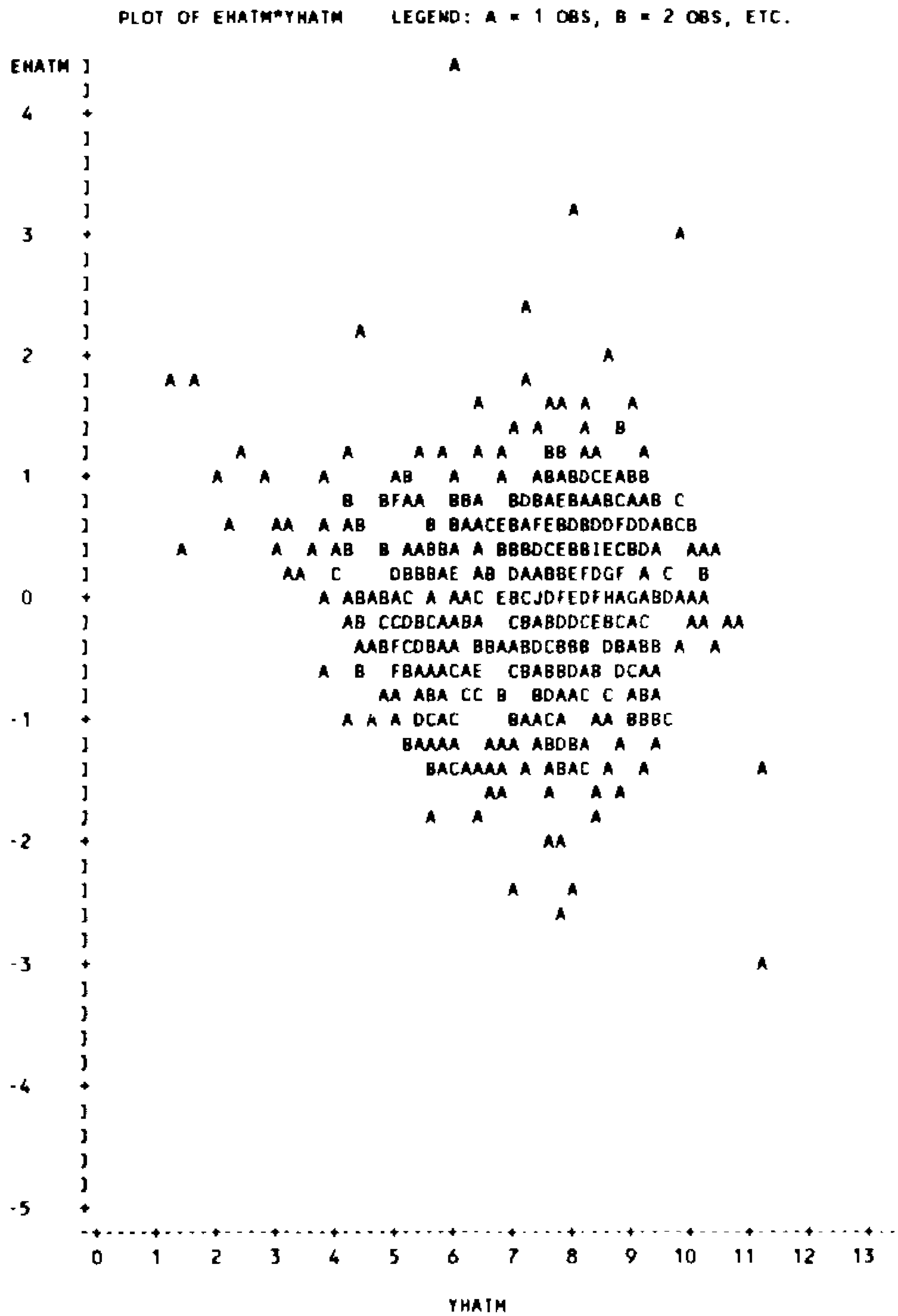
AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	230.78	6	0.000	0.310	0.226	0.242	0.225	0.181	0.208
12	365.98	12	0.000	0.195	0.201	0.157	0.162	0.177	0.180
18	462.35	18	0.000	0.147	0.163	0.176	0.117	0.113	0.175
24	501.21	24	0.000	0.167	0.095	0.104	0.026	0.040	0.068

Appendix B Figure 21. (Continued).



