EFFECTS OF COMPETITION AND SPACE ON COUNTRY ELEVATOR GRADING PRACTICES AND PRICES FOR WHEAT

BY

JOHN WESLEY ELLIOTT

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Thesis Approved:

Brian [illegible]
Thesis Advisor

Francis Epplin

Phil Kenkel

Wayne B. Powell
Dean of the Graduate College

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Chapter I

SUMMARY OF WORK, INTRODUCTION, OBJECTIVES, AND OVERVIEW OF THESIS

Summary of Work

A simulation analysis identifies optimal wheat grading and pricing strategies for country elevators under three possible competitive structures. The three competitive structures are: 1) an elevator is a perfect monopsony, with no competition in its potential trade area; 2) an elevator has competitors that do not follow its lead in formulating a grading and pricing strategy; and 3) an elevator has competitors that copy its grading/pricing strategy. For each structure, an elevator and its competitors consider three possible grading and pricing strategies: 1) an elevator grades and segregates the wheat delivered, and also pays producers prices that differ according to the quality of wheat they deliver; 2) an elevator grades the wheat received and segregates it to receive prices from next-in-line (NIL) buyers that are adjusted for quality, but pays producers one price for all qualities of wheat; and 3) an elevator does not grade the wheat received, nor does it segregate the wheat into different qualities or pay different prices to producers for different qualities.

A sensitivity analysis identifies the optimal strategies over a range of reasonably likely operating environments, consistent with the range of conditions observed during the 1995, 1996, and 1997 harvests.

The results show that country elevators facing no competition or competitors who did not copy should have graded and segregated, and paid producers different prices for different qualities on the basis of test weight and dockage for the 1995, 1996, and 1997 wheat harvests. The price differentials were large enough for elevators to profit by passing on to producers 70 % of the differential received from NIL buyers. However, the price differentials were not large enough for shrunken and broken kernels (SBK). Therefore, country elevators would not have profited by grading and segregating, and paying producers different quality prices on the basis of SBK. There were low percentages of SBK for the 1995, 1996, and 1997 harvests.

However, for elevators with competitors that copy their grading/pricing strategies, grading and paying producers different prices for different qualities would neither increase nor decrease profits compared to not grading. However, if the elevators chose to grade, and pay quality-related prices, they would pass on most or all of the price differential received from NIL buyers. This could potentially raise the quality of U.S. wheat.

The results from the simulation and sensitivity analysis showed that a country elevator can profit from paying producers quality-related prices if price differentials received from NIL buyers are greater than two cents per bushel. Since NIL buyers have begun to charge larger discounts for specific quality characteristics, the price differentials are usually greater than two cents for the most important quality characteristics. Therefore, early adopters can be expected to pass on 70% of price differentials. The results show that the higher the price differential from NIL buyers, the higher the profits can be made by an elevator that grades correctly and passes on the price differential to producers, if its competitors do not follow suit.

However, if competitors follow suit, there is no increase in profits by grading and segregating the wheat received, and paying producers different prices for different qualities. However, producers of high and middle quality wheat benefit from higher prices, while producers of low quality receive a lower price. To the extent producers can control wheat quality, this would increase the overall quality of wheat entering the marketing system. The results changed little when varying the overall production density and the quality proportions in an elevator's trade area.

The results are consistent with Hill's (1988) assertion that market prices should convey information about the quality of the grains and should provide incentives for improving quality. Hill argues that grain quality would be improved if participants were rewarded for improving quality and value. Producers could improve quality of wheat they deliver through weed control, time of sowing, wheat variety, and tillage methods. By eliminating incentives for diminishing value, quality-adjusted prices would increase the overall quality of U.S. wheat. This could increase the U.S. market share of world wheat exports because of increased demand by importing countries..

This research is important to the whole wheat industry of the United States. Kenkel, Anderson, and Attaway found that country elevators in Oklahoma were not grading and pricing wheat based on quality. Producers supplying high quality wheat were not being rewarded.

The results here show that an early adopter of the practice of grading and paying different prices to producers can increase profit significantly by increasing its trade area for high quality wheat. As other country elevators adopt the practice, producers would have increased incentives to improve the quality of wheat.

If country elevators don't begin grading and paying prices based on quality, it could be harmful for the U.S. wheat industry. This is because countries with the reputation of high quality wheat such as Canada and Australia will continue to increase their share of world wheat exports while U.S. market share continues to decrease. As Johnson and King note, most of the grain in traditional market channels passes through country elevators, so prices set by country elevators for wheat of various qualities provide important signals from world markets to producers. Also, as consumers increasingly demand differentiated products, a market pricing system that does not adequately reward quality may lead to increased alliances and vertical integration. These may introduce inefficiencies of their own. Therefore, this author recommends to the USDA and Federal Grain Inspection Service that it consider ways to encourage elevators to grade correctly and pass on to producers quality-related price differentials received from NIL buyers. Such action should increase overall quality of U.S. wheat, and might remove part of the incentive for increased contracting and vertical integration in the industry.

In the long run, profits would not be increased by elevators for doing this, nor would they be reduced. If this is done, it would adequately transmit correct price signals to producers and this would give them incentives to improve the quality.

<u>Introduction</u>

The grain grading system has provided little incentive to country elevators to provide premiums for producers with high quality grain and charge discounts for lower quality grain. For various reasons, elevators typically have penalized producers and firms who deliver grain of a quality below some standard quality level, often the level that separates one Federal Grain Inspection Service (FGIS)-defined grade from another, but have failed to reward producers who deliver higher-quality grain. In the last two or three years, though, next-in-line (NIL) buyers have begun to charge larger discounts for specific quality characteristics (Kenkel, Anderson, and Attaway). To some extent, better grain testing technology has facilitated this. In effect, the marketing system has begun to impose its own system of grades and standards.

Elevators now must decide to what extent they will impose these more rigorous standards on producers. Measuring quality characteristics more precisely will cost more, but will reward elevators that use the information to increase price received from next-in-line (NIL) buyers and facilitate supplying products that meet consumers' needs.

However, an elevator that imposes discounts for lower quality wheat, even while paying a higher price for high quality wheat, risks losing business if farmers believe that competing elevator is more likely to pay them a higher price net of discounts. To the extent that maintaining volume is important to an elevator's profits, elevators may lose money by grading correctly and passing on premiums and discounts. They may use lenient grading as a form of nonprice competition. On the other hand, firms with more market power may have greater ability to impose discounts (Hall and Rosenfeld). Kenkel, Anderson, and Attaway found that grade information on scale tickets by Oklahoma elevators tended to overestimate test weight and underestimate dockage and undesirable grade factors, such as damaged kernels, shrunken and broken kernels, and foreign material for hard red winter wheat in the 1995 and 1996 harvests. The authors suggested that elevators were losing up to 9.32 cents per bushel for the 1995 harvest and 3.75 cents per bushel for the 1996 harvest by not grading correctly. This reflects an apparent pricing inefficiency in the Oklahoma wheat market in that elevators paid more than they should have for low quality wheat and less than they should have for high quality wheat. The study also found that elevator grading practices were providing imperfect incentives for producers to deliver high quality grain, since current practices tended to disproportionally benefit producers with the lowest quality grain. Also, they may have received less from NIL buyers than they could have. This is because an elevator that grades and prices wheat incorrectly does not know the quality of grain it has, so it cannot blend and segregate in the best way to receive the highest price from NIL buyers.

Similar inefficiencies may have contributed to increased vertical integration in the pork market; the marketing system wasn't adequately transmitting price signals for quality characteristics. Moves toward value-based marketing have enhanced the industry's ability to satisfy the consumer and increase the competitiveness of the pork sector (Brorsen). For the same reason, the beef industry is considering moving to a value-based marketing system. Feuz, Fausti, and Wagner have found that the beef market is not effectively communicating the desires of the consumer to the producer.

Grain elevators are interested in maintaining adequate margins on the volume of grain they receive and maximizing the use of their fixed assets. To do this, they must pay prices that encourage producers to supply high quality grain, but that are also high enough for average quality grain to maintain an economically efficient volume of grain. Strict and accurate grading will maximize an elevator's margin on each bushel handled; the elevator can pass on to the producer the discounts imposed by the NIL buyer, and can use appropriate segregating and blending strategies to minimize the discounts it receives. However, more lenient grading may help an elevator maintain an economically efficient volume of grain. Therefore, Kenkel, Anderson, and Attaway may be incorrect in that elevators are losing money by not grading correctly. This is because stricter grading may not maintain an economically efficient volume of grain for an elevator. This means Oklahoma elevators may be passing the correct prices on to producers due to spatial competition. This paper attempts to determine if grading accurately increases the profits of an elevator.

The research here attempts to describe how the presence and nature of competition among elevators in sourcing grain may influence an elevator's behavior in passing on or absorbing quality discounts. It attempts to explain why elevators use grading practices that appear to overvalue low-quality grain and undervalue high-quality grain. Several factors may help explain current practices, including the additional costs of grading (time, labor, and equipment), the effect of space and distance on the difference between an elevator's bid price and the price at the farm net of transportation cost, competitive pressures faced by elevators, and elevator's use of grading practices as a form of nonprice competition where elevators may be consciously over-estimating grain quality in an attempt to gain market share. Other explanations include a "prospect theory" hypothesis that producers dislike discounts more than they like premiums of the same magnitude (Benartzi and Thaler), and risk averse behavior by producers who are uncertain about the quality of their grain and the grade their grain will be assigned. These explanations recognize that discounting by elevators may cause them to lose profitable business from producers concerned about receiving discounted prices for grain.

This research concentrates on the effect of transportation cost and space and competitive pressures faced by elevators. Transportation cost affects the price an elevator must pay to attract grain of various quality characteristics from various distances across its trade area. To the extent that space and transportation cost separate an elevator from competitors, it possesses monopsony power, and may be able to attract high quality grain without paying a substantially higher price for it. Conversely, increased competition among country elevators may limit an elevator's ability to pay different prices for wheat of different quality characteristics.

Grain elevators are interested in meeting buyer demands as efficiently as possible. Therefore, an elevator needs to know the optimal prices that must be offered to producers for wheat of different quality levels to profit from grading correctly and passing on the differential payments on the basis of quality for wheat.

Objectives

The general objective of this research is to increase the pricing efficiency of country elevators' pricing practices for wheat in the Oklahoma market.

The specific objectives are as follows:

(1) Determine a local elevator's optimal grading and pricing strategies, given prices offered by NIL buyers for different quality levels of wheat.

(2) Determine the effect of space and competition on the results of objective 1.

Overview of Thesis

A simulation analysis is used to determine the extent to which a country elevator will pass on to producers premiums and discounts it receives from next-in-line buyers. Simulations are run over a range of parameter values that reflect an elevator's potential operating environment. For each set of parameters, the choice variables (price(s) paid to producers for hard red winter wheat of different qualities) that maximize profit for an elevator are selected. A sensitivity analysis is conducted, varying the production densities, the proportion of each quality of wheat available in the elevator's trade area, and price differentials paid by NIL buyers. The simulation determines the optimal prices that an elevator should pass on to producers. Several scenarios for type of competition faced by an elevator are considered to determine how competitive pressures affect prices that should be paid to producers.

The following is a brief overview of subsequent chapters. Chapter 2, a review of literature, demonstrates the concern with grain grading accuracy that the industry and academic observers have shown historically, and that it has become more important as next-in-line buyers have begun to charge more substantial discounts for wheat with less desirable characteristics. The review also discusses costs and benefits of several different ways to improve the quality of wheat.

Chapter 3 describes a profit-maximizing model for an elevator. The model solves simultaneously for an elevator's trade area and prices paid to producers, that are a function of price paid to producers by competing elevators, transportation cost, and density of wheat production in the elevator's potential trade area.

Chapter 4 describes the procedures used in the simulation. It describes the scenarios over which elevator's grading and pricing decisions are simulated. A range of parameters that reflects elevator operating and competitive environments is considered. The range of parameters chosen reflects the range of conditions observed in the 1995, 1996, and 1997 harvests as well as the 1990 market environment for comparison. A sensitivity analysis varies overall wheat production densities, prices paid by NIL buyers for different qualities, and production densities of different qualities of wheat. For each scenario, a profit-maximizing algorithm in the simulation solves for the optimal prices that should be offered by elevators to producers.

Three years of harvest time grain quality data for the 1995, 1996, and 1997 harvests collected by Kenkel, Anderson, and Attaway from Oklahoma country elevators are used to determine the percentages of the various qualities of hard red winter wheat that is present throughout Oklahoma for the different harvest years. These data provide official measurements of several hard red winter wheat quality characteristics, and are used to estimate the distributions of the quality levels for 1995, 1996, and 1997 harvest years. NIL buyer discount schedules provide discounts that were passed on to country elevators for each quality level for the 1995, 1996, and 1997 harvests. These data are used to compare to the results of the simulation and sensitivity analysis to determine how country elevators should have graded and priced wheat for the 1995, 1996, and 1997 harvests.

Chapter 5 presents the results of the simulation, identifying optimal grading and pricing strategies for each operating environment. Chapter 6 summarizes the results of the simulation and sensitivity analysis and discusses the conclusions that have been made from this study. It then suggest ways to extend and improve upon this research.

Chapter II

LITERATURE REVIEW

Introduction

The purpose of this review is to point out the importance of grain grading accuracy and how it affects the price and quality relationship of grains in the United States. It begins by reviewing the history of grain grading practices. Then, it describes the relationship between grain price and quality, as well as activities such as segregation and blending that elevators can use to achieve specific quality levels. Next, it looks at the factors affecting the number, location, and the grading and pricing strategies of a country elevator. Finally, the review examines current grading and pricing practices at country elevators.

History of Grain Grading Practices

The search for uniform measures of quality of grain grading standards is very important in establishing standards to reward quality. Hill (1990) states that the debate, and proposals for legislation, indicate that the search for defining grades to show uniform measures of quality will continue for as long as grain is bought and sold.

Hill (1988) notes that the U.S. market share of grains has decreased in the export market. For more than a century, foreign buyers have been complaining how poor U.S. wheat is compared to Canadian and Australian wheat. Adam, Kenkel, and Anderson observe that in hopes of enhancing the reputation of the U.S. as a supplier of quality grain in world markets, numerous proposals have called for changes in the U.S. grain marketing system. Hill (1988) suggests that grades with market prices should convey information about the quality of the grains and should provide incentives for improving quality. However, current grades fail to do this. Hill (1988) suggests two approaches to solve grain quality problems: (1) prohibit practices that are considered detrimental to quality such as adulteration and (2) change grades and pricing strategies so that participants are rewarded for improving quality and value. If these are done, he argues, the market should provide premiums for higher quality wheat and eliminate incentives for diminishing value. This means grades should be based on economic values, and should provide incentives for better quality.

Price-Quality Relationship for Grain

In the last two or three years, domestic and international markets have began to tighten grain quality requirements and the marketing system has begun to impose its own system of grades and standards. Country elevators must now decide the extent to which they should impose these tighter standards on producers, offering premiums and charging discounts for various qualities of wheat. Hall and Rosenfeld formulated a theoretical model specifying quality characteristics for grain as a function of various economic elements. The economic relevance of quality factors in proper grading techniques can be assessed by determining the extent to which elevators' discount schedules are explained by these economic elements. Hall and Rosenfeld used an empirical model, the results of which indicated that damage and foreign matter were economically important quality factors that warranted discount pricing. However, test weight was not an economically significant factor for quality discounts for corn. Accordingly, Hill (1990) suggested that test weight should be considered for elimination from the United States official set of grain grades and standards for corn because there is no relationship between test weight and nutritional and protein values in corn. However, test weight may be more important. Flagg states that for wheat, flour milling yield is one of three important factors considered when buying wheat, and that test weight is strongly correlated with milling yield.

Also, dockage in the U.S. marketing system is a nongrade-determining factor but other countries include dockage as a grade-determining factor with many limits. Canadian and Australian regulations guarantee minimum dockage levels in exports, and these are uniform for all importing countries. This may be one reason Canada and Australia have increased their market share in the world wheat market. Since dockage in the U.S. is not a grade determining factor, competitive pressures and grain cleaning serve as the regulatory mechanism (Wilson, Scherping, Johnson, and Cobia). Brennan states that the Australian Wheat Board believes there are two reasons for implementing differential payments on the basis of quality. The first reason is to redistribute current payments to the producers whose wheat contributes most of the value to the overall profits of an elevator. The second reason is to provide an incentive for farmers to improve the quality of wheat delivered. Brennan states that incentives need to be adequate to revoke a response by farmers to improve the quality of Australian wheat. If there is not enough incentive, then quality will not be improved.

Wilson notes that price differentiation in the world wheat market has increased in the last 15 years. He finds that there is an implicit market for quality characteristics in export wheat. Therefore, as price differentials increase, the importance of differentiating increases. This implies that accurately grading grains will become important to country elevators and their profits. It also has important implications for competitive strategies among competing elevators.

Barkely and Porter discuss choices of wheat variety by Kansas producers during 1974 to 1993. The decisions were statistically associated with production characteristics and end-use qualities. The results provide evidence that producers are interested in end-use value characteristics, but economic considerations lead producers to plant varieties with high yields but low milling and baking qualities. Producers have few incentives to plant new varieties of wheat with high end-use milling and baking qualities.

Hill, Brophy, Zhang, and Florkowski conducted a questionnaire sent to corn and soybean farmers in Illinois, Iowa, and Indiana to determine farmers' attitudes toward discounts and premiums implemented by country elevators for different qualities of grain. One question asked was if they would like to eliminate all discounts and premiums for quality except for moisture, and receive one average price for grain regardless of quality, even if few grain buyers pay premiums for high quality corn. A response to eliminate discounts could be a way for farmers to increase their net price. They surprisingly found that 61.4% of Illinois farmers, 68.3% of Iowa farmers, and 55.8 % of Indiana farmers said they did not favor the elimination of quality discounts and premiums for corn and soybeans. Thus, a majority of these favored use of correct price differentials to help improve the quality of grains.

Hill, Brophy, and Florkowski estimated a supply function based on a farm survey to determine responses to price premiums on higher quality corn achieved by using low-temperature drying methods. Their research showed that farmers are willing to make investments to improve corn quality even though it may require several years to recover the investment costs. Also, the results of their model indicated that farmers will shift to low-temperature drying on corn at premiums as low as one cent per bushel. This suggests that farmers are likely to respond to premiums in a positive manner.

Research to improve wheat quality can help increase profits at a country elevator. Voon and Edwards evaluate the size and distribution of the economic benefits from research that increases the protein content in Australian wheat. They estimated that Australia has the potential to obtain net benefits of up to $53 million per year from a one percentage point increase in protein content in wheat. The most interesting result was that 90% of the gains accrue to wheat producers. Barkely and Porter state that research developing new varieties of wheat will achieve higher end-use qualities as well as high yields per acre. However, the creation of new varieties is estimated to require fifteen years which means other actions must be done to improve current quality of wheat.

Activities Improving the Quality of Grain at Country Elevators

Mechanically cleaning wheat can also improve quality. Cost of cleaning is an important factor in an elevator's choice to improve quality. A country elevator might want to provide premium incentives to farmers for cleaner wheat to try to eliminate costs of cleaning wheat, and to help improve blending and segregating activities by the elevator. Adam, Kenkel, and Anderson estimated the costs and benefits of cleaning export wheat at country elevators, subterminal elevators, and port elevators. The net cost of cleaning ranged from .5 cents to 2.0 cents per bushel, depending on wheat value, quality characteristics and cleaning location, with a nationwide average of 1.0 cent per bushel. These authors found that the largest cost of cleaning wheat is the value of wheat and other material lost in cleaning which averages 2.4 cents per bushel. However, although premiums for low dockage wheat were not generally available at the time of their study, elevators that are able to negotiate premiums would have found it profitable to clean wheat.