Appendix B Figure 22. Frequency Bar Chart of Autoregressive Errors, Medium Grain, 1987.



Appendix B Figure 23. Plot of Autoregressive Errors Against Predicted Values of Bid Price, Medium Grain, 1987.

```
                         ARIMA PROCEDURE

              NAME OF VARIABLE        =      EHATM
              MEAN OF WORKING SERIES=.000482982
              STANDARD DEVIATION      =   0.773091
              NUMBER OF OBSERVATIONS=         689

                         AUTOCORRELATIONS
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0   0.597669     1.00000  ]                    ]********************]
  1 -.00173744    -0.00291  ]                  . ] .                  ]
  2 -.00029509    -0.00049  ]                  . ] .                  ]
  3 -0.0154147    -0.02579  ]                  .*] .                  ]
  4 -0.0096325    -0.01612  ]                  . ] .                  ]
  5 -0.0233863    -0.03913  ]                  .*] .                  ]
  6  0.0287317     0.04807  ]                  . ]*.                  ]
  7  0.0212158     0.03550  ]                  . ]*.                  ]
  8  0.0434865     0.07276  ]                  . ]*.                  ]
  9 .000612476     0.00102  ]                  . ] .                  ]
 10  0.0130895     0.02190  ]                  . ] .                  ]
 11  0.0288737     0.04831  ]                  . ]*.                  ]
 12  0.0342662     0.05733  ]                  . ]*.                  ]
 13  0.0140865     0.02357  ]                  . ] .                  ]
 14  0.0227678     0.03809  ]                  . ]*.                  ]
 15  0.0451648     0.07557  ]                  . ]**                  ]
 16 .000774952     0.00130  ]                  . ] .                  ]
 17 -.00106117    -0.00178  ]                  . ] .                  ]
 18   0.053505     0.08952  ]                  . ]**                  ]
 19  0.0599055     0.10023  ]                  . ]**                  ]
 20 0.00485619     0.00813  ]                  . ] .                  ]
 21  0.0275813     0.04615  ]                  . ]*.                  ]
 22 -0.0418719    -0.07006  ]                  .*] .                  ]
 23  -0.015485    -0.02591  ]                  .*] .                  ]
 24  0.0102794     0.01720  ]                  . ] .                  ]
                            '.' MARKS TWO STANDARD ERRORS

                      PARTIAL AUTOCORRELATIONS
           LAG CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
             1    -0.00291  ]                  . ] .                  ]
             2    -0.00050  ]                  . ] .                  ]
             3    -0.02579  ]                  .*] .                  ]
             4    -0.01628  ]                  . ] .                  ]
             5    -0.03930  ]                  .*] .                  ]
             6     0.04722  ]                  . ]*.                  ]
             7     0.03503  ]                  . ]*.                  ]
             8     0.07122  ]                  . ]*.                  ]
             9     0.00292  ]                  . ] .                  ]
            10     0.02409  ]                  . ] .                  ]
            11     0.05739  ]                  . ]*.                  ]
            12     0.06191  ]                  . ]*.                  ]
            13     0.02896  ]                  . ]*.                  ]
            14     0.03539  ]                  . ]*.                  ]
            15     0.07982  ]                  . ]**                  ]
            16     0.00462  ]                  . ] .                  ]
            17     0.00085  ]                  . ] .                  ]
            18     0.08760  ]                  . ]**                  ]
            19     0.09899  ]                  . ]**                  ]
            20     0.00684  ]                  . ] .                  ]
            21     0.04128  ]                  . ]*.                  ]
            22    -0.07489  ]                  .*] .                  ]
            23    -0.03408  ]                  .*] .                  ]
            24     0.01101  ]                  . ] .                  ]
```

Appendix B Figure 24. Autocorrelations, Partial Correlations and Check for White Noise, Autoregressive Errors, Medium Grain, 1987. (Continued)

AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	3.32	6	0.767	-0.003	-0.000	-0.026	-0.016	0.039	0.048
12	12.19	12	0.430	0.035	0.073	0.001	0.022	0.048	0.057
18	23.33	18	0.178	0.024	0.038	0.076	0.001	-0.002	0.090
24	36.23	24	0.052	0.100	0.008	0.046	-0.070	-0.026	0.017

Appendix B Figure 24. (Continued).