Johnson and Wilson use a mathematical programming model to analyze cleaning decisions at country elevators in the United States. They compared the years 1987 and 1990, where 1987 was characterized by a crop with high dockage and low screening values, while the 1990 crop was more normal. They found that screening value and transportation cost had the most influence on cleaning decisions. Screening values greater than $20 to $25 per ton induced cleaning. Also in 1987, cleaning for long hauls was more profitable with transportation costs in excess of $.90 per bushel. The authors found that in the 1987 harvest year, a minimum discount of $.50 per bushel was necessary to induce cleaning down to .5% dockage. For 1990, no discount was necessary because other factors, such as transportation cost around $.50 per bushel, provided sufficient incentive to induce cleaning. The authors conclude that, although they were not pervasive in current trading practices, discounts for excess dockage can induce cleaning to satisfy the demands of next-in-line buyers.

Lin and Leath, summarizing several studies, concluded during the early 1990's that cleaning all U.S. export wheat would not be economically feasible. They suggest that the costs could exceed benefits by $8 million dollars if all wheat is cleaned. Therefore, they suggest that the best strategy is only to target countries that are willing to pay a premium for cleaner wheat. Lin and Leath state that if the U.S. were to target niche markets, it could gain $8 to $10 million in net benefits. Domestic benefits occur in the form of lower handling, storage, and transportation costs, and revenue from sales of screenings. International benefits stem from any premiums foreign buyers are willing to pay for cleaner wheat and from increases in U.S. wheat exports. In conclusion, cleaning wheat can be very expensive unless it is managed to clean wheat only for those markets that offer premiums for cleaner wheat. Therefore, correct grading procedures will be required to keep track of different qualities of wheat to be cleaned. To reduce cleaning cost, premiums offered to farmers to produce better quality wheat could reduce costs of cleaning because of the increased supply of better quality wheat.

Strategies such as segregation and blending can be used to increase the quality of wheat. Kenkel, Anderson and Attaway used a linear programming model to determine the most profitable segregation strategy for an elevator in the 1995 and 1996 wheat harvests in Oklahoma. The model assumed that the elevator had the ability to segregate wheat into three different bins as it was received. The quality of wheat in each bin was determined by the segregation strategy. These strategies included segregating by moisture, test weight, dockage, and grade. The model then selected blending and cleaning activities to maximize profits. For the 1995 harvest, segregation activities helped elevators with cleaning equipment increase their profits by 2.2 to 3.0 cents per bushel. The 1995 harvest year was a higher dockage year, with the wheat containing an average of about 3.85% dockage. For the 1996 harvest, segregating, blending, and cleaning strategies had little impact on elevator profits. The 1996 harvest year was a low dockage year, averaging about .97% dockage.

Hill (1988) notes that blending provides country elevators a source of income. This is because grain with higher moisture, foreign material, and damaged kernels will achieve a higher price if it can be blended with higher quality grain. For example, lower quality corn with 5% foreign material can be blended with 1% foreign material to achieve 3% foreign material which is the maximum allowed for No.2 corn at a base price. This means the better quality corn can be used to make poorer quality corn a better value (Hill 1988). Hill also states that economic incentives for blending exists for all grade factors.

Wrigley notes the best post-harvest strategy for ensuring grain of appropriate quality that is provided to the market is to correctly test for quality after harvest when the grain is delivered to the elevator. Also, segregate grain of different quality types into different bins and pay producers according to the respective market values. Wrigley states that this system has worked in Australia for many decades. The limitations for this strategy is quality testing must be fast and the extra cost of testing and of separate storage and transportation cost must be low enough to be justified by the increase in market value.

<u>Factors Affecting a Country Elevator's Grading and Pricing Practices</u>

Oppen and Hill discuss the differences in the number of size of country grain elevators among the various geographical regions in Illinois. The authors tried to gain an understanding of the factors influencing the size and number of elevators for use in predicting the future structure of the industry. They used a transportation model and assumed that storage costs increase at a linear rate and that transportation rates($/bu/mi) from the farm to the elevator decrease with disclosure at a decreasing rate. The model assumed that country elevators are of equal size. The expected increases in corn production and in the quantity of corn moved off-farm at harvest would cause elevators to grow in number if marginal storage capacity and marginal transportation cost stayed the same. Oppen and Hill found that since marginal capacity is likely to go up and marginal transportation costs are likely to go down, a decrease in the number of country elevators is likely. The model predicted a decrease in the number of elevators from 1,430 in 1967 to 692 in 1975, and an increase in the average capacity from 250 to 660 thousand bushels. Oppen and Hill fail to recognize other factors that might influence the location and number of elevators in Illinois, such as competition between elevators in the same region.

There are many factors that might influence a country elevator's grading and pricing strategies in passing premiums/discounts on to producers. Hall and Rosenfeld found that traditional arrangements may allow larger capacity elevators to pass on higher discounts to the extent they think the market will handle. This is because farmer relationships with smaller elevators tend to be on a more personalized basis and less on an economic standpoint, and these smaller elevators rely on local farmers for grain supplies. The larger elevators can extend their buying reach across a number of producing and trading areas. Hall and Rosenfeld's research found that the greater the market share of a single elevator, the higher its grain quality discounts. Therefore, an elevator's market power may have a large effect on its pricing and grading strategies.

Davis and Hill analyzed spatial price differentials for corn among Illinois country elevators. They looked at causes of price variability that can be attributed to differences in availability and cost of transportation, operating costs, local demand and supply conditions, and market power. Differences in transportation cost, operating cost, and supply and demand all have an economic reason for differences in price. Differences in market power, however result in a market imperfection. A geographical monopsony exists among country elevators because of spatial distances from the producer to an elevator and competing elevators, which influence opportunity costs and actual costs of shipping grain to elevators. Davis and Hill found that transportation costs, access to distant markets through rail and water, and the supply of corn available or purchased all affect the price variability among elevators. However, these variables are outside the control of the individual elevator. They found that a country elevator has a geographical monopsony where it can use cost as a basis for setting price: it's a market with many competing firms in a structure of monopsonistic competition as well as seasonally induced spatial monopsony. This means that a country elevator has little control over variability of prices among its competition except through its monopsony power due to spatial distance among competing elevators.

Thompson and Dziura analyzed a study of merchandising margins in 1982 and 1983 at different locations of grain elevators in Illinois. A merchandising margin is the difference between prices paid to producers and price received from next-in-line buyers. They ran a regression analysis to determine what factors such as storage capacity, number of competing elevators, and the area of an elevator's supply that might affect the merchandising margins for a country elevator. Thompson and Dziura found that there is an inverse relationship between the merchandising margin and the radius of the firm's supply, capacity utilization, and the scale of operation. Also, a negative relationship was found between merchandising margins and number of competing country elevators. This means that more competitors surrounding a country elevator imply that the country elevator will receive smaller merchandising margins.

Grain Grading Accuracy

Grain grading accuracy is very important in determining the appropriate grades assigned to grains. Kenkel, Anderson, and Attaway have found that Oklahoma elevators tend to grade inaccurately, costing a typical elevator more than 9.32 cents per bushel in the 1995 harvest year and 3.75 cents per bushel in the 1996 harvest year. These authors collected harvest-time quality data from Oklahoma country elevators in 1995 ,1996, and 1997. Their project was based on over 3,900 tail-gate truck samples at 43 elevators throughout the Oklahoma wheat production areas. They are currently working on the data for the 1997 harvest. They selected sampling sites to represent all major wheat producing areas, and to include elevators with trade territories that extended into Texas and Kansas. Their samples were obtained using truck (tailgate) sampling procedures recommended by the Federal Grain Inspection Service (FGIS). Kenkel, Anderson, and Attaway collected four to six-samples from each truck by pulling the truck sampling container in random interval through the entire falling grain stream in a continuous motion. The four to six sub-samples were then combined to provide a 1,200 to 1,500 gram sample for each truck. Each sample was identified by an elevator scale ticket number and stored in a sealed container. These data were then officially graded by the Enid FGIS and compared to country elevator grades. Complete scale ticket data were obtained for each sample, including net weight, moisture, dockage, test weight, grade and other grade factors such as shrunken and broken kernels, foreign material, and total defects. The elevators tended to overestimate test weight and underestimate dockage and other undesirable grade factors such as damaged kernels, and shrunken and broken kernels. The inaccuracy results in a higher grade assigned to the grain than should be assigned.

The major portion of the loss to elevators in both years resulted from underestimating dockage in wheat. Kenkel, Anderson, and Attaway state that underestimating dockage has two impacts on the country elevator. This is because terminal elevators remove dockage from weight and they impose price discounts for dockage levels above specified levels. Therefore, a country elevator who underestimates dockage pays wheat price for material that is removed from weight by the terminal elevator and an elevator ends up paying cleaning fees or losing some of their margin in excess of the price discounts it originally charged to the producer.

Kenkel, Anderson, and Attaway considered three different methods to help improve grading. They measured the benefits using automated probes versus hand probes and from mechanical dockage testers versus hand pan sieves in grading accurately, as well as the importance of each step in the grading process. They found that the use of mechanical dockage testers improved the accuracy of dockage estimates from country elevators. Specifically, they found that elevators with dockage machines were less likely to underestimate dockage. In the 1995 harvest, elevators using hand pan sieves underestimated the true dockage level by twice as much as those using mechanical dockage testers and elevators using hand probes versus automatic probes found no significant difference in dockage estimation. In the 1996 harvest, elevators with mechanical dockage testers had a third less error in estimating dockage than elevators using hand sieves. There was little difference in accuracy of dockage estimation in either year between elevators using automated probes and those using hand probes, although in 1996 the error was slightly higher for automated probes. Kenkel, Anderson, and Attaway also measured the importance of each grading step. The three most important steps were the determination of dockage, test weight, and shrunken and broken kernels. Checking for dockage was the most important because it would have benefited the elevator almost 25 cents per bushel in 1995 and over 5 cents per bushel during the low dockage 1996 harvest. They found that checking for test weight was worth about 16 cents per bushel to elevators in 1995 and over 9 cents per bushel in 1996. Checking for shrunken and broken kernels would have benefited an elevator 0.9 cents per bushel in 1995 and around a third of a cent per bushel in 1996. Therefore, using mechanical dockage testers and recognizing the importance of each grading step can significantly increase an elevator's returns.

The results by Kenkel, Anderson, and Attaway suggest that inaccurate grading elevators tend to benefit producers delivering the lowest quality wheat. This means that the producers bringing higher quality wheat do not benefit in the form of higher price, and thus have no incentive to deliver higher quality wheat.

Kiser and Frey's working paper on dockage survey results on the 1990 Kansas wheat harvest showed that most of the grain elevators measured for dockage. However, only fifty-four percent of the respondents that reported they measured for dockage in wheat subtracted the dockage from the net weight of the purchased wheat. Also, some elevator operators planned to deduct for dockage but stopped the practice when nearby competitors did not also adjust for dockage. However, the survey results only indicated whether or not elevators were measuring for dockage; it did not determine if they were discounting it correctly and checking for undesirable characteristics such as foreign matter and shrunken and broken kernels.

Gunn and Wilson looked at grading and pricing practices of North Dakota country elevators for durum and hard red spring wheat. They conducted personal interviews with 77 country elevator managers to compare the grading practices of country elevators to the federal grain inspection standards. They found that some grading steps were skipped to save time and money. Pricing strategies at these elevators were compared to determine if location in the state, storage capacity, distance to competition, and the board price for durum and hard red spring wheat affected their pricing strategies from country elevators. The only important factor affecting pricing strategy was price offered for wheat protein, which varied by location in the state. Therefore, Gunn and Wilson found that elevators are not grading as accurately as they could but their pricing practices are consistent with the market.

Grading inaccuracy at country elevators is not a recent phenomenon. Farris collected samples from Indiana country elevators for the 1955 wheat harvest season and compared elevator grading and pricing practices to official grades measured at the Purdue Agronomy Laboratory. Farris's results found that most elevators discounted less than the laboratory findings would indicate. Farris indicated that country elevators were afraid to discount grain too heavily to avoid farmer dissatisfaction. Therefore, most of the country elevators followed a practice of grading leniently. Farris found that for the 1955 harvest in Indiana, there is evidence of considerable opportunity for increasing the effectiveness of the wheat pricing system. Farris noted that the observed grading practices appear to overvalue low quality wheat and fail to reward producers of high quality wheat. This means that an incorrect price signal is sent to the producers, so that the qualities of wheat that consumers and the market really want is not revealed.

Summary

This review has demonstrated the concern with grain grading accuracy that the grain industry and academic observers have shown historically. This concern has become more pronounced as next-in-line buyers have begun to charge more substantial discounts for wheat with less desirable characteristics.

The review has also noted several ways that have been suggested for improving wheat quality. However, each of these has associated costs that must be compared with their expected benefits. As Johnson and King note, most of the grain in traditional marketing channels passes through country elevators, so prices set by country elevators for wheat of various qualities provide important signals from world markets to producers. Hill (1988) has argued that if grain quality characteristics were measured and recorded as accurately as measurement technology permits, the market would establish value, reward efforts to improve quality, and eliminate incentives for diminishing value of grain.

This research attempts to increase efficiency in wheat markets by measuring the extent to which country elevators should measure grain quality characteristics more precisely, and the extent to which they should pass on premiums and discounts to producers for various qualities of wheat. The research explicitly considers the tradeoff an elevator faces between paying lower prices to receive a larger merchandising margin and paying higher prices to attract enough grain to optimize capacity utilization. The results help identify useful pricing strategies by individual elevators. They also have important implications for the structure of the industry. If elevators are not able to pass on price signals from consumers of grain to producers, the wheat industry may be forced into more contracting arrangements or even vertical integration, as consumers express demand for increasingly differentiated products.

The theoretical model introduced in Chapter 3 shows an elevator profit model. The model shows an elevator's profit is dependent on the price paid to producers. This model is modified because an elevator's profit is a function of price paid to producers, competition price paid to producers, transportation cost, and density of production. This modified model determines an elevator's trade area given space and competition. To find the trade area of an elevator, mathematical equations are used to find the radius of the trade area. The modified elevator model is used to determine an elevator's optimal grading and pricing strategy to maximize profit.

Chapter III

THE MODEL

Theoretical Model

Chapter 1 suggests that grain elevators are interested both in maintaining adequate margins on the volume of grain they receive and in maximizing the use of their fixed assets. Accurate grading and the correct price differentials passed on for the different qualities of grain will maximize an elevator's margin on each bushel handled. However, lenient grading techniques may help increase the volume of grain it receives from the producer.

Chapter 2 discussed the importance of accurately grading grains and passing on the correct price differentials to the producers because it is a very important mechanism to improve the quality of grains in the United States. The model specified here will determine the best grading and pricing strategy to maximize profit for a profit-maximizing elevator facing competitors that are separated by space and transportation cost. In other words, the elevator has a degree of spatial monopsony (Davis and Hill).

The objective of a country elevator is assumed here to be profit maximization. It performs only merchandising activities, which means grain is purchased from farmers and sold directly to next-in-line (NIL) buyers. It is assumed that no grain is left in storage at the country elevator at the end of harvest, so that quantity purchased from farmers equals quantity sold to NIL buyers. Therefore, the elevator's profit function can be written as (Adam, Attaway, Dicks, and Garrison):

(1) $$Profit = P_{NIL}Q(P_f) - P_fQ(P_f) - C_vQ(P_f) - C_{fx}$$

where:

P_{NIL} = price received by the elevator from NIL buyers for wheat
P_f = price paid by the elevator to farmers for the average quality of wheat delivered by farmers
C_v = variable merchandising costs
C_{fx} = fixed costs
Q = quantity purchased by elevator and sold to NIL buyers

The Elevator Model

The model above is extended to consider several specific factors that influence an elevator's profit. The elevator chooses the price paid to farmers that maximizes profit. The quantity received from producers by an elevator is a function of density of production in the elevator's trade area, price offered to producers, competitor's price offered to producers, and transportation cost. The model allows the elevator to pay different prices for, and merchandise different quantities of, each of several qualities of wheat. The model assumes that the elevator has three bins in which to segregate three different qualities of wheat. The quality of wheat in each bin is determined by the quality of wheat received from producers (Kenkel, Anderson, and Attaway). From this, the elevator's model can be expressed as:

(2) $$\max_{P_{fib}} Profit = \sum_{b=1}^{m}\sum_{i=1}^{n} [P_{NIL_b}Q_{ib} - P_{fib}Q_{ib}(k_i, P_{fib}, P^C{}_{fib}, t_i)] - C_{vib}Q_{ib} - C_{fx}$$

where:

$$(3) \qquad \sum_{i=1}^{n} Q_{ib} = \sum_{i=1}^{n} k_i[\pi(\frac{1}{2t_i}(P_{fib} - P^C_{fib} + t_i U)^2)],\ \textit{for all } b$$

$$(4) \qquad Q = \sum_{b=1}^{m} \sum_{i=1}^{n} Q_{ib}$$

where:

P_{NIL_b} = price received from NIL buyer for blend b
P_{fib} = price paid to farmers by elevator (P_{fib}) for i^{th} quality used in blend b
P^c_{fib} = price paid to farmers from competing elevator (P^C_{fib}) for i^{th} quality used in blend b
C_{vib} = variable costs for handling ith quality in blend b
Q_{ib} = quantity of wheat of i^{th} quality purchased by elevator for use in blend b
k_i = density of production of wheat of quality i in elevator's trade area (bu/mi^2)
U = distance (miles) between elevator (P_{fib}) and competing elevator (P^C_{fib})
t_i = transportation cost for i^{th} quality ($/mi/bu)
π = pi (circumference of a circle divided by the diameter)

The assumptions for this profit maximization model, are summarized as follows:

(1) The elevator and competing elevators have the same facility constraints.

(2) Transportation cost per bushel per mile is identical between any elevator and any farm.

(3) Wheat production occurs in a homogeneous unbounded plain at uniform density k_i.

(4) The market areas of the elevators are circular because they possess some monopsony power (Capozza and Van Order).

(5) Producers know the quality of their wheat before they deliver it to the elevator.

Equation 3 provides a measure of the quantity of wheat available in an elevator's trade area. The elevator's trade area is assumed to be the area of a circle surrounding the elevator (Bressler and King). The radius of the elevator's trade area depends on the difference between the price paid to the producer by the elevator (P_{fib}) and the best competitive price by another elevator (P^c_{fib}), adjusted for transportation cost. The law of market areas asserts that the boundary between the two elevators is the locus of points where market price net of transportation cost for loads of wheat shipped to Elevator P_{fib} and Elevator P^c_{fib} are equal (Bressler and King). Modifying Capozza and Order's model for oligopolistic firms, this can be mathematically expressed for oligopsonistic firms as follows:

(5) $P_{fib} - t_i R = P^c_{fib} - t_i (U-R)$, where R is the radius of the elevator's market area.

This means that at the edge of an elevator's trade area, transportation-adjusted price at the elevator is equal to transportation-adjusted price at a competing elevator. In addition, producers may have a market for wheat other than elevators. Equation 5 can be expressed as follows where x is the alternative value of wheat for use in say, cattle feeding:

$$P_{fib} - t_i R = \text{Max}\,(x, P^c_{fib} - t_i (U-R)) \quad (6)$$

With six competitors (P^c_{fib}) U miles away, each paying the same price, so that the elevator's trade area is circular. Therefore, the radius is equal to the following:

$$R = 1/2t_i\,(P_{fib} - \max(x, P^c_{fib} - t_i U)) \quad (7)$$

When an elevator raises it's price and the competitor's firm stays the same, then the radius of the trade area of the firm with the highest price will increase and the competing firm's radius will decrease. Mathematically, the radius is equal to the following:

$$R = 1/2t_i\,(P_{fib} + \Delta P_{fib} - \max\,(x, P^c_{fib} - t_i U) \quad (8)$$

The area of the circle (the elevator's trade area), is π times the square of the radius (R). The quantity of wheat of quality i is determined by multiplying by the production density of wheat of quality i (k_i) in the trade area.

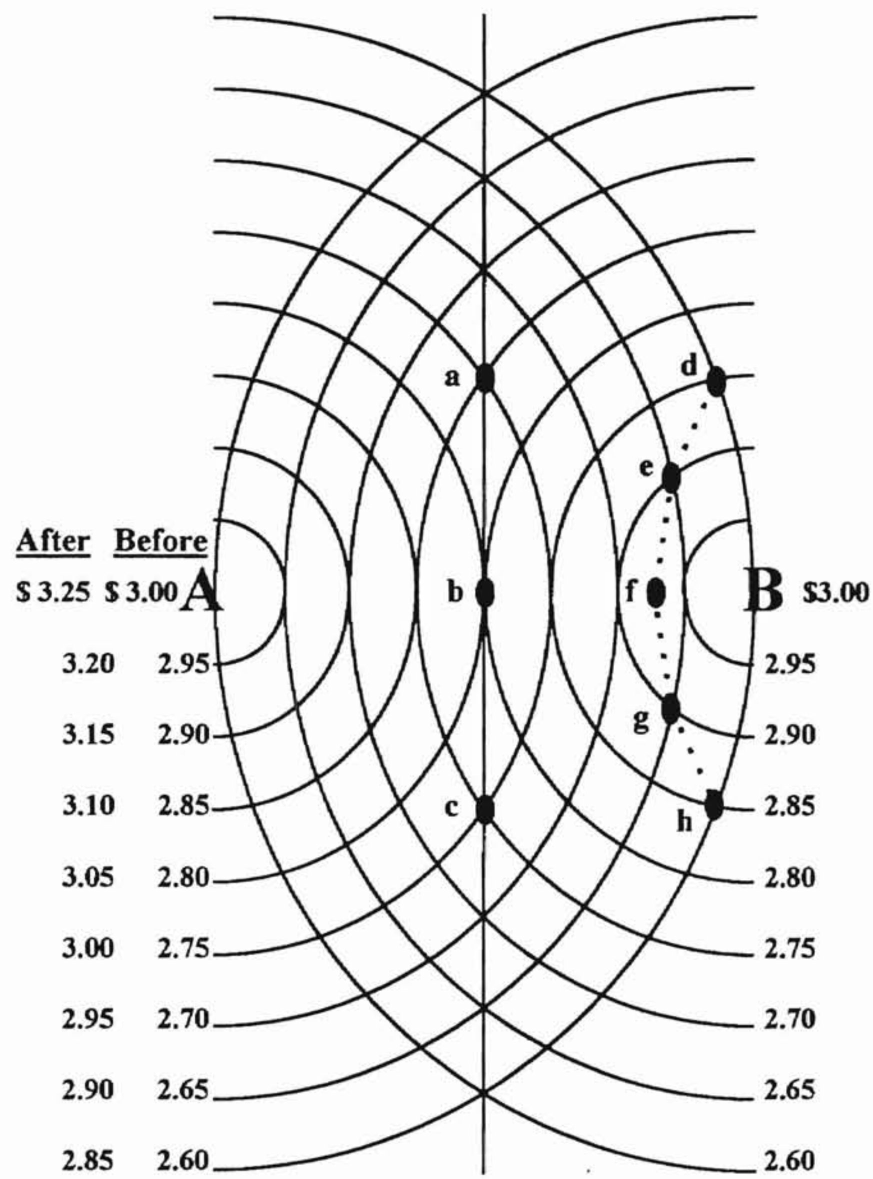
Thus, the quantity of wheat purchased by the elevator is positively related to the price paid by the elevator, with associated monopsony pricing characteristics, and to the density of production, but negatively related to the competing price and transportation cost. For a given price paid to farmers at the elevator, a higher transportation cost reduces the net price paid to producers. Since transportation costs typically increase with distance from the elevator, the farther a producer is from the elevator, the lower will be the net price to the producer. At some distance from the elevator, the elevator price minus transportation cost equals the producer's alternative price (which could be a competitor's price net of transportation cost or the value of alternative use for the grain such as for feeding cattle), marking the edge of the elevator's trade area (Bressler and King). The lower the price at the elevator, the higher the transportation rate, or the higher the value of an alternative use for grain, the smaller the elevator's trade area. From the producer's perspective, the lower the producer's alternative market value for grain the more monopsony power that can be exerted by the elevator.

When the market price net of transfer cost is the same between two different elevators, the law of market areas asserts that the boundary between two competing markets is a straight line perpendicular to one connecting the two elevators. This means prices paid to farmers hauling wheat to two different elevators are assumed to decrease uniformly in direct relation to the distances from each market, for the case where transportation cost is a linear function of distance (Tomek and Robinson). However, if one elevator raises its price and the other elevator leaves its price the same, the boundary line will lie closer to the lower price elevator than to the higher price elevator. The line becomes curvilinear, with the elevator with the higher price extending its trade area by taking some of the competitor's trade area. Therefore, the boundary is a constant difference in distances to the two markets, and the market boundary would be a hyperbola (Bressler and King). The market boundary is a hyperbola because Bressler and King assumes only two elevators competing against one another.

For example, in Figure 3.1, Elevator A, paying price P_{fib}, and Elevator B, paying price P^c_{fib}, are located 40 miles from each other and each concentric circle represents an additional 5 miles distance from an elevator. First, suppose that transportation cost is \$.01/bu/mi and that Elevator A and Elevator B both set the price of wheat at \$3.00 per bushel. The law of market areas asserts that the boundary between the two elevators is the locus of points where market prices net of transportation cost for loads of wheat shipped to Elevator A (P_{fib}) and Elevator B (P^c_{fib}) are equal (Bressler and King). Equations 5 and 7 are used to solve for the boundary and the radius. Since prices and per mile transport costs for the two different elevators are the same, the price boundary is a straight line that lies halfway between the two markets and is perpendicular to one connecting the two elevators. The straight line joins point b, which is equidistant from the two markets at \$2.80 per bushel and it joins points a and c at \$2.75 per bushel.

If Elevator A raises its price to \$3.25 per bushel while elevator B keeps its price at \$3.00 per bushel, the boundary becomes a curved line because the price is higher in one

Figure 3.1
Spatial Competition Between Two Elevators



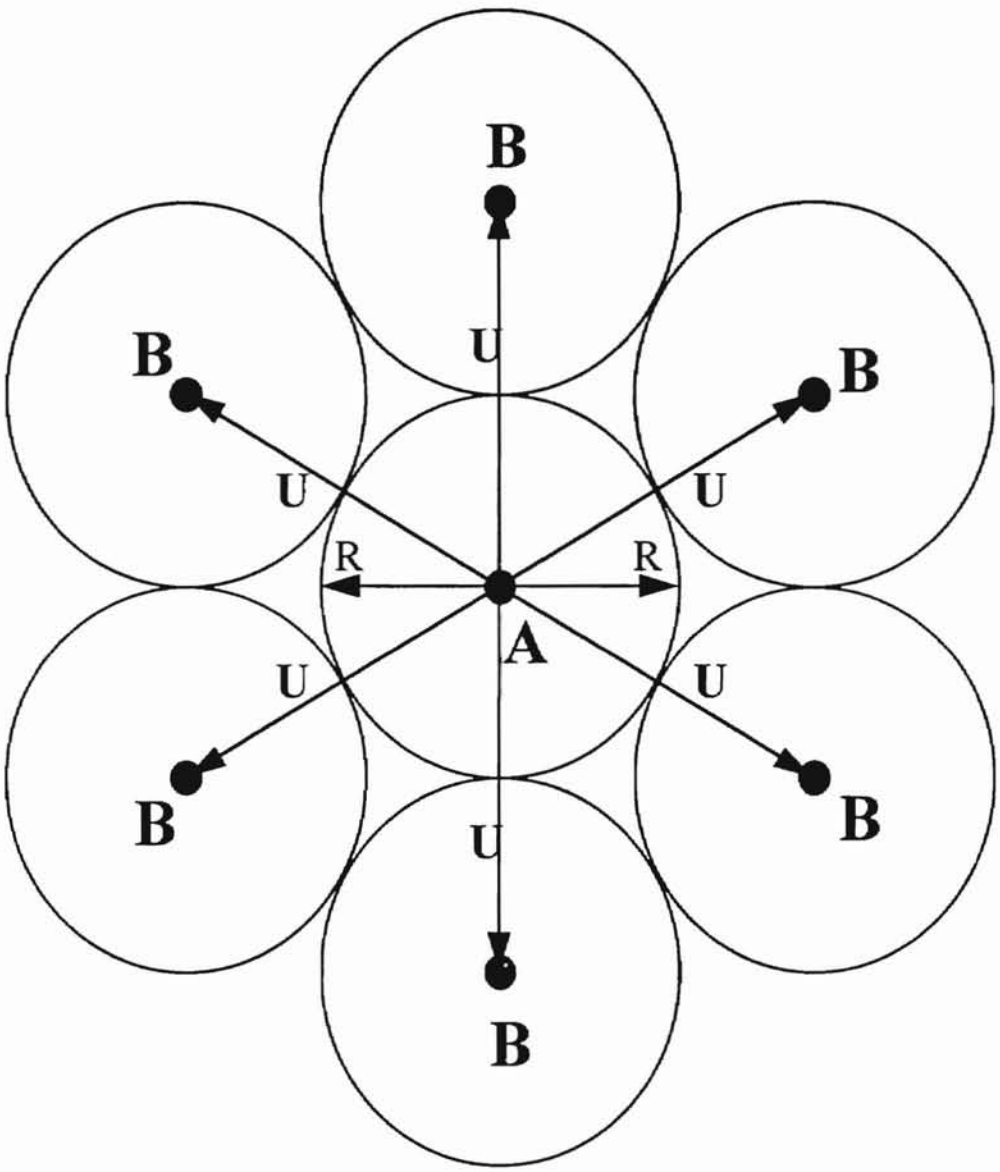
elevator than in the other. Since transportation cost is the same for the two elevators, and is a linear function of distance, the boundary line will lie closer to the lower price elevator than to the higher price elevator. The boundary starts at point f at $2.925 per bushel and intersects points e and g at $2.90 per bushel. This means farmers located at points e and g receive $2.90 per bushel regardless of where they sell their wheat, while farmers at points d and h receive $2.85 per bushel. Farmers at point f receive $2.925 per bushel regardless of where they sell their wheat. This shows the market boundary to be the shape of a hyperbola. This means prices paid to producers will strongly determine the trade area of a certain elevator.

Theoretically, Figure 3.1 is correct if there are only two elevators competing against each other. The market boundary would be shaped like a hyperbola if one elevator has a higher price than a competing elevator net of transportation cost. However, there are usually more than two elevators competing against each other in the Oklahoma wheat market. Capozza and Van Order assumed there are six competitors surrounding each firm where each surrounding firm is a small proportion of the total competition faced by the firm. If this is correct, then the market boundary would not be shaped like a hyperbola for the higher priced elevator. Many competing elevators surrounding an elevator would make that elevator's trade area approximate a circle. An elevator paying a higher price would extend the radius of its trade area.

Using the model by Capozza and Van Order implies that the elevator's trade area will be circular, regardless of the price differences between an elevator and its competitors net of transportation cost. This means the price offered to producers will determine the radius of the circle shaped market area of an elevator. There has been great controversy on what is the true shape of a market area for a firm to maximize profit. Mills and Lav hypothesize the shape to be circular while Greenhut claims it to be hexagonal. Greenhut states that the hexagon fills up empty spaces which the circle cannot do. Greenhut claims that the hexagon would be more profitable than its inscribed circle in competitive equilibrium. However, Mills and Lav state that a firm will always choose a circular market area unless competitors constrain it to some other market-area form. This is because firms prefer circular market areas because if a firm finds it profitable to buy from a producer t miles away in one direction, it must be profitable to buy from a producer t miles away in each direction. Mills and Lav present proof that under certain cost and demand relationships, a circular market area of a given size would provide greater profits under competition than would a hexagon of that same size. Therefore, spatial competition need not result in space-filling market areas to maximize profit for a firm. Therefore, this paper uses a circular shape for the market area of an elevator.

Following Capozza and Van Order, Figure 3.2 shows six competing elevators (represented by elevator B) located around an elevator (A). This figure shows that, due to many competitors, the trade area of an elevator will approximate a circular shape regardless of the different prices offered to the producers net of transportation cost. The radius (R) of elevator A's trade area is marked by a circle around A. Wheat production inside each circle has uniform density (k_i bushels per square mile) and the transportation cost is identical between any elevator and farm at t_i units per mile per bushel. The distance from the elevator (A) to its competitors (B) is U. The next section discusses the other

Figure 3.2
Spatial Competition Among Many Elevators



reasons besides space and competition why elevators tend to grade and price wheat incorrectly to producers.

Other Reasons Country Elevators Bids May Not Reflect Quality Differences

Other explanations are discussed briefly on why country elevators don't pass on the correct discounts to producers resulting in pricing inefficiencies in the grain marketing system. The model and simulation analysis ignore these factors because they are difficult to display in a mathematical model. Farmers face price risk in that they don't know exactly the quality characteristics of their wheat. They don't know until the wheat is delivered to the elevator the final price they will receive after the elevator discounts for quality levels that are lower than expected. This paper assumes a farmer knows the quality of wheat they bring in.

Compounding this risk is the possibility that, as prospect theory suggests, farmers value discounts differently than premiums, so that a discount decreases utility more than a premium of the same magnitude increases it. For example, farmers might prefer to take their wheat to an elevator that is not checking for dockage and offering an average price than to an elevator that is charging discounts for high dockage and offering premiums for low dockage wheat. The theory suggests that farmers are more adversely affected by the possibility of a discount for low quality wheat than they are positively affected by an equal probability of a premium for high-quality wheat (Benartzi and Thaler).

Country elevators face competition in their trading area from other elevators. This could be the reason that elevators are afraid to adopt new grading practices to discount properly for low quality wheat and reward producers for high quality wheat. If prospect theory is correct, an elevator may believe that discounting for low-quality wheat will cause farmers to go to other elevators that are not discounting, even though it is also offering premiums for high-quality wheat. Therefore, quantity purchased from farmers may also depend on other factors such as risk faced by farmers and the effects on producer preferences explained by prospect theory. These factors all could affect the profit maximizing pricing decisions of a country elevator. However, they are not included in this analysis, and further research should address them.

<u>Summary</u>

Grain elevators need to know the prices they should pay to producers for wheat of different quality levels to profit from grading correctly and passing on the appropriate premiums/discounts. It is expected that the results from objectives 1 and 2 will show that at some magnitude of price differences paid by NIL buyers for different qualities of wheat, elevators will find it profitable to grade correctly and pass on correct price differentials.

Chapter 4 describes the procedures and various data used to calibrate the model. The elevator model in the next chapter takes the form of a simulation analysis to determine the optimal grading and pricing practices that should be used by an elevator given particular operating environments.

Chapter IV

PROCEDURES

Chapter 4 describes the data and procedures used in the simulation analysis. A simulation analysis is used to determine the optimal grading and pricing strategies under various scenarios for country elevators.

Model Specification

This section describes the scenarios over which elevator's grading and pricing decisions are simulated. A range of parameters that reflects elevator operating and competitive environments is considered. For each set of parameters, a profit maximizing algorithm chooses the optimal prices the elevator should pay producers for different qualities of wheat. The range of parameters chosen reflects the range of conditions observed in the 1995, 1996, and 1997 harvests, as well as from 1990.

Wheat grown in an elevator's trade area is assumed to fall into any of three quality categories: high, middle, and low. As wheat is harvested and delivered to the elevator, the elevator may choose to grade each unit of wheat delivered to determine whether it is high, middle, or low quality wheat. If it does so, it can keep the different qualities separate to receive the highest possible price from NIL buyers. In practice, elevators may additionally increase profits by blending to take advantage of the discrete differences between quality levels. In this model, however, since each load of grain delivered to the elevator fits precisely into one of the three strategies, blending provides no additional benefit in most scenarios. Further, to maximize profits, the elevator may choose to pay producers different prices for the different qualities of wheat to encourage delivery of more high quality wheat. The elevator's choices are hypothesized to depend on prices paid by NIL buyers for the different qualities of wheat, amount of wheat produced in the elevator's trade area, the relative amounts of each quality of wheat produced in the elevator's trade area, and on the type of response by competing elevators to the elevator's grading/pricing strategy.

To focus on the benefits to an elevator of grading correctly and of paying prices to producers that depend on quality, the simulations are organized into three possible grading/pricing strategies, and three possible competitive industry structures. The three grading/pricing strategies are: 1) an elevator grades and segregates the wheat received, and also pays producers prices that differ according to the quality of wheat they deliver; 2) an elevator grades the wheat received and segregates it to receive prices from NIL buyers that are adjusted for quality, but it pays producers one price for all qualities of wheat; and 3) an elevator does not grade the wheat received, nor does it segregate the wheat into different qualities or pay different prices to producers for different qualities.

The three competitive structures are: 1) an elevator is a perfect monopsony, with no competition in its potential trade area; 2) an elevator has a competitor that formulates its grading/pricing strategy independently of the first elevator; and 3) an elevator has a competitor that copies its grading/pricing strategy exactly.

The three grading/pricing strategies combined with the three possible competitive structures make up nine scenarios. For each of these scenarios, the sensitivity of the elevator's optimal pricing decisions to a range of parameters is simulated. The range of parameters represents the range of values observed from 1990 to 1997.

Following the spatial competition model described in the previous chapter (Figure 3.2), Elevator A is assumed to be the leader in grading/pricing strategies, and elevator B is assumed to be the follower. Elevator B is representative of the six elevators that surround Elevator A. It is assumed the six competing elevators are located around elevator A at a distance of 40 miles. The scenarios are summarized in an outline as follows:

Competitive Structure 1. No Competition (Elevator A is a Perfect Monopsony)

Strategy 1.
  Elevator A Grades and Segregates (Pays Different Quality Prices)

Strategy 2.
  Elevator A Grades and Segregates (Pays One Average Price)

Strategy 3.
  Elevator A Does Not Grade or Segregate (Pays One Average Price)

Competitive Structure 2. Competition (Elevators A and B Don't Copy Each Other)

Strategy 1.
  Elevator A Grades and Segregates (Pays Different Quality Prices)
  Elevator B Grades and Segregates (Pays One Average Price)

Strategy 2.
  Elevator A Grades and Segregates (Pays Different Quality Prices)
  Elevator B Does Not Grade or Segregate (Pays One Average Price)

Strategy 3.
  Elevator A Grades and Segregates (Pays One Average Price)
  Elevator B Does Not Grade or Segregate (Pays One Average Price)

Competitive Structure 3. Competition (Elevators A & B Copy Each Other)

Strategy 1.
  Elevators A & B Grade and Segregate (Pay Different Quality Prices)

Strategy 2.
  Elevators A & B Grade and Segregate (Pay One Average Price)

Strategy 3.
  Elevators A & B Do Not Grade or Segregate (Pay One Average Price)

No Competition

In the first scenario, an extreme case where the elevator has no competition is assumed. Three different grading and pricing practices are considered. The first strategy is that elevator A grades and segregates the wheat received, and also pays producers prices that differ according to the quality of wheat they deliver. Elevator A segregates to receive prices from NIL buyers that are adjusted for quality. The model is mathematically shown as follows:

$$\text{(9)} \qquad \underset{P_{fi}}{\text{Max}}\ Profit = \sum_{i=1}^{n} [P_{NIL_i} Q_i - P_{fi} Q_i(k_i, P_{fi}, t_i)] - C_{vi} Q_i - C_{fx}$$

where:

$$\text{(10)} \qquad \sum_{i=1}^{n} Q_i = \sum_{i=1}^{n} k_i [\pi (\frac{P_{fi} - x_i}{t_i})^2],\ for\ all\ i$$

$$\text{(11)} \qquad Q = \sum_{i=1}^{n} Q_i$$

$$\text{(12)} \qquad P_{fi} - x_i \geq 0$$

where:

P_{NILi} = price received from NIL buyer for quality i ($/bu)
P_{fi} = price paid to farmers by elevator (A) for ith quality ($/bu)
x_i = alternative outlet price to producer for wheat of quality i
C_{vi} = variable costs for handling ith quality
Q_i = quantity of wheat of ith quality purchased by elevator
k_i = density of production of wheat of quality i in elevator's trade area (bu/mi^2)
t_i = transportation cost for ith quality ($/bu/mi)
π = pi (circumference of a circle divided by the diameter)

In the second strategy, the elevator A grades the wheat received and segregates it to receive prices from NIL buyers that are adjusted for quality, but it pays producers one price for all qualities of wheat. Elevator A's objective function can be expressed as:

(13) $$\underset{P_f}{\text{Max}}\ Profit = \sum_{i=1}^{n} P_{NIL_i} Q_i - P_f \sum Q_i(k_i, P_f, t_i, x_i) - C_{vi} Q_i - C_{fx}$$

where:

P_f = price paid to farmers by elevator (P_{fi}) for wheat of all qualities.