APPENDIX C
OTHER HEDONIC MODELS EXPLORED

Appendix C Table 6. OLS Estimates of a Hedonic Price Model for Long and Medium Grain Rough Rice, 1986 and 1987 Years Combined, Louisiana.

Quality Factors	Combined Medium Grain 1986-1987	Combined Long Grain 1986-1987
Constant	-9.355 (11.1)*	-11.65 18.60)*
Mill Price	0.4592 (78.47)*	0.535 (133.9)*
Head Rice	0.141 (12.19)*	0.1628 (18.8)*
Broken Kernels	0.059 (4.57)*	0.0815 (8.24)*
Lot Size	0.000019 (1.47)	0.000019 (1.63)
Foreign Seeds	-0.00516 (4.28)*	-0.0022 (4.50)*
Heat Damage	-0.0191 (7.94)*	-0.0196 (5.93)*
Red Rice	-0.0354 (2.29)*	-0.017 (1.34)
Peck Damage	0.164 (3.283)*	-0.3276 (5.23)*
Smut Damage	-0.237 (1.074)	-0.278 (2.76)*
Chalk Damage	0.086 (3.63)*	0.2564 (7.13)*
R^2	87%	90%
Mean Square Error	0.5959	0.9229
F	827	2040
T	1262	2363

Notes: Absolute t-values in parenthesis; * indicates parameter is significantly different from zero at the 95 percent level.

Appendix C Table 7. OLS Estimates of a Hedonic Price Model for Combined Long and Medium Grain Rough Rice, 1986 and 1987 in Louisiana.

Quality Factors	Combined Long & Medium Grain 1986	Combined Long & Medium Grain 1987
Constant	0.8277 (2.96)*	-17.08 (17.92)*
Mill Price	-0.091 (4.874)*	0.511 (75.03)*
Head Rice	0.069 (21.79)*	0.2601 (20.2)*
Broken Kernels	0.030 (8.58)*	0.591 (10.9)*
Lot Size	0.000016 (3.88)*	0.000037 (2.44)
Foreign Seeds	-0.00153 (9.43)*	-0.0084 (6.44)*
Heat Damage	-0.0066 (7.06)*	-0.0401 (10.5)*
Red Rice	-0.0162 (3.25)*	-0.045 (2.79)
Peck Damage	0.035 (0.493)	-0.1052 (1.81)
Smut Damage	0.0076 (0.202)	-0.014 (0.08)
Chalk Damage	-0.011 (1.49)	-0.177 (6.73)*
R^2	62%	82%
Mean Square Error	0.0894	1.243
F	300.33	794.2
T	1,851	1,774

Notes: Absolute t-values in parenthesis; * indicates parameter is significantly different from zero at the 95 percent level.

Appendix C Table 8. OLS Estimates of a Hedonic Price Model for Harvest and Post Harvest Seasons for Long Grain Rouge Rice, 1986 in Louisiana.

Quality Factors	Harvest Long Grain 1986	Post Harvest Long Grain 1986
Constant	-0.28 (0.76)	2.22 (2.99)*
Mill Price	-0.026 (1.57)	-0.25 (3.75)*
Head Rice	0.071 (15.6)*	0.076 (17.3)*
Broken Kernels	0.042 (8.55)*	0.031 (6.3)*
Lot Size	0.00001 (2.66)	0.00003 (3.80)
Foreign Seeds	-0.0012 (5.80)*	-0.0018 (9.26)*
Heat Damage	0.003 (1.55)	-0.0031 (1.9)*
Red Rice	-0.029 (4.71)*	0.003 (0.43)*
Peck Damage	-0.001 (0.009)	-0.322 (1.21)
Smut Damage	0.084 (2.04)*	-0.091 (1.47)
Chalk Damage	0.001 (0.05)	0.035 (1.61)
R^2	65%	74%
Mean Square Error	0.05	0.069
F	128.8	160.2
T	698	580

Notes: Absolute t-values in parenthesis; * indicates parameter is significantly different from zero at the 95 percent level.

Appendix C Table 9. OLS Estimates of a Hedonic Price Model for Harvest and Post Harvest Seasons for Long Grain, Grain Rough Rice, 1987 in Louisiana.

Quality Factors	Harvest Long Grain 1987	Post Harvest Long Grain 1987
Constant	-10.328	-14.29
	(8.69)*	(18.59)*
Mill Price	0.726	0.338
	(23.04)*	(18.59)*
Head Rice	0.11	0.277
	(7.17)*	(15.1)*
Broken Kernels	0.075	0.1218
	(4.53)*	(5.6)*
Lot Size	0.00001	0.00003
	(0.91)	(1.35)
Foreign Seeds	-0.0116	-0.0065
	(5.47)*	(4.33)*
Heat Damage	0.0021	-0.0259
	(0.313)	(4.5)*
Red Rice	-0.042	-0.076
	(2.21)*	(3.13)*
Peck Damage	0.0094	0.2682
	(0.213)	(2.32)*
Smut Damage	0.138	0.076
	(0.768)	(0.38)
Chalk Damage	0.035	0.289
	(0.02)	(3.61)*
R^2	69%	73%
Mean Square Error	0.13	1.37
F	65.0	790.0
T	295	790

Notes: Absolute t-values in parenthesis; * indicates parameter is significantly different from zero at the 95 percent level.

Appendix C Table 10. OLS Estimates of a Hedonic Price Model for Harvest and Post Harvest Seasons for Medium Grain Grain Rough Rice, 1986 in Louisiana.

Quality Factors	Harvest Medium Grain 1986	Post Harvest Medium Grain 1986
Constant	-4.68	4.78
	(2.25)	(2.99)*
Mill Price	0.408	-0.433
	(2.36)*	(7.48)*
Head Rice	0.07	0.064
	(4.9)*	(8.3)*
Broken Kernels	0.03	0.017
	(1.95)*	(1.9)*
Lot Size	0.00002	0.00002
	(1.40)	(2.45)*
Foreign Seeds	-0.0028	-0.0022
	(2.90)*	(3.55)*
Heat Damage	0.0065	-0.010
	(2.37)*	(9.5)*
Red Rice	-0.046	0.080
	(1.50)	(5.47)*
Peck Damage	0.062	-0.063
	(0.388)	(0.73)
Smut Damage	-0.015	-0.037
	(0.08)	(0.42)
Chalk Damage	0.091	0.021
	(2.90)*	(1.39)
R^2	47%	83%
Mean Square Error	0.196	0.043
F	24.8	128.0
T	293	280

Notes: Absolute t-values in parenthesis; * indicates parameter is significantly different from zero at the 95 percent level.

Appendix C Table 11. OLS Estimates of a Hedonic Price Model for Harvest and Post Harvest Seasons for Medium Grain Grain Rough Rice, 1987 in Louisiana.

Quality Factors	Harvest Medium Grain 1987	Post Harvest Medium Grain 1987
Constant	-6.34 (2.42)*	-11.83 (7.40)*
Mill Price	0.584 (9.29)*	0.361 (16.73)*
Head Rice	0.10 (3.38)*	0.199 (11.0)*
Broken Kernels	0.038 (1.06)	0.078 (3.9)*
Lot Size	-0.00006 (1.77)	0.00004 (1.35)
Foreign Seeds	-0.0065 (1.19)	-0.013 (4.03)*
Heat Damage	-0.054 (1.127)	-0.041 (9.6)*
Red Rice	-0.047 (1.27)	-0.023 (1.17)
Peck Damage	-0.546 (4.02)*	0.0929 (1.36)
Smut Damage	-1.85 (1.487)	1.604 (0.95)
Chalk Damage	0.013 (0.24)	0.041 (1.03)
R^2	68%	73%
Mean Square Error	0.336	0.705
F	23.7	151.8
T	123	566

Notes: Absolute t-values in parenthesis; * indicates parameter is significantly different from zero at the 95 percent level.