Finally, in the third strategy, elevator A does not grade the wheat received, nor does it segregate the wheat into different qualities or pay different prices to producers for different qualities. The elevator's objective function can be expressed as:

(14) $$\underset{P_f}{\text{Max}}\ Profit = P_{NIL} \sum_{i=1}^{n} Q_i - P_f Q_i(k_i, P_f, t_i, x_i) - C_{vi} Q_i - C_{fx}$$

where:

P_{NIL} = price received by the elevator from NIL buyers for all wheat merchandised

Competition (Elevators Don't Copy Each Other)

For this competitive structure, there are assumed to be six competitors located around elevator A, 40 miles away (see Figure 3.2 in Ch. 3). It is assumed that elevator A's competitors (represented by elevator B) maximize profits, but pay the same price for all qualities regardless of A's prices within this structure.

The first strategy specifies that elevators A and B grade and segregate the wheat received to receive prices from NIL buyers that are adjusted for quality. However, elevator A pays producers prices that differ according to the quality of wheat they deliver, but elevator B pays producers one price for all qualities of wheat. Thus, A iteratively solves expression (15), while B iteratively solves expression (17).

(15) $$\underset{P_{fi}}{\text{Max}}\ Profit = \sum_{i=1}^{n} [P_{NIL_i} Q_i - P_{fi} Q_i(k_i, P_{fi}, P^C{}_f, t_i)] - C_{vi} Q_i - C_{fx}$$

where:

(16) $$Q_i = k_i[\pi(\frac{1}{2t_i}(P_{fi} - \max(x, P^C{}_f - t_i U))^2)],\ for\ all\ i$$

(17) $$\underset{P_f}{\text{Max}}\ Profit = \sum_{i=1}^{n} [P_{NIL_i} Q_i - P_f \sum Q_i(k_i, P_f, P^C{}_{fi}, t_i)] - C_{vi} Q_i - C_{fx}$$

where:

(18) $$Q_i = k_i[\pi(\frac{1}{2t_i}(P_f - \max(x, P^C{}_{fi} - t_i U))^2)],\ for\ all\ i$$

$P^c{}_{fi}$ = price paid to farmers by competing elevators for ith quality
$P^c{}_f$ = price paid to farmers by competing elevators for all qualities
U = distance between elevator(A) and competing elevators

In the iterative process, the price paid to producers by competing elevators (represented by elevator B) is itself the result of elevator B optimizing some variant of expression (17) with P_{fi} representing elevator B's price to producers and $P^c{}_{fi}$ representing elevator A's price to producers. The expressions are solved iteratively. First, A solves for its price(s) given some starting value for B's competing prices. Then B solves for its price(s) using A's solution as the competing price(s). Then A solves again for its price(s) using B's solution as updated competing price(s). The iterations continue until neither A nor B changes its optimal price(s) from one iteration to the next by more than some small amount epsilon.

The second strategy is the same as the first strategy except that A's competitors do not grade or segregate; they receive a blend price for the average quality of wheat they merchandise. Thus, A iteratively solves expressions (15) while B iteratively solves expression (19).

$$(19) \qquad \underset{P_f}{\text{Max}}\ Profit = P_{NIL}\sum_{i=1}^{n} Q_i - P_f Q_i(k_i, P_f, t_i, P^C{}_{fi}) - C_{vi}Q_i - C_{fx}$$

where:

$$(20) \qquad Q_i = k_i[\pi(\frac{1}{2t_i}(P_f - \max(x, P^C{}_{fi} - t_i U))^2)],\ for\ all\ i$$

In the third strategy, elevator A grades and segregates the wheat received, but pays producers one price for all qualities of wheat. Elevator B does not grade the wheat received, nor does it segregate the wheat into different qualities or pay different prices to producers for different qualities. Therefore, elevator A solves expressions (21) while B iteratively solves expressions (23).

$$(21) \qquad \underset{P_f}{\text{Max}}\ Profit = \sum_{i=1}^{n} P_{NILi}\ Q_i - P_f Q_i(k_i, P_f, t_i, P^C{}_f) - C_{vi}Q_i - C_{fx}$$

where:

$$(22) \qquad Q_i = k_i[\pi(\frac{1}{2t_i}(P_f - \max(x, P^C{}_f - t_i U))^2)],\ for\ all\ i$$

$$\text{(23)} \qquad \underset{P_f}{\text{Max}}\ \textit{Profit} = P_{NIL}\sum_{i=1}^{n} Q_i - P_f Q_i(k_i, P_f, t_i, P^C{}_f) - C_{vi} Q_i - C_{fx}$$

where:

$$\text{(24)} \qquad Q_i = k_i[\pi(\frac{1}{2t_i}(P_f - \max(x, P^C{}_f - t_i U))^2)],\ \textit{for all } i$$

In this competitive structure, P^c_{fi}, price paid to farmers by competing elevators, (represented by elevator B) is itself the result of elevator B optimizing equations 17, 19, or 23 with P_{fi}, representing elevator B's price to producers and P^c_{fi} representing elevator A's price to producers. The optimizations are solved iteratively. First A solves for either expressions 15 or 21 given some starting value for B's competing price. Then B solves expressions 17, 19, or 23 using A's solution as the competing price. Then A solves expressions 15 or 21 using B's solution as the competing price. This iteration combination continues until neither A nor B changes its optimal price from one iteration to the next by more than some small amount epsilon.

Competition (Elevators Copy Each Other)

For the third competitive structure, there are assumed to be six competitors located around elevator A, 40 miles away, as with the second competitive structure (see Figure 3.2 in Ch. 3). However, in the third competitive structure, all elevators are assumed to follow elevator A's grading and pricing strategies.

Three different grading and pricing strategies are considered. The first strategy is that elevator A and its competitors grade and segregate the wheat received, and also pay producers prices that differ according to the quality of wheat they receive. The model is mathematically shown as equation 25.

$$(25) \qquad \underset{P_{fi}}{\text{Max}}\ Profit = \sum_{i=1}^{n} [P_{NIL_i} Q_i - P_{fi} Q_i(k_i, P_{fi}, P^C_{fi}, t_i)] - C_{vi} Q_i - C_{fx}$$

where:

$$(26) \qquad Q_i = k_i[\pi(\frac{1}{2t_i}(P_{fi} - \max(x, P^C_{fi} - t_i U))^2)],\ for\ all\ i$$

For the second strategy, elevator A and its competitors grade the wheat received and segregate to receive prices from NIL buyers that are adjusted for quality, but they pay producers one price for all qualities of wheat. In the second scenario, each elevator's objective function can be expressed as equation 21.

Finally, in the third strategy, elevator A and its competitors do not grade the wheat received, nor do they segregate the wheat into different qualities or pay different prices to producers for different qualities. Each elevator's objective function can be expressed as equation 23.

In this competitive structure, P^c_{fi}, price paid to farmers by competing elevators, (represented by elevator B) is itself the result of elevator B optimizing equations 21, 23, or 25 with P_{fi}, representing elevator B's price to producers and P^c_{fi} representing elevator A's price to producers. The optimizations are solved iteratively. First A solves for either expressions 21, 23, or 25 given some starting value for B's competing price. Then B solves expressions 21, 23, or 25 using A's solution as the competing price. Then A solves expressions 21, 23, or 25 using B's solution as the competing price. This iteration combination continues until neither A nor B changes its optimal price from one iteration to the next by more than some small amount epsilon.

If an elevator does not segregate the wheat into three qualities in the models above, it would receive one average price from NIL buyers. This is a naive sort of blending because they are just mixing together all the wheat purchased; the elevator receives one average price from NIL buyers. This is modeled by first multiplying the quantity of wheat of quality i by the number i, for all i. If this weighted average is less than 1.1, it receives the quality 1 price; if the average is less than 2.1 but greater than 1.1, it receives the quality 2 price; and if the average is greater than 2.1 it receives quality 3 price. For example, if 10,000 bushels are quality 1, 50,000 bushels are quality 2, and 20,000 bushels are quality 3, the weighted average quality is (10,000 x 1 + 50,000 x 2 + 20,000 x 3)/90,000 = 1.9. This mixture of wheat would receive the price for quality 2 wheat. The dividing lines between qualities of wheat are chosen arbitrarily, but changing those lines does not change the results qualitatively; using other dividing lines would change the relative profitability of segregating the wheat vs. blending, and this itself depends on the proportion of each quality of wheat available in the elevator's trade area. Thus, the sensitivity analysis conducted for varying proportions of each quality level provides perspective on how the results might change if this blending rule is changed.

Grain Grading System

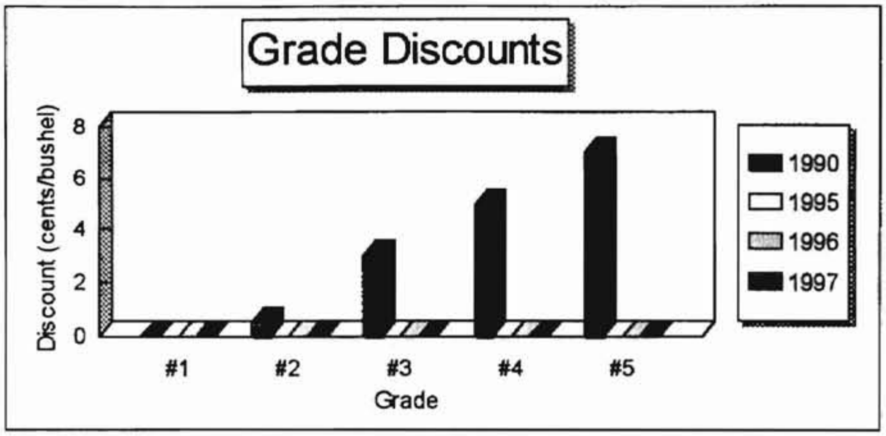
This section reviews data that are used to parameterize the simulation. In the last two or three years, domestic and international markets have begun to tighten grain quality requirements and the marketing system has begun to impose its own system of grades and standards. Hard red winter wheat in the United States is graded based on physical quality characteristics outlined in the Official U.S. Standards for Grain (FGIS 1997). Grades for wheat are based on test weight, foreign material, shrunken and broken kernels (SBK), damaged kernels, and total defects, which is a combination of foreign material, shrunken and broken kernels, and damaged kernels. There are five numerical grades of hard red winter wheat, where #1 represents the highest quality. Wheat which does not meet the requirements for #5 is considered U.S. Sample Grade (S.G.) and can be used only in nonfood products. The nongrade factors are dockage and moisture and are reported on the official grain ticket but do not determine the numerical grade of wheat.

From Chapter 2, Kenkel, Anderson, and Attaway stated that the three most important steps in grain grading were the determination of dockage, test weight, and shrunken and broken kernels. Figures 4.1, 4.2, 4.3, and 4.4 show the change in discount schedules from 1990 to the more stricter 1995, 1996, and 1997 schedules for grades, dockage, test weight, and shrunken and broken kernels.

Figure 4.1 shows that NIL buyers no longer discount for the numerical grade of hard red winter wheat as they did in 1990. On the other hand, NIL buyers have begun to discount more strictly for grade and nongrade determining factors. Thus, specific factors have replaced the numerical grade in NIL buyers' discount schedules.

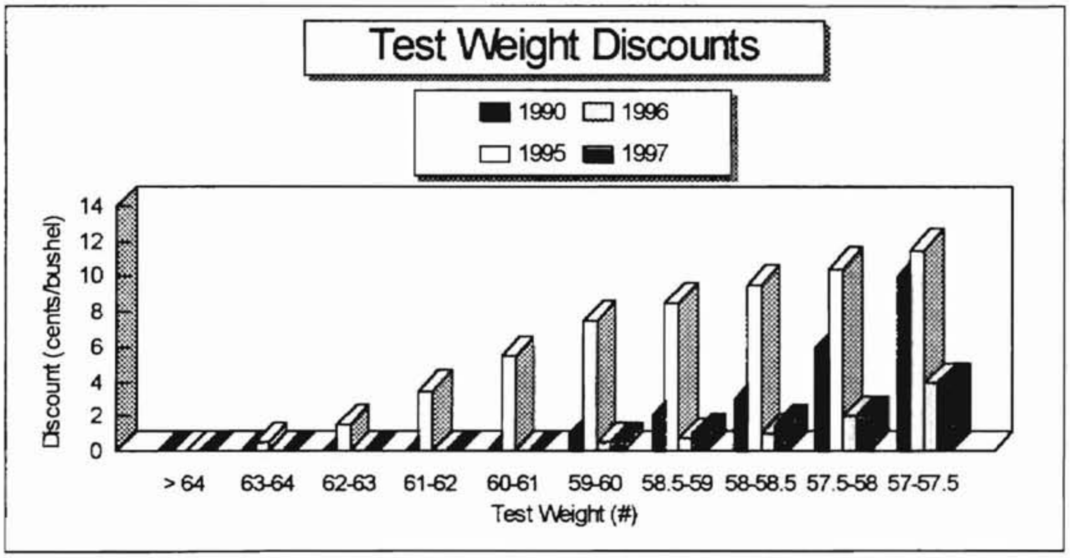
Figure 4.2 shows the changes in discounts for test weight from 1990 to 1995, 1996, and 1997. This figure shows that NIL buyers discounted for low test weight in each of those years. According to Flagg, test weight is the most reliable indication of potential flour yield, which means that low test weight reduces flour mill profits. Thus, test weight has been important for many years because it is positively related to the end use

Figure 4.1
Grade Discounts From NIL Buyers
For 1990, 1995, 1996, and 1997 Wheat Harvest



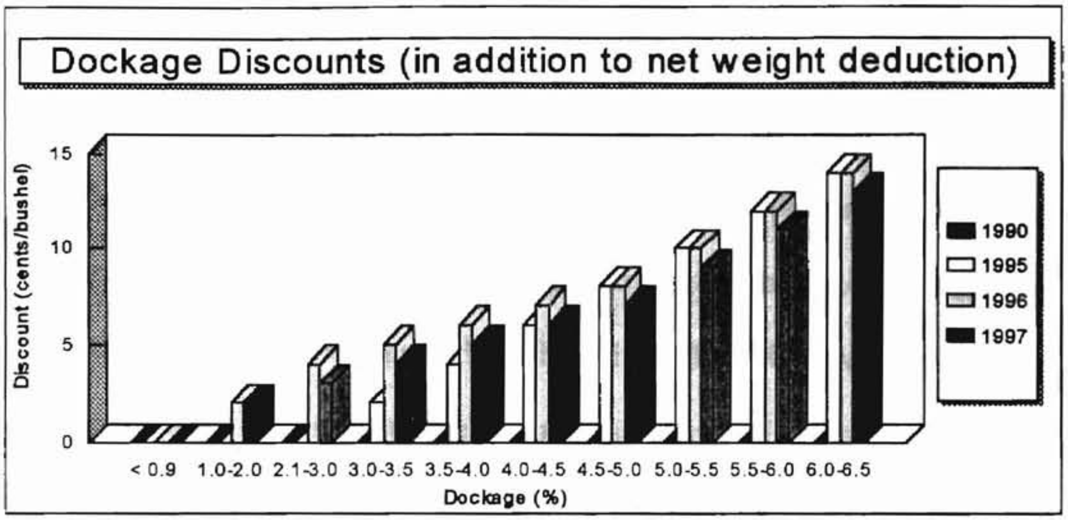
Source: 1990 information -- Adam, Kenkel, and Anderson
1995 and 1996 information -- Kenkel, Anderson, and Attaway
1997 information -- Farmland Grain Division

Figure 4.2
Test Weight Discounts From NIL Buyers
For 1990, 1995, 1996, and 1997 Wheat Harvest



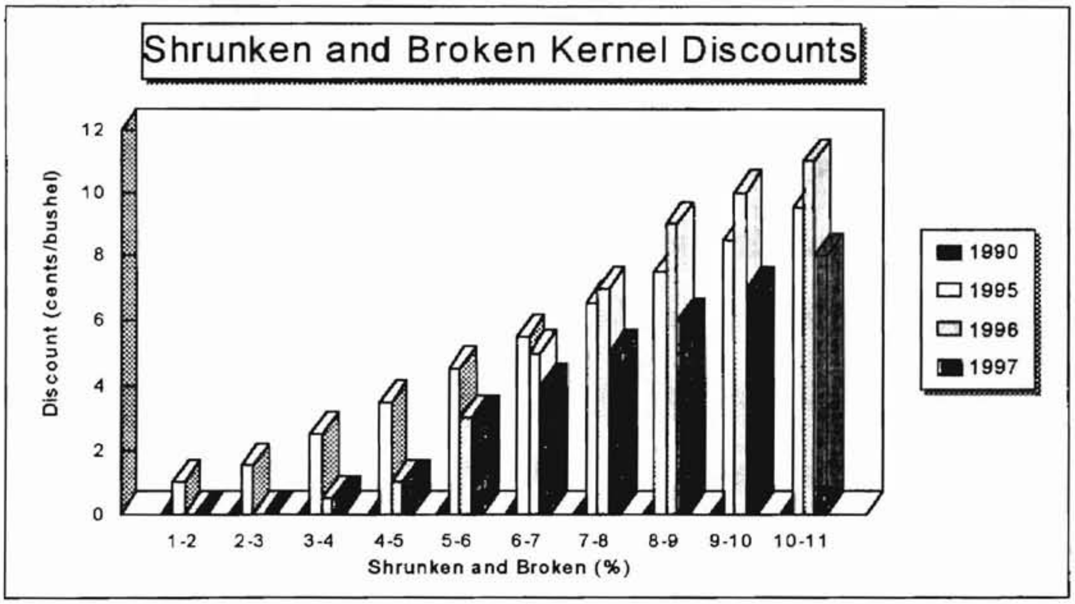
Source: 1990 information -- Adam, Kenkel, and Anderson
1995 and 1996 information -- Kenkel, Anderson, and Attaway
1997 information -- Farmland Grain Division

Figure 4.3
Dockage Discounts From NIL Buyers
For 1990, 1995, 1996, and 1997 Wheat Harvest



Source: 1990 information -- Adam, Kenkel, and Anderson
1995 and 1996 information -- Kenkel, Anderson, and Attaway
1997 information -- Farmland Grain Division

Figure 4.4
SBK Discounts From NIL Buyers
For 1990, 1995, 1996, and 1997 Wheat Harvest



Source: 1990 information -- Adam, Kenkel, and Anderson
1995 and 1996 information -- Kenkel, Anderson, and Attaway
1997 information -- Farmland Grain Division

characteristics of wheat.

Figure 4.3 shows the changes in discounts for dockage from 1990 to 1995, 1996, and 1997. The figure shows that NIL buyers have become stricter on dockage. In 1990, there were no discounts for dockage except that its weight is subtracted from the net weight of a load. However, in 1995, 1996, and 1997, dockage discounts were imposed, in addition to the deduction from weight, and are becoming increasingly important. China, the largest buyer of U.S. wheat, has indicated that it will buy wheat with eight tenths of one percent dockage or less. Japan, the second largest buyer of U.S. wheat, has indicated that it is limiting dockage to five tenths of one percent. This shows that importing countries are demanding a cleaner product, and dockage discounts will get tougher (Johnston Grain Company). Flagg states that overseas millers do not want dockage because the transportation cost on dockage reduces profit.

Figure 4.4 shows the changes in discounts for shrunken and broken kernels from 1990 to 1995, 1996, and 1997. In 1990, there were no discounts for shrunken and broken kernels, but discounts were imposed for the 1995, 1996, and 1997 harvests. This is because domestic and international buyers are demanding a higher quality product. Flagg states that a lot of shrunken and broken kernels results in low test weight wheat.

These figures show that the grade factors and other nongrade quality factors have become increasingly important to the elevators' grading and pricing practices. Country elevators must now decide the extent to which they should impose these tighter standards on producers by passing on different prices for various qualities of wheat. Wrigley states that the obvious strategy of ensuring that grain of appropriate quality is provided to the market is to correctly grade for wheat when it is delivered to the country elevator, to segregate grain of different quality types into different bins, and to pay producers correct price differentials for the different qualities. Wrigley noted that this has worked well in Australia for many years. However, there are three drawbacks to grading correctly: testing must be fast (preferably less than 3 min, while the truck is waiting), the increase in market value must be large enough to justify the extra cost of testing and segregation, and the risk of losing business to competitors by correctly grading. Brennan mentions two reasons for implementing differential payments on the basis of quality: (a) redistribute current payments to the producers whose wheat contributes the most value to the overall profits of an elevator, and (b) provide incentives for farmers to improve the quality of wheat delivered.

Grain Quality Data

Harvest-time quality data from Oklahoma country elevators have been collected for the 1995, 1996, and 1997 hard red winter wheat harvests (Kenkel, Anderson, and Attaway). These data provide official measurements from FGIS of several wheat quality characteristics, and are used to estimate the distributions of these characteristics in loads of wheat delivered to elevators at harvest. These data are broken down by the yearly NIL discount schedule to determine the different prices that are paid for the different qualities of wheat. Appendix table A.1 shows the different qualities of wheat that were distributed throughout Oklahoma during the 1995 harvest. These data were collected from 1,314 loads of wheat delivered by farmers to 16 different elevators. Appendix table A.2 represents the different qualities of wheat that were distributed throughout Oklahoma during the 1996 harvest. These data were collected from 13 elevators and 1,366 loads. Appendix table A.3 represents the different quality characteristics of wheat that were distributed throughout Oklahoma during the 1997 harvest. These data came from 14 Oklahoma country elevators and 1,251 loads. These data are used to provide a representative range of relative quality densities for the simulation model.

Hard red winter wheat discount schedules implemented by NIL buyers during the 1995 and 1996 harvests were collected from Kenkel, Anderson, and Attaway. A 1997 NIL discount schedule from Farmland Grain Division is used to represent discounts imposed by NIL buyers for the 1997 harvest. Appendix tables A.4, A.5, and A.6 show these discount schedules.

For this study, only test weight, dockage, and SBK are considered when determining how elevators should grade and price wheat for the 1995, 1996, and 1997 harvests. These three characteristics are considered because they are three most important steps in the grading process. Appendix tables A.7, A.8, and A.9 show the quality distribution of test weight, dockage, and SBK categorized by high quality, middle quality, and low quality for the 1995, 1996, and 1997 harvests. These tables also show the NIL buyer discounts on each quality level for test weight, dockage, and SBK.

Although the discount schedules do not reflect any premiums paid for high quality wheat, but rather discount from the highest price for less than top quality. This assumes the base price for wheat is the price for middle quality wheat. It assumes there are premiums offered for high quality wheat, and discounts imposed for low quality wheat. The reason for this departure is to ensure that comparing the effects of varying the size of discounts does not at the same time change the simulated average price paid for wheat production.

The Oklahoma Agricultural Statistics Service is used to estimate the density of wheat production for representative wheat-producing districts. The density of production in an elevator's trade area (bu/mi^2) is calculated by taking the bushels per farmland acre times 640 acre/square mile. Farmland acres includes all land in Oklahoma in farms. This is a total of 32,143,030 acres of land, or 73.1% of the total land area in Oklahoma (Oklahoma Agricultural Census).

The density of production is summarized by nine Agricultural Statistical Reporting Districts consisting of the Panhandle, West Central, Southwest, North Central, Central, South Central, Northeast, East Central, and the Southeast Districts. The total farm land area for each district is calculated and multiplied by the production of each district, to get the production density. Yield data from 1997 has not yet been released. Appendix tables A.10 and A.11 show the density of production of wheat for each district and the overall average for Oklahoma for 1995 and 1996.

<u>Simulation Analysis</u>

Simulations are run over a range of parameter values that reflect elevator operating conditions under three different scenarios and three different strategies for each one. For each set of parameters, the choice variables (price(s) paid to producers for wheat of different qualities) that maximize profit are selected for the main elevator and the competing elevators. GAUSS is used to run the simulations; each iteration within the simulation is solved using the constrained optimization module.

The data discussed above are used to select a range of parameters that reflect elevator operating and competitive environments. For the base simulation, differentials for each quality of $0.10, with a base price of $4.90 per bushel, are used. This means that $5.00 is paid for high quality wheat, $4.90 is paid for middle quality wheat, and $4.80 is paid for low quality wheat. The production density that is used is 2,174 bushels per square mile, the average production density throughout Oklahoma in 1995. Of this production, it is assumed that 10% is high quality, 60% middle quality, and 30% low quality. This is consistent with the relative proportions of test weight observed in the Oklahoma region in 1995.

Sensitivity Analysis

A sensitivity analysis is conducted on the scenarios above to reflect an overall picture of an elevator's operating and competitive environments for the 1995, 1996, and 1997 wheat harvests. Price differentials are varied from $.10 to $.08, $.06, $.04, $.02, and $.00 to reflect potential changes in premiums and discounts offered by NIL buyers. Next, the production densities are varied to include 1,000, 2,174, and 4,000 bushels per square mile to represent the amount of wheat produced in different areas of Oklahoma. Also, the relative distribution of high quality, middle quality, and low quality wheat is varied. First, 10% high quality, 60% middle quality, and 30% low quality is used. It then is varied to 30% high quality, 40% middle quality, and 30% low quality. Finally, it is changed to 50% high quality, 20% middle quality, and 30% low quality. These quality levels are used to represent the changes in the quality levels for different harvest years.

The results of the analysis will be useful in assessing the effects of varying operating environments on elevator strategies. Much of the variation in parameters modeled by the sensitivity analysis was realized over the three crop years of 1995, 1996, and 1997, and across production regions in Oklahoma. For example, the 1995 wheat harvest in Oklahoma was known as a high dockage year, with an average of 4% dockage. The 1996 crop year was a drought year, with low production. The 1997 crop year was a freeze year but production densities were still high because the freeze affected only the southwest part of the state. The results will also provide insight into the effects of particular strategies had they actually been implemented in those years.

Cost Data

This paper assumes producers use trucks to haul their wheat to country elevators, which transport the wheat to next-in-line buyers. Fuller used models containing linear mileage equations to determine truck cost. The model from Fuller represents short haul costs as well as long hauls. The transportation cost estimated by Fuller is $.00108 per bushel per mile. NIL buyer prices are specified to be prices actually received by country elevators after paying transportation cost. The transportation cost used by Fuller assumes a truck with a hopper and bottom dump that can hold 833 bushels. These costs are used in the simulation analysis to determine an elevator's trade area.

Data for both fixed and variable elevator operating costs is taken from Kenkel and Anderson (1992). Fixed cost include depreciation, administrative overhead, market information, and interest and is assumed to be $100,000. Variable costs include labor, utility, chemical, and repairs. Variable cost are assumed to be $.05 cents per bushel. The fixed and variable costs assumed used are an average of the estimates by Kenkel and

Anderson's work of grain handling cost at Oklahoma elevators.

Finally, elevators that grade wheat are assumed to purchase a Carter-Day Dockage Tester (which is used by the official inspection agencies), at an estimated cost of $5,000. This model assumes that an elevator that is grading correctly purchases a mechanical dockage machine. This grading machine amortized over a 20-year life at 10% interest, for an annual cost of $587 at 1,000,000 bushels/year throughput. Also, grading correctly and segregating is assumed to require one additional worker at an elevator. The additional worker is required at the leg and dump pits to segregate the qualities of wheat. The additional worker is assumed to cost $12 an hour for 52 weeks at 40 hours per week during the year. This results in an additional $25,000 variable cost per year; for an elevator handling 1,500,00 bushels per year, average variable cost would increase from $.05/bushel to $.067/bushel if the elevator began to grade and segregate the wheat. Also, the elevator that is correctly grading segregates three different qualities into three bins for sale directly to NIL buyers. It is assumed elevators require no additional capital or equipment to segregate up to three different qualities of wheat since most elevators already have facilities appropriate for that.

Summary

Three competitive structures, with three possible grading and pricing strategies for each one are simulated. The simulation uses base numbers of $4.90 per bushel for middle quality wheat, with a premium of $0.10/bushel for high quality wheat and a discount of $0.10/bushel for low quality wheat, and production density of 2,174 bushels per square mile, consisting of 10% high quality, 60% middle quality, and 30% low quality wheat. A sensitivity analysis is ran conducted from the base levels, varying the production densities, price differentials, and quality levels to determine the best grading and pricing strategy for test weight, dockage, and SBK for the 1995, 1996, and 1997 harvests.

Chapter 5 describes the results of the simulations and determines the optimal grading and pricing strategies for each competitive structure. This will show if grading correctly by elevators will increase profits, and answers the question to what extent elevators should pass on to producers the premiums and discounts received from NIL buyers.

Chapter V

SIMULATION RESULTS

This chapter presents the results of the simulation and sensitivity analysis to determine the effects of competition and other variables on optimal grading and pricing strategies. The simulations run consist of nine different scenarios, as explained in Chapter 4.

Simulation Results

The numbers used in the simulation analysis consisted of a base price of $4.90 paid by NIL buyers to country elevators, with a $0.10/bu. price differential/between qualities. Therefore, NIL buyers pay $5.00 for high quality wheat, $4.90 for middle quality wheat, and $4.80 for low quality wheat to the elevators that are segregating by the different qualities. The elevators that are not segregating receive one price from NIL buyers of either $5.00, $4.90, or $4.80, depending on the average quality of wheat received. The production density used was 2,174 bushels per square mile. Wheat in the elevator's trade area is assumed to consist of 10% high quality, 60% middle quality, and 30% low quality wheat. This was the actual quality distribution of test weight for the 1995 harvest.

No Competition

In the first competitive structure, the elevator is a perfect monopsony, with no competition in its potential trade area. It is assumed that the best alternative use for wheat is for livestock feed, with a value at \$3.00 per bushel. Tables 5.1, 5.2, and 5.3 show the results under this structure.

The first strategy is where elevator A grades and segregates the wheat received, and also pays producers prices that differ according to the quality of wheat they deliver. As indicated in table 5.1, Elevator A achieves a profit of \$94.42 million with a trade area radius of 161 miles for the high quality, 153 miles for the middle quality, and 144 miles for the low quality. However, the prices paid by the elevator -- \$4.29/bu. for high quality, \$4.22/bu. for middle quality, and \$4.15/bu. for low quality -- show that the country elevator should absorb some of the price differential between qualities. It passes on \$.07 of the price differential to the producer and absorbs 3 cents of it; in other words, the elevator passes on the producer only 70% of the price differential it receives from NIL buyers..

Table 5.2 shows the results of the second strategy. In this strategy, elevator A grades the wheat received and segregates it to receive prices from NIL buyers that are adjusted for quality, but pays producers one price for all qualities of wheat. It receives a profit of \$94.11 million. It pays producers \$4.21/bu. for all the qualities and has a trade area radius of 151 miles for all the qualities.

Table 5.3 shows the results of third strategy in which elevator A does not grade the wheat received, nor does it segregate the wheat into different qualities or pay different prices to producers for different qualities. This model shows a profit of \$84.63 million, which is much lower than that achieved with other strategies. It pays a price of \$4.17 for all qualities and has a trade area of 146 miles for all qualities.

Table 5.1
Structure 1: Strategy 1, Results of Elevator A Maximizing Profits:
No Competition, Elevator A Grades and Segregates (Pays Different Quality Prices)

Elevator	Quality (Radius)	Prices by NIL Buyers ($/bu.)	Prices Paid to Producers ($/bu.)	Quantity Purchased from Producers (bu.)	Profit
A	High Quality (161)	5.00	4.29	17.72 M	$94.42 M
	Middle Quality (153)	4.90	4.22	95.61 M	
	Low Quality (144)	4.80	4.15	43.73 M	

Alternative Price = $3.00/bu.

Table 5.2
Structure 1: Strategy 2, Results of Elevator A Maximizing Profits:
No Competition , Elevator A Grades and Segregates (Pays One Average Price)

Elevator	Quality (Radius)	Prices by NIL Buyers ($/bu.)	Prices Paid to Producers ($/bu.)	Quantity Purchased from Producers (bu.)	Profit
A	High Quality (151)	5.00	4.21	15.59 M	$94.11 M
	Middle Quality (151)	4.90	4.21	93.54 M	
	Low Quality (151)	4.80	4.21	46.77 M	

Alternative Price = $3.00/bu.

Table 5.3
Structure 1: Strategy 3, Results of Elevator A Maximizing Profits:
No Competition, Elevator A Does Not Grade or Segregate (Pays One Average Price)

Elevator	Quality (Radius)	Prices by NIL Buyers ($/bu.)	Prices Paid to Producers ($/bu.)	Quantity Purchased from Producers (bu.)	Profit
A	High Quality (146)	4.80	4.17	14.52 M	$84.63 M
	Middle Quality (146)	4.80	4.17	87.15 M	
	Low Quality (146)	4.80	4.17	43.58 M	

Alternative Price = $3.00/bu.

The results for the no competition structure show that the most profitable strategy is when elevator A grades and segregates, and pays producers different prices for different qualities. However, only 70% of the price differences received from NIL buyers are passed on to the producers. Figure 5.1 show trade areas of the different qualities for elevator A under each strategy. Strategy 1 under the no competition structure achieves the highest profits because elevator A receives relatively more of the high and middle quality wheat.

Competition (Elevators Don't Copy Each Other)

This competitive structure on it has three different strategies. Tables 5.4, 5.5, and 5.6 show the results of the three strategies for this scenario when elevator A has six competitors located around it, 40 miles away. Elevator A is assumed to be the leader in grading/pricing strategies, and elevator B is assumed to be the competitors that follow. This scenario is where the competition formulates it grading/pricing strategy independently of elevator A.

Table 5.4 shows the results for the first strategy. This strategy assumes elevators A and B grade and segregate the wheat received. However, elevator A pays producers prices that differ according to the quality of wheat they deliver while elevator B pays producers one price for all qualities of wheat. Elevator A achieves a profit of $209,102 while elevator B achieves a profit of only $68,976. Elevator A receives more of the high quality and middle quality wheat while elevator B attracts more of the low quality wheat. As with the no competition structure, elevator A passes on to producers only 70% of the price differential received from NIL buyers. Elevator A has a trade area radius of 31 miles for

Figure 5.1
Structure 1: No Competition
Elevator Trade Area (Radius):
Strategy 1: Elevator A Grades and Segregates (Pays Different Quality Prices)
Strategy 2: Elevator A Grades and Segregates (Pays One Average Price)
Strategy 3: Elevator A Does Not Grade or Segregate (Pays One Average Price)

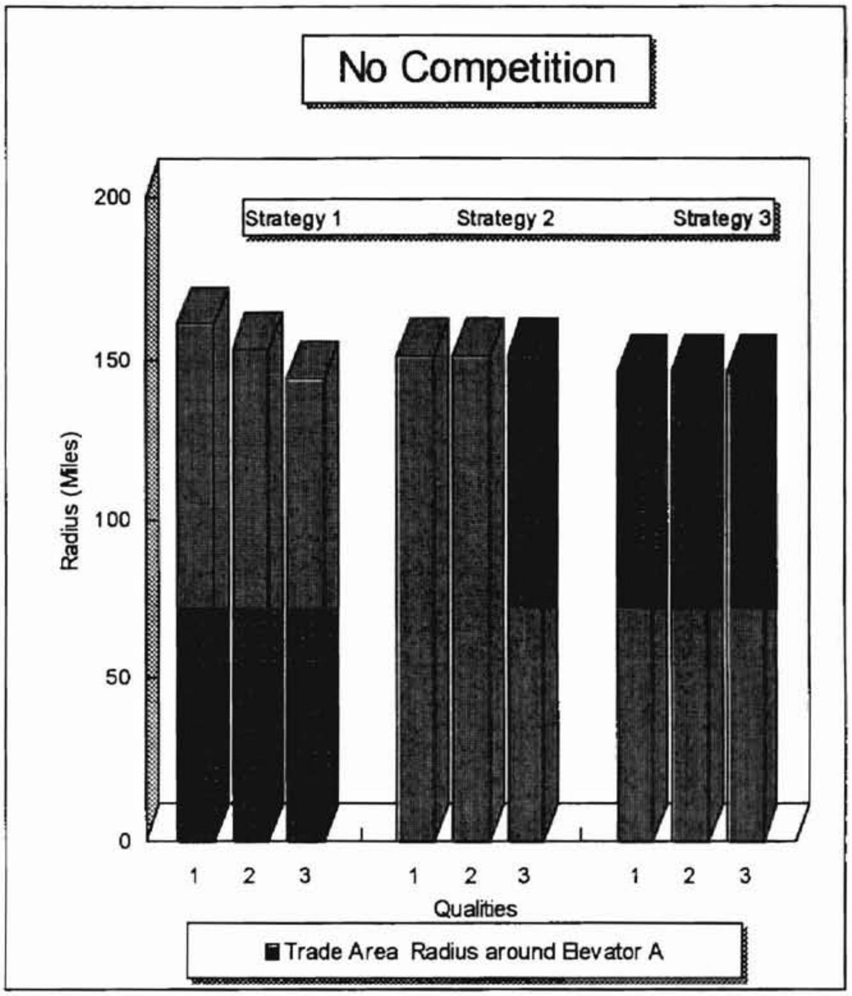


Table 5.4
Structure 2: Strategy 1, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Don't Copy Each Other)
Elevator A Grades and Segregates (Pays Different Quality Prices)
Elevator B Grades and Segregates (Pays One Average Price)

Elevator	Quality (Radius)	Prices by NIL Buyers ($/bu.)	Prices Paid to Producers ($/bu.)	Quantity Purchased from Producers (bu.)	Profit
A	High Quality (31)	5.00	4.81	670,845	$209,102
	Middle Quality (23)	4.90	4.74	2,169,147	
	Low Quality (15)	4.80	4.67	441,614	
B	High Quality (9)	5.00	4.72	51,214	$68,976
	Middle Quality (17)	4.90	4.72	1,183,285	
	Low Quality (25)	4.80	4.72	1,314,955	

Table 5.5
Structure 2: Strategy 2, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Don't Copy Each Other)
Elevator A Grades and Segregates (Pays Different Quality Prices)
Elevator B Does Not Grade or Segregate (Pays One Average Price)

Elevator	Quality (Radius)	Prices by NIL Buyers ($/bu.)	Prices Paid to Producers ($/bu.)	Quantity Purchased from Producers (bu.)	Profit
A	High Quality (34)	5.00	4.80	805,271	$343,545
	Middle Quality (26)	4.90	4.73	2,771,376	
	Low Quality (18)	4.80	4.66	640,308	
B	High Quality (6)	4.80	4.68	21,901	$27,485
	Middle Quality (14)	4.80	4.68	802,541	
	Low Quality (22)	4.80	4.68	1,022,241	

Table 5.6
Structure 2: Strategy 3, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Don't Copy Each Other)
Elevator A Grades and Segregates (Pays One Average Price)
Elevator B Does Not Grade or Segregate (Pays One Average Price)

Elevator	Quality (Radius)	Prices by NIL Buyers ($/bu.)	Prices Paid to Producers ($/bu.)	Quantity Purchased from Producers (bu.)	Profit
A	High Quality (24)	5.00	4.72	391,357	$274,164
	Middle Quality (24)	4.90	4.72	2,348,140	
	Low Quality (24)	4.80	4.72	1,174,771	
B	High Quality (16)	4.80	4.69	176,209	$13,254
	Middle Quality (16)	4.80	4.69	1,057,252	
	Low Quality (16)	4.80	4.69	529,093	

high quality, 23 miles for the middle quality, and 15 miles for the low quality wheat. Elevator B has a trade area radius of 9 miles for high quality, 17 miles for middle quality, and 25 miles for low quality. Table 5.5 shows the results of the second strategy. This strategy is where elevator A grades and segregates the wheat received, and also pays producers prices that differ according to the quality of wheat they deliver. Elevator B does not grade the wheat received, nor does it segregate the wheat into different qualities or pay different prices to producers for different qualities. This results in a profit of $343,545 for elevator A and $27,485 for elevator B. Elevator A receives even more of the high and middle quality wheat while elevator B receives more of the low quality wheat. Again, elevator A passes on to producers 70% of the price differential received from NIL buyers. Elevator A has a trade area radius of 34 miles for high quality, 26 miles for middle quality, and 18 miles for low quality wheat. Elevator B has a radius of 6 miles for high quality, 14 miles for middle quality, and 22 miles for low quality wheat. The results show that elevators that grade correctly and pay different prices for different qualities of wheat can substantially increase profits relative to its competitors that do not grade correctly and pay different prices.