APPENDIX D
SPECIFIC RESULTS FOR THE EVM MODEL FOR LONG GRAIN 1986 MARKET

Appendix D Table 12. Bounds for Preminums/Discounts, Full Model for $R^{*2} = 1$, Long Grain 1986, Medium Grain 1986, Long Grain 1987, and Medium Grain 1987, Louisiana.

Quality Factors	LG86	MG86	LG87	MG87
Red Rice:UB	0.1108	0.8108	0.4203	0.2777
Red Rice:LB	-1.7563	-3.7561	-9.3726	-8.8669
Mill Price:UB	1.4738	0.1166	1.0177	0.6561
Mill Price:LB	-3.7361	-46.0577	-6.9827	-7.2385
Head Rice:UB	2.5688	1.5133	2.6255	3.4462
Head Rice:LB	-0.2102	-0.7303	-8.3622	-0.6349
Brokens:UB	2.3568	1.6345	2.9198	3.8557
Brokens:LB	-0.2829	-0.7597	-7.2996	-0.7522
Lot Size:UB	0.0018	0.0018	0.0164	0.0109
Lot Size:LB	-0.0007	-0.0001	-0.0005	-0.0010
Seeds:UB	0.0057	0.0187	0.1245	0.1422
Seeds:LB	-0.0205	-0.0788	-0.3841	-0.8411
Heat:UB	0.0020	0.0159	0.0255	0.1853
Heat:LB	-0.8429	-0.1442	-1.0638	-1.5081
Peck:UB	88.5801	99.7396	2.8437	1.4843
Peck:LB	-323.2110	-1.3220	-259.7740	-174.8450
Smut:UB	6.2772	0.7633	3.9561	581.9480
Smut:LB	-258.3800	-149.4010	-853.3200	-161.2010
Chalk:UB	16.2304	3.1984	17.8326	13.9707
Chalk:LB	-2.1458	-0.0678	-12.0577	-2.4030

Appendix D Table 13. Matrix of Least Squares Estimates.

B	COL1
Intercept	2.58041
Red Rice	-0.021351
Milled Price	-0.084003
Head Rice	0.0434835
Lot Size	0.000018166
Foreign Seed	-0.00146884
Heat Damage	-0.00292549

Note: R^2 = 0.646286.

Appendix D Table 14. Cross Product Matrix S.

	Bid Price	Red Rice	Milled Price	Head Rice	Lot Size	Foreign Seeds	Heat Damage
Bid Price	254.701	-291.614	17.7376	3300.54	225113	-8103.83	-123.613
Red Rice	-291.614	3548.5	-35.3427	-4304.36	-559251	14472.2	79.8903
Milled Price	17.7376	-35.3427	245.864	724.362	152566	-1982.91	-155.331
Head Rice	3300.54	-4304.36	724.362	71667	2994082	-66468.7	-389.398
Lot Size	225113	-559251	152566	2994082	3782068706	-18135047	-154889
Foreign Seeds	-8103.83	14472.2	-1982.91	-66468.7	-18135047	3227500	336.591
Heat Damage	-123.613	79.8903	-155.331	-389.398	-154889	336.591	39212.3

Appendix D Table 15. Matrix S^{-1}.

	Bid Price	Red Rice	Milled Price	Head Rice	Lot Size	Foreign Seeds	Heat Damage
Bid Price	0.0110999	0.000236993	0.000932421	-0.00048266	-2.0164E-07	.0000163039	.0000324725
Red Rice	0.000236993	0.000315352	-.000011031	.0000065791	2.5138E-08	-5.4905E-07	2.3025E-07
Milled Price	0.000932421	-.000011031	0.00436046	-.000078608	-1.5774E-07	.0000025624	.0000188092
Head Rice	-0.00048266	.0000065791	-.000078608	.0000368292	1.1404E-09	-5.2465E-07	-1.4716E-06
Lot Size	-2.0164E-07	2.5138E-08	-1.5774E-07	1.1404E-09	2.9007E-10	9.3748E-10	-1.6265E-10
Foreign Seeds	.0000163039	-5.4905E-07	.0000025624	-5.2465E-07	9.3748E-10	3.4927E-07	5.8161E-08
Heat Damage	.0000324725	2.3025E-07	.0000188092	-1.4716E-06	-1.6265E-10	5.8161E-08	

Note: This matrix is the inverse of the cross products matrix. It is used to derive the k+1 set of parameter estimates.