Table 5.6 shows the results of the third strategy. This strategy is where elevator A grades and segregates the wheat received, but pays producers one price for all qualities of wheat. Elevator B does not grade the wheat received, nor does it segregate the wheat into different qualities or pay different prices to producers for different qualities. This results in a profit of $274,164 for elevator A and $13,254 for elevator B. This strategy shows that it can substantially increase profits by grading and segregating, even if it pays producers one price for all qualities of wheat.

The results of the strategies under this competitive structure show that early adopters that grade and segregate wheat, especially if they pay premiums for high quality wheat and discounts for low quality wheat, can profit significantly compared to competitors that either don't grade or grade but do not pay different prices. This is because premiums and discounts induce farmers to bring in high quality wheat. However, the full price differential from NIL buyers is not passed on to producers. For a 10 cent price differential, only 7 cents of it is passed on to producers. Figure 5.2 shows the different trade areas for each elevator under the three different strategies.

Competition (Elevators Copy Each Other)

For this competitive structure scenario, elevator A has six competitors located around it, 40 miles away. Elevator A is assumed to be the leader in grading/pricing strategies, and elevator B is assumed to represent the competitors that follow, copying elevator A's grading/pricing strategy.

Tables 5.7, 5.8, and 5.9 show the results of the three different strategies for this scenario. For each of the three strategies, elevators A and B achieve the same profits, pay the same prices, and purchase the same quantity of each of the three qualities of wheat. Table 5.7 shows the results of the first strategy. In this model, elevators A and B grade and segregate the wheat received, and also pay producers prices that differ according to the quality of wheat they deliver. Since the elevators are copying each other, the elevators pay the same prices and have the same trade areas for all qualities. The trade areas for elevators A and B are 20 miles (half the distance between the two elevators) for all

Figure 5.2
Structure 2: Competition (Elevators A & B Don't Copy Each Other),
Elevator Trade Areas (Radius):
Strategy 1: Elevator A Grades and Segregates (Pays Different Quality Prices)
Elevator B Grades and Segregates (Pays One Average Price)
Strategy 2: Elevator A Grades and Segregates (Pays Different Quality Prices)
Elevator B Does Not Grade or Segregate (Pays One Average Price)
Strategy 3: Elevator A Grades and Segregates (Pays One Average Price)
Elevator B Does Not Grade or Segregate (Pays One Average Price)

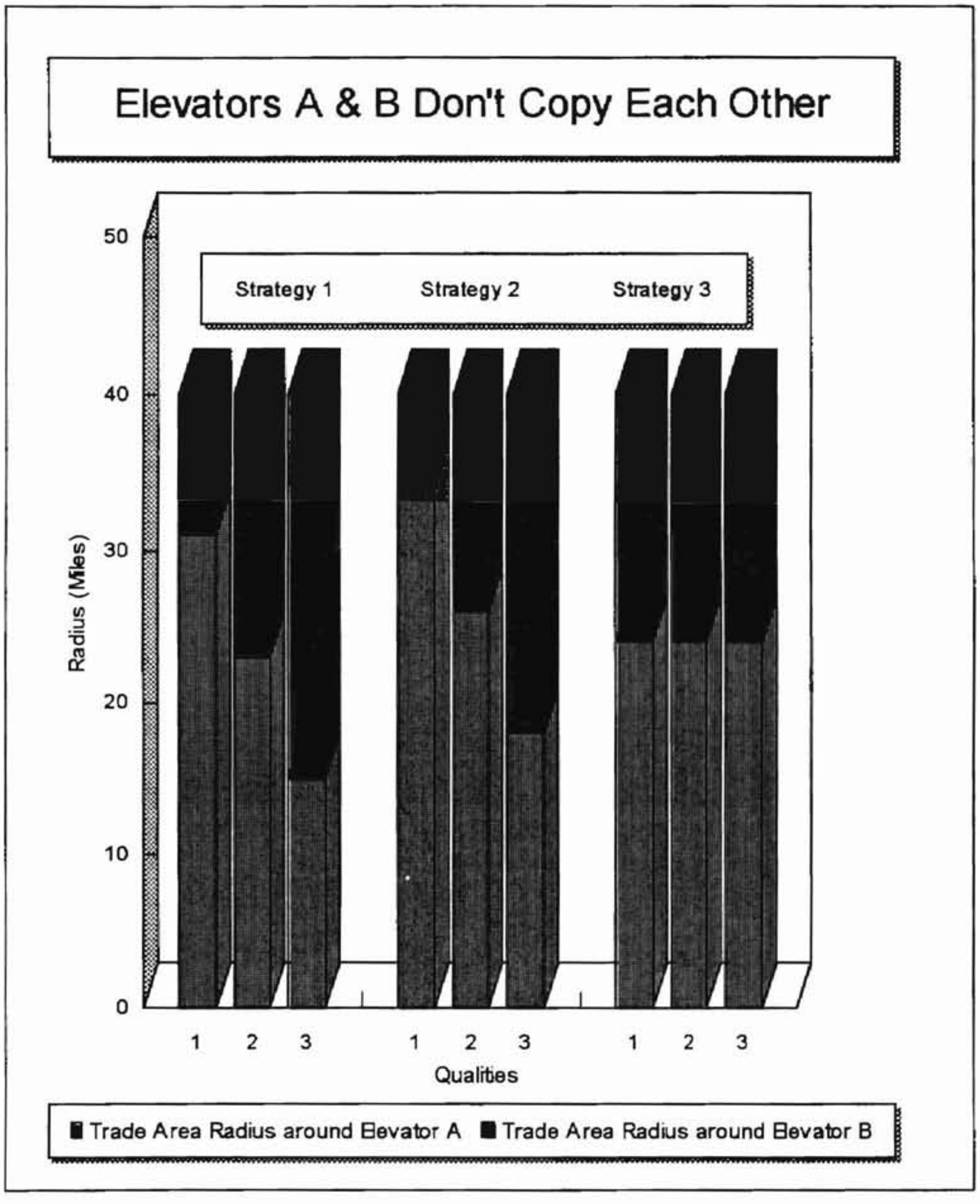


Table 5.7
Structure 3: Strategy 1, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Copy Each Other)
Elevators A & B Grade and Segregate (Pay Different Quality Prices)

Elevator	Quality (Radius)	Prices by NIL Buyers ($/bu.)	Prices Paid to Producers ($/bu.)	Quantity Purchased from Producers (bu.)	Profit
A	High Quality (20)	5.00	4.85	273,193	$118,032
	Middle Quality (20)	4.90	4.75	1,639,157	
	Low Quality (20)	4.80	4.65	820,156	
B	High Quality (20)	5.00	4.85	273,193	$118,032
	Middle Quality (20)	4.90	4.75	1,639,157	
	Low Quality (20)	4.80	4.65	820,156	

Table 5.8
Structure 3: Strategy 2, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Copy Each Other)
Elevators A & B Grade and Segregate (Pay One Average Price)

Elevator	Quality (Radius)	Prices by NIL Buyers ($/bu.)	Prices Paid to Producers ($/bu.)	Quantity Purchased from Producers (bu.)	Profit
A	High Quality (20)	5.00	4.73	273,193	$117,983
	Middle Quality (20)	4.90	4.73	1,639,157	
	Low Quality (20)	4.80	4.73	820,156	
B	High Quality (20)	5.00	4.73	273,193	$117,983
	Middle Quality (20)	4.90	4.73	1,639,157	
	Low Quality (20)	4.80	4.73	820,156	

Table 5.9
Structure 3: Strategy 3, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Copy Each Other)
Elevators A & B Do Not Grade or Segregate (Pay One Average Price)

Elevator	Quality (Radius)	Prices by NIL Buyers ($/bu.)	Prices Paid to Producers ($/bu.)	Quantity Purchased from Producers (bu.)	Profit
A	High Quality (20)	4.80	4.67	273,193	$118,639
	Middle Quality (20)	4.80	4.67	1,639,157	
	Low Quality (20)	4.80	4.67	820,161	
B	High Quality (20)	4.80	4.67	273,193	$118,639
	Middle Quality (20)	4.80	4.67	1,639,157	
	Low Quality (20)	4.80	4.67	820,161	

qualities, since they are pricing the same. They pay prices of $4.85, $4.75, and $4.65 for the different qualities. When all elevators are grading and pricing the same, then elevators pass on the full price differentials received from NIL buyers for the different qualities. The profit for each elevator is $118,032.

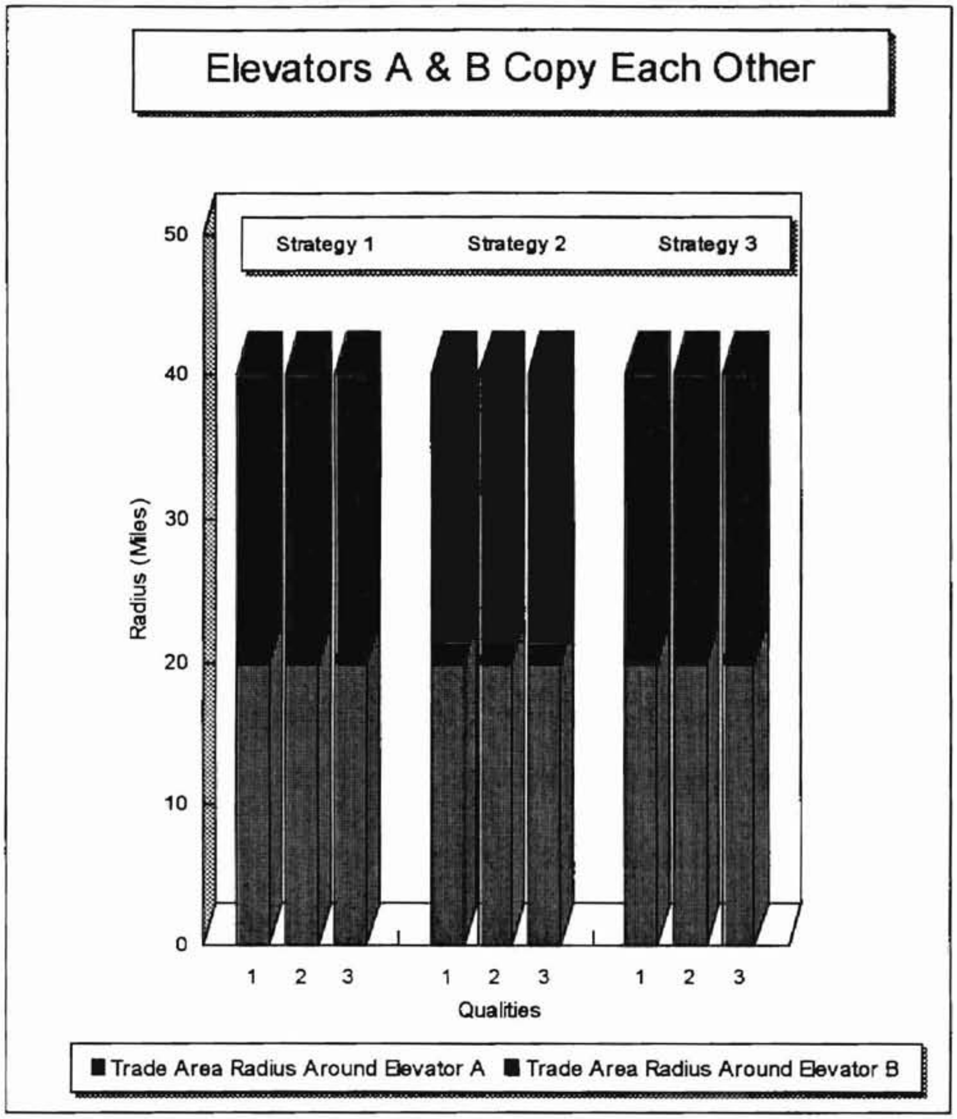
Table 5.8 shows the results of the second strategy. This strategy assumes elevators A and B grade the wheat received and segregate it to receive prices from NIL buyers that are adjusted for quality, but they pay producers one price for all qualities of wheat. The trade area for each elevator is 20 miles. The price paid to producers is $4.73 for all qualities. The profit for both elevators is $117,983, which is slightly lower than in the first strategy.

Table 5.9 shows the results of the third strategy. This strategy assumes elevators A and B do not grade the wheat received, nor do they segregate the wheat into different qualities or pay different prices to producers for different qualities. The profit for both elevators is $118,639 which is slightly higher than profits under strategies 1 and 2. But, both elevators pay a price of $4.67 for all qualities, which is lower than the price paid under strategy 2.

All three strategies for this scenario result in similar profits. The trade areas of elevator A and B are 20 miles for all qualities because the competitors are following elevator A's grading/pricing strategy. Figure 5.3 shows the trade areas of elevators A and B for each strategy under this competitive structure.

One important result under this structure is that elevators A and B are able to pass on full price differentials to producers when they are grading and segregating the wheat

Figure 5.3
Structure 3: Competition (Elevators A & B Copy Each Other)
Elevator Trade Areas (Radius):
Strategy 1: Elevators A & B Grade and Segregate (Pay Different Quality Prices)
Strategy 2: Elevators A & B Grade and Segregate (Pay One Average Price)
Strategy 3: Elevators A & B Do Not Grade or Segregate (Pay One Average Price)



received, and paying producers prices that differ according to the quality of wheat they deliver. This means that the country elevators would not absorb any of the price differentials from NIL buyers. The results found that the profits varied little by strategy under this structure. This means that an elevator has very little incentive to invest in proper grading equipment and additional labor to grade because there is little increase in profits if other elevators copy the innovator's grading/pricing strategy. If all elevators adopt grading and pricing practices that reflect the true value of all qualities, elevators might find it more profitable in the long run to pass on price differentials for the different qualities because of NIL buyers tightening grain grading standards year by year. It would also improve the wheat industry and the quality of wheat in the United States because farmers would be given incentives to improve their quality of wheat if all elevators passed on price differentials for the different qualities.

Simulation Analysis Summary

The results show that "early adopters" that grade and segregate the wheat received, and pay producers prices that differ according to the quality of wheat they deliver, can achieve substantial profits if its competitors are paying just one price for all qualities of wheat. However, only 70% of the price differential would be passed on to producers. The early adopters accomplish this by attracting more of the high and middle quality wheat.

If other elevators copy the early adopters, profits drop back to the level achieved when none of the elevators graded and priced accordingly. However, by grading, segregating, and paying producers different prices for different qualities, producers receive the full value of the grain they deliver. Producers delivering high quality grain do not subsidize those delivering low quality grain. To the extent wheat quality is affected by cultural and harvesting practices, elevators paying higher prices for higher quality wheat can increase the overall quality of wheat produced.

Sensitivity Analysis

The sensitivity analysis results are discussed below and these results used a range of parameters that reflects the range of conditions observed in the 1995, 1996, and 1997 harvest. The price differentials for each quality are varied to show prices paid by NIL buyers for each year. Also, production densities are changed to represent different amounts of wheat harvested for the different years. Relative quality densities are also varied to show different proportions of high quality, middle quality, and low quality wheat. These results provide perspective answers for the 1995, 1996, and 1997 harvest years on how elevators should have graded and priced wheat on the basis of test weight, dockage, and SBK.

Various Price Differentials

First, price differentials were varied by 2-cent increments from \$0.00 to \$0.10 per bushel while holding production density constant at 2,174 bu./mi^2, and quality densities constant at 10% high quality, 60% middle quality, and 30% low quality. Appendix tables B.1 - B.9 show the results for each structure.

Appendix tables B.1 - B.3 show the results under structure one when varying price differentials. The simulations with no competition show the most profitable strategy is when elevator A grades and segregates the wheat received, and also pays producers prices that differ according to the quality of wheat they deliver. However, when price differentials for the various quality levels are two cents or less, the most profitable strategy is when elevator A does not grade the wheat received. If there is little price differential between the qualities by NIL buyers, there is no reason to grade and segregate because of the increased cost. However, in all recent years, the price differentials for at least one quality characteristic has been more than two cents, suggesting that in the current marketing environment, grading would be profitable.

Under the second structure where elevator A has competitors that formulates their grading/pricing strategies independently of elevator A, results were similar. Appendix tables B.4 - B.6 show the results of the second structure when varying price differentials. Elevator A's profits are higher than elevator B's when elevator A grades and segregates the wheat received, and pays producers different prices for different qualities of wheat, while at the same time elevator B pays producers only one price for all qualities of wheat. However, when the price differential is 2 cents or lower, elevator B's profits are higher. If there is a small price differential between qualities, there is little incentive for elevators to invest in grading equipment and labor. It would be more profitable for an elevator to not grade and segregate, and pay one price for all qualities if the price differentials from NIL buyers are 2 cents or less.

When price differentials are greater than 2 cents, elevator A maximizes profits by grading and segregating and passing on approximately 65% to 70% of the price differential to producers. Elevator A achieves substantially higher profits than its competitors when they pay only one price for all qualities. This is because such a strategy could cause elevator A to attract more of the high and middle quality grain while its competitors are left with most of the lower quality wheat.

Figure 5.4 shows trade area and prices paid to producers by elevators A and B under structure 2 and strategy 2. This is where elevator A grades and segregates the wheat received, and pays producers prices that differ according to the quality of wheat they deliver. Elevator B does not grade the wheat received, nor does it segregate the wheat into different qualities or pay different prices to producers for different qualities. It shows that elevator A receives more of the high and middle quality wheat when the price differentials are more than 2 cents. As price differentials increase, elevator B receives more of the low quality wheat resulting in a lower average price paid to producers. This is because elevator B receives a lower average price from NIL buyers. Figure 5.5 shows the trade area and profits by elevators A and B under this same strategy. Profits are higher for elevator B when the price differentials are less than two cents (because elevator A pays grading and segregating cost and elevator B does not). However, profits are higher for elevator A when the price differential between qualities is greater than two cents.

The third structure where elevator A has competitors that copy its grading/pricing strategy produced results similar to those above. Appendix tables B.7 -B.9 show results under the third structure when varying price differentials. If both elevators A and B grade and segregate, and pay producers different quality prices, they pass on 100% of the NIL buyer price differentials to producers. No matter what grading/pricing strategy elevator A chooses, however, as long as B copies A the elevators achieve similar profits. While there is little profit incentive for Elevator A to grade correctly and pass on premiums and

Figure 5.4
(Trade Area & Prices)
Structure 2: Strategy 2, Sensitivity Analysis: Various Price Differentials
Elevator A Grades and Segregates (Pays Different Quality Prices)
Elevator B Does Not Grade or Segregate (Pays One Average Price)

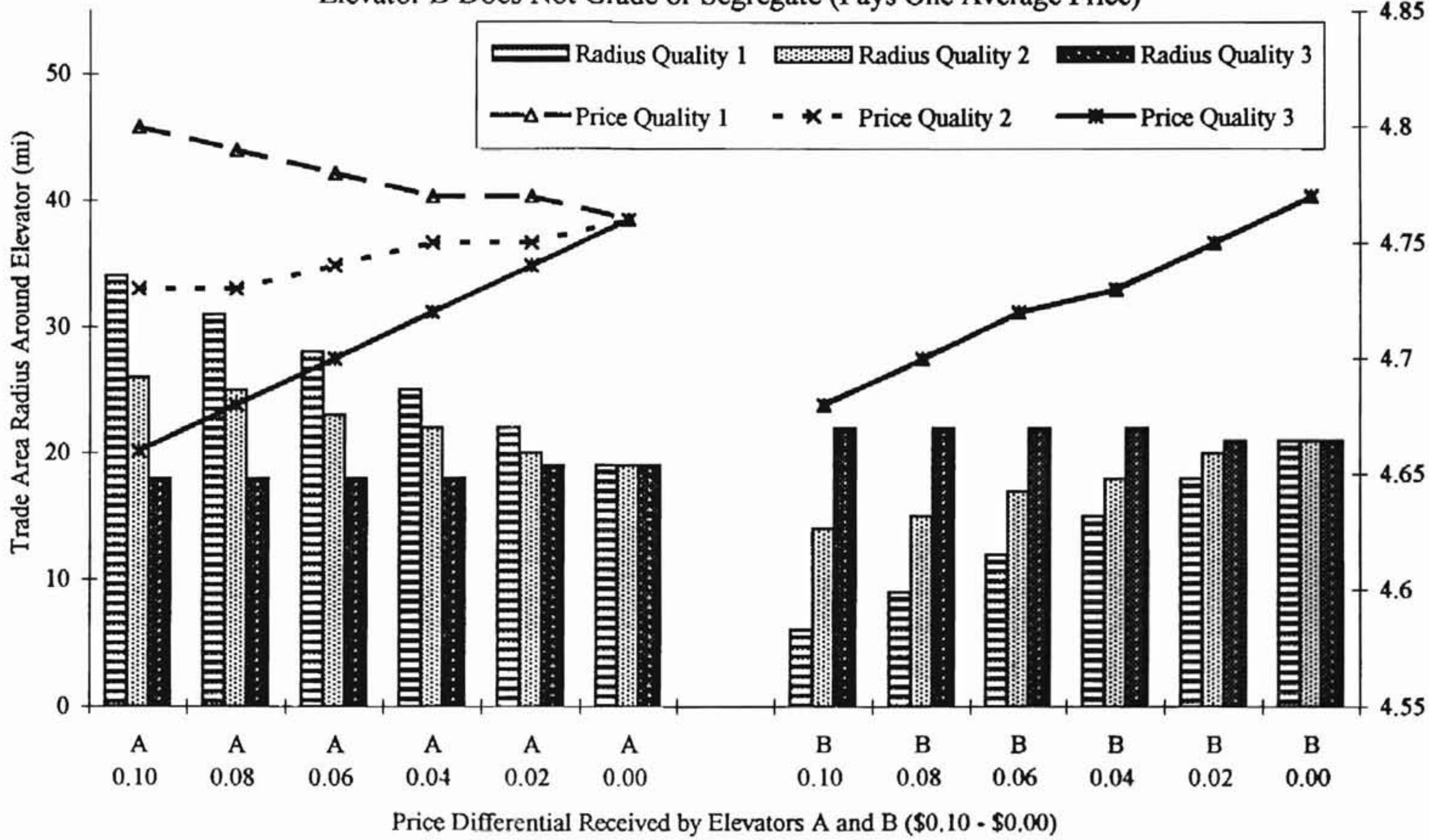
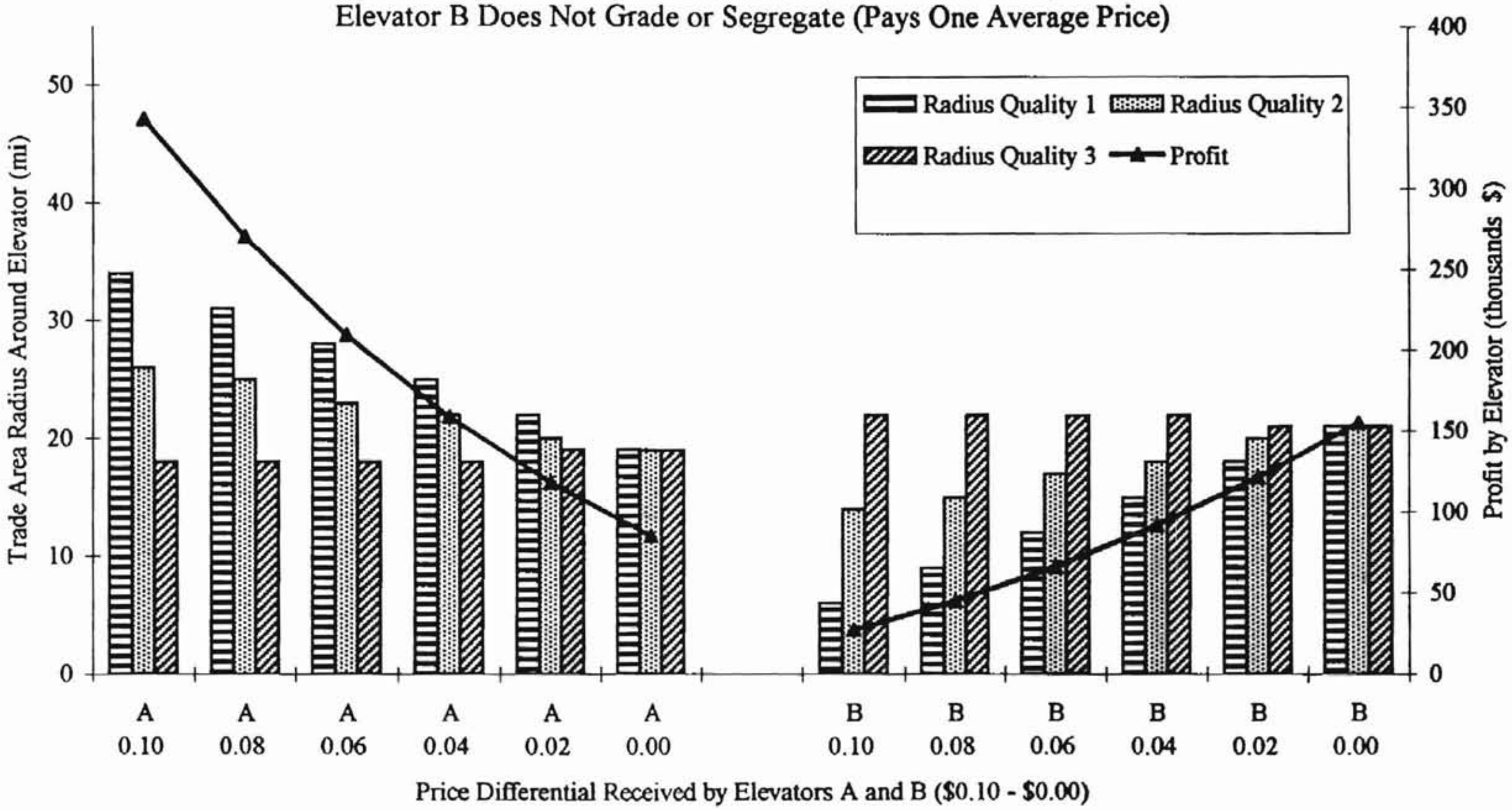


Figure 5.5
(Trade Area & Profits)
Structure 2: Strategy 2, Sensitivity Analysis: Various Price Differentials
Elevator A Grades and Segregates (Pays Different Quality Prices)
Elevator B Does Not Grade or Segregate (Pays One Average Price)



discounts to producers if it knows that elevator B will copy it, producers would benefit from such a choice. Also, such a choice could increase quality of U.S. wheat to the extent producers are able to respond to the price differentials for higher quality wheat.

These results suggest that elevators will find it profitable to pass on different price differentials to producers when the price differentials are greater than 2 cents. Early adopters will maximize profits by passing on 70% of the NIL price differential to producers. When all elevators begin grading correctly and paying different prices for different qualities, then all elevators will maximize profits by passing on the full NIL price differential to producers.

Various Production Densities

The second part of sensitivity analysis varies production density while holding the price differentials and quality levels constant. The production densities considered were 1000, 2174, and 4000 bushels per square mile. The price differentials were held constant at 10 cents, quality proportions were held at 10% high quality, 60% middle quality, and 30% low quality. Appendix Tables B.10 - B.18 show the results of each structure as production density is varied.

Appendix tables B.10 - B.12 show the results of varying production density when there is no competition. The prices paid to producers stay the same regardless of the production density production density for each strategy. The most profitable strategy is when elevator A grades and segregates the wheat received, and pays producers prices that differ according to the quality of wheat they deliver.

Appendix tables B.13 - B.15 show the results under second structure, where elevator B does not follow elevator A's grading/pricing strategy. The results show that elevator A achieves substantial profits when it grades and segregates, and pays different prices for different qualities while its competitors pays one price for all qualities. In this case, elevator A passes on approximately 65% to 70% of the price differential to the producers.

Appendix tables B.16 - B.18 show the results when varying production densities under the structure where elevator B copies elevator A's grading and pricing strategies. The profits are similar for each of these strategies, no matter how elevators A and B grade and priced wheat. When elevators A and B grade and segregate wheat, and pay producers different prices for each quality, they pass on 100% of the price differential to the producers.

Various Quality Levels

The third part of the sensitivity analysis varies relative proportions of each quality while the price differential and production densities are held constant. The relative proportion of each quality are varied from quality levels: 10% high quality, 60% middle quality, and 30% low quality to 30% high quality, 40% middle quality, and 30% low quality to 50% high quality, 20% middle quality, and 30% low quality wheat. The price differential was held constant at 10 cents, and the production density was held constant at 2,174 bushels per square mile. Appendix Tables B.19 - B.27 show the results of each strategy under each structure.

Appendix tables B.19 - B.21 show the results of the no competition structure when varying the quality proportions. The most profitable strategy, as before, is when elevator

A grades and segregates the wheat received, and pays producers prices that differ according to the quality of wheat they deliver.

Appendix tables B.22 - B.24 show the results when varying the quality proportions under the structure where elevator B does not copy elevator A's grading and pricing strategies. Elevator A achieves substantial profits when it grades and segregates the wheat, and pays producers prices that differ according to the quality of wheat they deliver, while its competitors pay producers one price for all qualities of wheat. Elevator A passes on approximately 65% to 70% of the price differential to the producers. This implies that elevators that begin to tighten grading standards can profit significantly if their competitors continue to pay just one price for all qualities. This is because these elevators will attract more of the high and middle quality grain, while competitors get most of the poor quality wheat. As the relative proportion of high quality wheat increases relative to middle and low quality wheat in the elevator's trade area, the profits of elevator A increases relative to those of its competitors.

Appendix tables B.25 - B.27 show results under the third structure, where elevator B copies elevator A's grading and pricing strategies. If both elevators pay different prices for each quality, they pass on 100% of the NIL buyer price differential to producers. However, the profits under this structure change little across strategies. Therefore, there is little incentive for elevators to grade if all competing elevators are doing the same.

Sensitivity Analysis Summary

The results of the sensitivity analysis show that the first elevators to begin grading correctly achieve substantial profits when they pass on 70% of the NIL price differential to producers, as long as the price differentials is greater than two cents. When all elevators begin grading correctly, they have incentive to pass on to producers the full amount of the NIL buyer price differentials.

1995, 1996, and 1997 Harvest

Appendix tables A.7 - A.9 shows the quality distributions for test weight, dockage, and SBK during the 1995, 1996, and 1997 Oklahoma wheat harvests. The tables also show the actual discounts that were implemented during the 1995, 1996, and 1997 wheat harvests. For all three years, the price differentials for test weight and dockage were compared to the price differentials for SBK. This is because in each of the years the wheat had a low level of SBK.

The results show that a country elevator should have graded and segregated for test weight and dockage, and paid producers 70% of the price differential received by NIL buyers if its competitors were paying producers one price for all qualities. However, it would not have been profitable to grade and segregate for SBK since the price differentials for SBK were so small.

Summary

The results from the simulation and sensitivity analysis found that a country elevator can increase profits significantly by grading and segregating the wheat received, and paying producers prices that differ according to the quality of wheat they deliver, if its competitors are paying producers one price for all qualities of wheat. These early adopters would pass on to producers 70% of the price differentials. The results show that the higher the price differential by NIL buyers, the higher the profits that can be made by elevators that grade correctly and pay producers quality-adjusted prices. However, if NIL buyer price differentials are two cents or less, elevators would not achieve higher profits.

When all elevators grade and pass on price differentials, they pass on to producers the full amount of the price differential. The drawback is elevator profits are not increased. However, producers of high and middle quality wheat benefit from higher prices, while producers of low quality receive a lower price. To the extent producers can control wheat quality, this would increase the overall quality of wheat entering the marketing system.

Chapter 6 summarizes the results, and suggests implications of the results for the wheat industry. Finally, it suggests further work that can improve upon this study.

Chapter VI

SUMMARY AND CONCLUSIONS

Summary

A simulation analysis identifies optimal wheat grading and pricing strategies for country elevators under three possible competitive structures. The three different competitive structures are: 1) an elevator is a perfect monopsony, with no competition in its potential trade area; 2) an elevator has competitors that do not follow its lead in formulating a grading and pricing strategy, and 3) an elevator has competitors that copy its grading/pricing strategy exactly. For each structure, an elevator and its competitors consider three possible grading and pricing strategies: 1) an elevator grades and segregates the wheat delivered, and also pays producers prices that differ according to the quality of wheat they deliver; 2) an elevator grades the wheat received and segregates it to receive prices from NIL buyers that are adjusted for quality, but pays producers one price for all qualities of wheat; and 3) an elevator does not grade the wheat received, nor does it segregate the wheat into different qualities or pay different prices to producers for different qualities.

A sensitivity analysis identifies the optimal strategies over a range of reasonably likely operating environments, consistent with the range of conditions observed during the 1995, 1996, and 1997 harvests.

The results show country elevators facing no competition or competitors who did not copy should have graded and segregated, and paid producers different prices for different qualities on the basis of test weight and dockage for the 1995, 1996, and 1997 wheat harvests. The price differentials were large enough for elevators to profit by passing on to producers 70 % of the differential received from NIL buyers. However, the price differentials were not large enough for shrunken and broken kernels (SBK). Therefore, country elevators would not have profited by grading and segregating, and paying producers different quality prices on the basis of SBK. There were low percentages of SBK for the 1995, 1996, and 1997 harvests.

However, for elevators with competitors that copy their grading/pricing strategies, grading and paying producers different prices for different qualities would neither increase nor decrease profits compared to not grading. However, if the elevators chose to grade, and pay quality-related prices, they would pass on most or all of the price differential received from NIL buyers. This could potentially raise the quality of U.S. wheat.

The results from the simulation and sensitivity analysis showed that a country elevator can profit from paying producers quality-related prices if price differentials received from NIL buyers are greater than two cents. Since NIL buyers have begun to charge larger discounts for specific quality characteristics, the price differentials are usually greater than 2 cents for the most important quality characteristics. Therefore, early adopters can be expected to pass on 70% of price differentials. The results show that the higher the price differential from NIL buyers, the higher the profits that can be made by an elevator that grades correctly and passes on the price differential to producers, if its competitors do not follow suit.

However, if competitors follow suit, there is no increase in profits by grading and segregating the wheat received, and paying producers different prices for different qualities. However, producers of high and middle quality wheat benefit from higher prices, while producers of low quality wheat receive a lower price. To the extent producers can control wheat quality, this would increase the overall quality of wheat entering the marketing system. The results changed little when varying the overall production density and quality proportions in an elevator's trade area.

The results are consistent with Hill's assertion that market prices should convey information about the quality of the grains and should provide incentives for improving quality. Hill argues that grain quality would be improved if participants were rewarded for improving quality and value. Producers could improve quality of wheat they deliver through weed control, time of sowing, wheat variety, and tillage methods. By eliminating incentives for diminishing value, quality-adjusted prices would increase the overall quality of U.S. wheat. This could increase the U.S. market share of world wheat exports because of increased demand by importing countries..

Importance of Study

This research is important to the whole wheat industry of the United States. Kenkel, Anderson, and Attaway found that country elevators in Oklahoma were not grading and pricing wheat based on quality. Producers supplying high quality wheat were not being rewarded.

The results here show that an early adopter of the practice of grading and paying different prices to producers can increase profit significantly by increasing its trade area for high quality wheat. As other country elevators adopt the practice, producers would have increased incentives to improve the quality of wheat.

If country elevators don't begin grading and paying prices based on quality, it could be harmful for the U.S. wheat industry. This is because countries with the reputation of high quality wheat such as Canada and Australia will continue to increase their share of world wheat exports while U.S. market share continues to decrease. As Johnson and King note, most of the grain in traditional market channels passes through country elevators, so prices set by country elevators for wheat of various qualities provide important signals from world markets to producers. Also, as consumers increasingly demand differentiated products, a market pricing system that does not adequately reward quality may lead to increased alliances and vertical integration. These may introduce inefficiencies of their own. Therefore, this author recommends to the USDA and Federal Grain Inspection Service that it consider ways to encourage elevators to grade correctly and pass on to producers quality-related price differentials received from NIL buyers. Such action should increase overall quality of U.S. wheat, and might remove part of the incentive for increased contracting and vertical integration in the industry.

In the long run, profits would not be increased by elevators for doing this, nor would they be reduced. If this is done, it would adequately transmit correct price signals to producers and give them incentives to improve quality.