Appendix D Table 16. Matrix of k+1 Parameter Estimates, EVM.

	Bid Price	Red Rice	Milled Price	Head Rice	Lot Size	Foreign Seeds	Heat Damage
Bid Price	-0.021351	-1.33064	0.0118[illegible]03	0.0136308	0.124668	0.0336761	-0.00709071
Red Rice	-0.084003	0.0465449	-4.67649	-0.162864	-0.78229	-0.157167	-0.579234
Milled Price	0.0434835	-0.0277606	0.0843052	0.0763047	0.00565578	0.0321795	0.0453181
Head Rice	0.000018166	-.000106071	0.000169173	.0000023628	0.00143857	-0.0000575	.0000050089
Lot Size	-0.00146884	0.00231675	-0.00274817	-0.001087	0.00464927	-0.0214223	-0.00179108
Foreign Seeds	-0.00292549	-.000971561	-0.0201724	-0.00304892	-.000806648	-0.00356728	-0.790295

Note: This matrix contains the set of k+1 parameter estimates. The values in this matrix were derived by dividing Rows 2 - 7 into Row 1 of Appendix D Table 15. Each row in the above matrix represents a variable. Each column represents a different parameter estimate with the estimates (columns) differing by the direction of minimization of the sum of squared errors.

Appendix D Table 17. Matrix of $(1-\beta_{ij}/b_j)$ factors.

	Red Rice	Milled Price	Head Rice	Lot Size	Foreign Seeds	Heat Damage
Red Rice	0.0163073	0.643465	0.610345	0.14622	0.388009	1.49723
Milled Price	0.643465	-0.0182914	-1.06521	-0.120299	-1.14814	-0.169624
Head Rice	0.610345	-1.06521	-1.32486	1.14951	3.84673	-23.7015
Lot Size	0.14622	-0.120299	1.14951	-0.0127893	0.240081	1.3807
Foreign Seeds	0.388009	-1.14814	3.84673	0.240081	-0.0736136	-4.55829
Heat Damage	1.49723	-0.169624	-23.7015	1.3807	-4.55829	-0.0037

Note: This matrix is used to calculate the R^*_n. The only values considered in the above table are those values which represent values of Appendix D Table 16 which when divided by the least square estimates are negative, i.e., $\beta_{ij}/b_j < 0$.

Appendix D Table 18. Matrix of R^{*2}_{*} factors.

	Red Rice	Milled Price	Head Rice	Lot Size	Foreign Seeds	Heat Damage
Red Rice	0.640518	0.873889	0.862174	0.698006	0.78353	1.175
Milled Price	0.873889	0.639816	0.269508	0.603735	0.240173	0.586
Head Rice	0.862174	0.269508	0.177665	1.05289	2.00693	-7.73
Lot Size	0.698006	0.603735	1.05289	0.641762	0.731206	1.134
Foreign Seeds	0.78353	0.240173	2.00693	0.731206	0.620248	-0.966
Heat Damage	1.17588	0.586288	-7.73728	1.13466	-0.966044	0.644

Note: The R^{*}_{n} is found by selecting the largest value in the above table. However, not all values are relevant to the above table because only those values which represent corresponding estimates which are of opposite sign of least square estimates.

VITA

John F. Denison was born in Lake Charles, Louisiana, on October 17, 1963. He was reared on a rice, soybean, and cattle farm 7 miles north of Iowa, Louisiana. John was a 1981 graduate of Iowa High School, Iowa, Louisiana. He entered Louisiana State University, of Baton Rouge, in August of 1981. In the summer of 1982, he moved back to Iowa and entered McNeese State University. John married Lynne Fontenot of Vinton, Louisiana, in December of 1984. In May of 1985 he received a Bachelor of Science Degree in Agriculture and Business from McNeese State University. In May of 1987, John received a Master of Science Degree in Agricultural Economics from Louisiana State University. Currently, Mr. Denison is an Assistant Professor of Agricultural Economics at Northeast Louisiana University, Monroe, Louisiana.

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