Need for Further Study

The models used in chapter 4 ignore optimal blending activities by elevators. They only consider segregation strategies. Therefore, blending activities by country elevators need to be incorporated into the models to expand on this research. This likely would increase profits even further for an elevator that grades, segregates, and blends the wheat received, and pays producers prices that differ according to the quality of wheat they deliver, particularly if its competitors are not grading, segregating, and blending wheat.

Prospect theory was discussed in chapter 3. Prospect theory suggests farmers value discounts differently than premiums, so that a discount decreases utility more than a premium of the same magnitude increases it. Further work needs to incorporate prospect theory in to the mathematical models to assess its impact.

The model assumes a linear cost structure for an elevator's operating activities. Other nonlinear cost structures that incorporate economies of size and effects of capacity constraints may alter these results.

Finally, research is needed to determine the amount of incentive producers, plant breeders, and others need to improve overall wheat quality. More information is needed to determine the extent to which quality can be improved through variety selection and cultural and harvesting practices, and the extent to which quality is determined by random factors such as weather.

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APPENDIX A

SUPPORTING DATA

Appendix Table A.1
1995 Wheat Quality Harvest Data Distribution

Total Defects	Samples	Percentage
<=7	1266	96.3%
7.1-8.0	20	1.5%
8.1-9	5	0.4%
9.1-10	7	0.5%
10.1-11	3	0.2%
11.1-12	2	0.2%
12.1-13	3	0.2%
13.1-14	3	0.2%
14.1-15	0	0.0%
>15	5	0.4%
Avg.	**1314**	**2.6%**

Moisture	Samples	Percentage
<14	1186	90.3%
14-14.5	65	4.9%
14.6-15	22	1.7%
15.1-15.5	16	1.2%
15.6-16	6	0.5%
16.1-16.5	7	0.5%
16.6-17	8	0.6%
>17	4	0.3%
Avg.	**1314**	**12.1%**

Shrunken & Broken	Samples	Percentage
<=1.4	747	56.8%
1.5-1.9	172	13.1%
2-2.4	127	9.7%
2.5-2.9	91	6.9%
3-3.4	51	3.9%
3.5-3.9	44	3.3%
4-4.4	27	2.1%
4.5-4.9	18	1.4%
5.0-5.9	16	1.2%
6.0-6.9	10	0.8%
7.0-7.9	6	0.5%
8.0-8.9	1	0.1%
9.0-9.9	2	0.2%
>=10	2	0.2%
Avg.	**1314**	**1.7%**

Test Weight	Samples	Percentage
62-62.9	3	0.2%
61-61.9	24	1.8%
60-60.9	100	7.6%
59-59.9	247	18.8%
58-58.9	311	23.7%
57-57.9	224	17.0%
56-56.9	176	13.4%
55-55.9	110	8.4%
54-54.9	53	4.0%
53-53.9	30	2.3%
52-52.9	13	1.0%
51-51.9	12	0.9%
50-50.9	6	0.5%
<50	5	0.4%
Avg.	**1314**	**57.7**

Damage	Samples	Percentage
<=1	1226	93.3%
1.1-2	38	2.9%
2.1-3	14	1.1%
3.1-4	10	0.8%
4.1-5	6	0.5%
5.1-6	4	0.3%
6.1-7	3	0.2%
7.1-8	2	0.2%
>8	11	0.8%
Avg.	**1314**	**0.5%**

Protein	Samples	Percentage
>=16	3	0.2%
15-15.9	22	1.7%
14-14.9	115	8.8%
13-13.9	307	23.4%
12-12.9	427	32.5%
11-11.9	305	23.2%
10-10.9	111	8.4%
9.0-9.9	22	1.7%
8.0-8.9	2	0.2%
<8.0	0	0.0%
Avg	**1314**	**12.6%**

Dockage	Samples	Percentage
<=2.9	866	65.9%
3-3.5	26	2.0%
3.6-3.9	16	1.2%
4-4.5	23	1.8%
4.6-4.9	15	1.1%
5.0-5.5	23	1.8%
5.6-5.9	27	2.1%
6-6.5	28	2.1%
6.6-6.9	16	1.2%
7-7.5	25	1.9%
7.6-7.9	20	1.5%
8-8.9	28	2.1%
9-9.9	34	2.6%
10-10.9	22	1.7%
11-11.9	14	1.1%
12-13	19	1.4%
>13	112	8.5%
Avg.	**1314**	**4.0%**

Grade	Samples	Percentage
#1	112	8.5%
#2	528	40.2%
#3	390	29.7%
#4	187	14.2%
#5	68	5.2%
SG	29	2.2%
Avg.	**1314**	**2.7**

Foreign Material	Samples	Percentage
<=1.4	1257	95.7%
1.5-1.9	14	1.1%
2-2.4	10	0.8%
2.5-2.9	12	0.9%
3.0-3.4	7	0.5%
3.5-3.9	2	0.2%
4.0-4.4	0	0.0%
4.5-4.9	1	0.1%
5.0-5.9	4	0.3%
>6	7	0.5%
Avg.	**1314**	**0.4%**

Source: Calculated from data in Kenkel, Anderson, and Attaway

Appendix Table A.2
1996 Wheat Quality Harvest Data Distribution

Total Defects	Samples	Percentage
<=3	1120	82.0%
3.1-4	154	11.3%
4.1-5	55	4.0%
5.1-6	25	1.8%
6.1-7	4	0.3%
7.1-8	7	0.5%
8.1-9	1	0.1%
9.1-10	0	0.0%
10.1-11	0	0.0%
11.1-12	0	0.0%
12.1-13	0	0.0%
13.1-14	0	0.0%
>14	0	0.0%
Avg.	**1366**	**2.0%**

Test Weight	Samples	Percentage
>=60	225	16.5%
59-59.9	221	16.2%
58-58.9	200	14.6%
57.5-57.9	101	7.4%
57-57.4	86	6.3%
56.5-56.9	75	5.5%
56-56.4	112	8.2%
55.5-55.9	87	6.4%
55-55.4	80	5.9%
54.5-54.9	55	4.0%
54-54.4	40	2.9%
<54	84	6.1%
Avg.	**1366**	**57.60**

Dockage	Samples	Percentage
<=.9	875	64.1%
1-2	376	27.5%
2.1-3	65	4.8%
3.1-4	22	1.6%
4.1-5	9	0.7%
5.1-6	7	0.5%
6.1-7	1	0.1%
7.1-8	3	0.2%
8.1-9	5	0.4%
9.1-10	1	0.1%
>10.1	2	0.1%
Avg.	**1366**	**1.0%**

Grade	Samples	Percentage
#1	215	15.7%
#2	425	31.1%
#3	373	27.3%
#4	261	19.1%
#5	81	5.9%
S.G.	11	0.8%
Avg.	**1366**	**2.71**

Moisture	Samples	Percentage
<14	1111	81.3%
14-14.5	120	8.8%
14.6-15	51	3.7%
15.1-15.5	30	2.2%
15.6-16	23	1.7%
16.1-16.5	18	1.3%
16.6-17	2	0.1%
>17	11	0.8%
Avg.	**1366**	**12.8%**

Damage	Samples	Percentage
<=1	1364	99.9%
1.1-2	2	0.1%
2.1-3	0	0.0%
3.1-4	0	0.0%
4.1-5	0	0.0%
5.1-6	0	0.0%
6.1-7	0	0.0%
7.1-8	0	0.0%
8.1-9	0	0.0%
9.1-10	0	0.0%
>10	0	0.0%
Avg.	**1366**	**0.1%**

Foreign Material	Samples	Percentage
<.5	1337	97.88%
.5-.7	14	1.02%
.8-1	6	0.44%
1.1-1.3	0	0.00%
1.4-2	4	0.29%
2.1-2.5	1	0.07%
2.6-3	1	0.07%
3.1-3.5	2	0.15%
3.6-4.0	1	0.07%
4.1-4.5	0	0.00%
>4.6	0	0.00%
Avg.	**1366**	**0.09%**

Shrunken & Broken	Samples	Percentage
<3	1142	83.6%
3-3.9	144	10.5%
4-4.9	48	3.5%
5-5.9	21	1.5%
6-6.9	6	0.4%
7-7.9	5	0.4%
8-8.9	0	0.0%
8-9.9	0	0.0%
10-10.9	0	0.0%
11-11.9	0	0.0%
>12	0	0.0%
Avg.	**1366**	**1.9%**

Protein	Samples	Percentage
>=18	3	0.2%
17-17.9	6	0.4%
16-16.9	88	6.4%
15-15.9	286	20.9%
14-14.9	474	34.7%
13-13.9	278	20.4%
12-12.9	155	11.3%
11-11.9	54	4.0%
10-10.9	19	1.4%
9.0-9.9	3	0.2%
Avg.	**1366**	**14.2%**

Source: Calculated from data in Kenkel, Anderson, and Attaway

Appendix Table A.3
1997 Wheat Quality Harvest Data Distribution

Total Defects	Samples	Percentage
<=3	1102	88.1%
3.1-4	105	8.4%
4.1-5	26	2.1%
5.1-6	9	0.7%
6.1-7	3	0.2%
7.1-8	3	0.2%
8.1-9	1	0.1%
9.1-10	2	0.2%
10.1-11	0	0.0%
11.1-12	0	0.0%
12.1-13	0	0.0%
13.1-14	0	0.0%
>14	0	0.0%
Avg.	**1251**	**1.9%**

Test Weight	Samples	Percentage
>=60	475	38.0%
59-59.9	212	16.9%
58-58.9	238	19.0%
57.5-57.9	92	7.4%
57-57.4	61	4.9%
56.5-56.9	47	3.8%
56-56.4	47	3.8%
55.5-55.9	26	2.1%
55-55.4	18	1.4%
54.5-54.9	11	0.9%
54-54.4	5	0.4%
<54	19	1.5%
Avg.	**1251**	**59.20**

Dockage	Samples	Percentage
<=.5	470	37.6%
.6-1	395	31.6%
1.1-2	254	20.3%
2.1-3	55	4.4%
3.1-4	16	1.3%
4.1-5	17	1.4%
5.1-6	11	0.9%
6.1-7	12	1.0%
7.1-8	6	0.5%
8.1-9	5	0.4%
9.1-10	1	0.1%
>10.1	9	0.7%
Avg.	**1251**	**1.2%**

Grade	Samples	Percentage
#1	452	36.1%
#2	449	35.9%
#3	254	20.3%
#4	70	5.6%
#5	15	1.2%
S.G.	11	0.9%
Avg.	**1251**	**2.02**

Moisture	Samples	Percentage
<=13.5	966	77.2%
13.6-13.7	37	3.0%
13.8-14	55	4.4%
14.1-14.2	40	3.2%
14.3-14.5	39	3.1%
14.6-14.7	22	1.8%
14.8-15	21	1.7%
15.1-16	53	4.2%
16.1-17.0	11	0.9%
17.1-18	5	0.4%
18.1-19	2	0.2%
Avg.	**1251**	**12.6%**

Damage	Samples	Percentage
<=1	1206	96.4%
1.1-2	31	2.5%
2.1-3	4	0.3%
3.1-4	4	0.3%
4.1-5	3	0.2%
5.1-6	2	0.2%
6.1-7	0	0.0%
7.1-8	0	0.0%
8.1-9	0	0.0%
9.1-10	1	0.1%
>10	0	0.0%
Avg.	**1251**	**0.3%**

Foreign Material	Samples	Percentage
<.5	1174	93.8%
.5-.7	37	3.0%
.8-1	12	1.0%
1.1-1.3	9	0.7%
1.4-2	9	0.7%
2.1-2.5	2	0.2%
2.6-3	2	0.2%
3.1-3.5	3	0.2%
3.6-4.0	0	0.0%
4.1-5	1	0.1%
>5	2	0.2%
Avg.	**1251**	**0.2%**

Shrunken & Broken	Samples	Percentage
<3	1190	95.1%
3.1-4	46	3.7%
4.1-5	10	0.8%
5.1-6	2	0.2%
6.1-7	2	0.2%
7.1-8	0	0.0%
8.1-9	0	0.0%
9.1-10	1	0.1%
10.1-11	0	0.0%
11.1-12	0	0.0%
>12	0	0.0%
Avg.	**1251**	**1.4%**

Protein	Samples	Percentage
>=18	0	0.0%
17-17.9	0	0.0%
16-16.9	2	0.2%
15-15.9	8	0.6%
14-14.9	32	2.6%
13-13.9	164	13.1%
12-12.9	400	32.0%
11-11.9	419	33.5%
10-10.9	191	15.3%
9.0-9.9	29	2.3%
8.0-8.9	6	0.5%
Avg.	**1251**	**11.9%**

Source: Calculated from data in Kenkel, Anderson, and Attaway

Appendix Table A.4
Discount Schedule from NIL Buyers for the 1995 Wheat Harvest (Cents/Bushel)

Dockage	Test Weight	Foreign Material	Total Defects
≤2.9=0	≥64# = 0	≤1.4 = 0	≤7= 0
3.0-3.5 = 2	63#-63.9 = .5	1.5-1.9 = 1	7.1-8.0 = 1
3.6-3.9 = 4	62#-62.9 = 1.5	2.0-2.4 = 2	8.1-9.0 = 2
4.0-4.5 = 6	61#-61.9 = 3.5	2.5-2.9 = 3	9.1-10.0 = 3
4.6-4.9 = 8	60#-60.9 = 5.5	3.0-3.4 = 4	10.1-11.0 = 4
5.0-5.5 = 10	59#-59.9 = 7.5	3.5-3.9 = 5	11.1-12.0 = 5
5.6-5.9 = 12	58#-58.9 = 9.5	4.0-4.4 = 6	12.1-13.0 = 6
6.0-6.5 = 14	57#-57.9 = 11.5	4.5-4.9 = 7	13.1-14.0 = 7
6.6-6.9 = 16	56#-56.9 = 13.5	5.0-5.9 = 8	14.1-15.0 = 8
7.0-7.5 = 18	55#-55.9 = 15.5	≥6 = 10	>15 = 10
7.6-7.9 = 20	54#-54.9 = 17.5		
8.0-8.9 = 22	53#-53.9 = 20.5		
9.0-9.9 = 26	52#-52.9 = 26.5		
10.0-10.9 = 30	51#-51.9 = 32.5		
11.0-11.9 = 34	50#-50.9 = 38.5		
12.0-13.0 = 38	<50# = 44.5		
>13.0 = 42			

Shrunken &Broken	Moisture	Damage
≤1.4 = 0	<14=0	≤2 = 0
1.5-1.9 = 0.5	14.0-14.5 = 3	2.1-3 = 1
2.0-2.4 = 1.0	14.6-15.0 = 6	3.1-4.0 = 2
2.5-2.9 = 1.5	15.1-15.5 = 9	4.1-5.0 = 3
3.0-3.4 = 2.0	15.6-16.0 = 12	5.1-6.0 = 5
3.5-3.9 = 2.5	16.1-16.5 = 15	6.1-7.0 = 7
4.0-4.4 = 3.0	16.6-17.0 = 18	7.1-8.0 = 9
4.5-4.9 = 3.5	>17.0 = 21	8.1-9.0 = 11
5.0-5.9 = 4.5		9.1-10.0 = 13
6.0-6.9 = 5.5		>10 = 16
7.0-7.9 = 6.5		
8.0-8.9 = 7.5		
9.0-9.9 = 8.5		
≥10.0 = 9.5		

Source: Kenkel, Anderson, and Attaway

Appendix Table A.5
Discount Schedule from NIL Buyers for the 1996 Wheat Harvest (Cents/Bushel)

Dockage	Test Weight	Foreign Material	Total Defects
≤.9=0	≥60# = 0	<0.5 = 0	≤3=0
1.0-2.0 = 2	59.0#-59.9 = .5	0.5-0.7 = .5	3.1-4.0 = .5
2.1-3.0 = 4	58.0#-58.9 = 1	0.8-1.0 = 3	4.1-5.0 = 1
3.1-4.0 = 6	57.5#-57.9 = 2	1.1-1.3 = 5	5.1-6.0 = 3
4.1-5.0 = 8	57.0#-57.4 = 4	1.4-2.0 = 6	6.1-7.0 = 5
5.1-6.0 = 12	56.5#-56.9 = 6	2.1-2.5 = 7	7.1-8.0 = 7
6.1-7.0 = 16	56.0#-56.4 = 8	2.6-3.0 = 8	8.1-9.0 = 9
7.1-8.0 = 20	55.5#-55.9 = 10	3.1-3.5 = 9	9.1-10.0 = 11
8.1-9.0 = 24	55.0#-55.4 = 12	3.6-4.0 = 10	10.1-11.0 =14
9.1-10.0 = 28	54.5#-54.9 = 15	4.1-4.5 = 11	11.1-12.0 =17
>10.1 =32	54.0#-54.4 = 18	≥4.6 = 12	12.1-13.0 =20
	<54# = 24		13.1-14.0 =23
			>14 = 26

Shrunken &Broken	Moisture	Damage
<3.0 = 0	<14=0	≤2.0 = 0
3.0-3.9 = .5	14.0-14.5 = 3	2.1-3.0 = 1
4.0-4.9 = 1	14.6-15.0 = 6	3.1-4.0 = 2
5.0-5.9 = 3	15.0-15.5 = 9	4.1-5.0 = 3
6.0-6.9 = 5	15.6-16.0 = 12	5.1-6.0 = 5
7.0-7.9 = 7	16.0-16.5 = 15	6.1-7.0 = 7
8.0-8.9 = 9	16.6-17.0 = 18	7.1-8.0 = 9
9.0-9.9 = 10	>17.0 = 21	8.1-9.0 = 11
10.0-10.9 = 11		9.1-10.0 = 13
11.0-11.9 = 13		>10 = 16
≥12.0 = 15		

Source: Kenkel, Anderson, and Attaway

Appendix Table A.6
Discount Schedule from NIL Buyers for the 1997 Wheat Harvest (Cents/Bushel)

Dockage	Test Weight	Foreign Material	Total Defects
≤1 = 0	≥60# = 0	<0.5 = 0	<3=0
1.1-2.0 = 2	59.0#-59.9 = .5	0.5-0.7 = .5	3.1-4.0 = .5
2.1-3.0 = 3	58.0#-58.9 = 1	0.8-1.0 = 3	4.1-5.0 = 1
3.1-4.0 = 5	57.5#-57.9 = 2	1.1-1.3 = 5	5.1-6.0 = 3
4.1-5.0 = 7	57.0#-57.4 = 4	1.4-2.0 = 6	6.1-7.0 = 5
5.1-6.0 = 11	56.5#-56.9 = 6	2.1-2.5 = 7	7.1-8.0 = 7
6.1-7.0 = 15	56.0#-56.4 = 8	2.6-3.0 = 8	8.1-9.0 = 9
7.1-8.0 = 19	55.5#-55.9 = 10	3.1-3.5 = 9	9.1-10.0 = 11
8.1-9.0 = 23	55.0#-55.4 = 12	3.6-4.0 = 10	10.1-11.0 =14
9.1-10.0 = 27	54.5#-54.9 = 15	4.1-5.0 = 12	11.1-12.0 =17
>10.0 =31	54.0#-54.4 = 18	>5.0= 14	12.1-13.0 =20
	<54# = 24		13.1-14.0 =23
			>14 = 26

Shrunken &Broken	Moisture	Damage
≤3.0 = 0	≤13.5=0	≤2.0 = 0
3.1-4.0 = .5	13.6-13.7 = 2	2.1-3.0 = 1
4.1-5.0 = 1	13.8-14.0 = 4	3.1-4.0 = 2
5.1-6.0 = 3	14.1-14.2 = 6	4.1-5.0 = 3
6.1-7.0 = 5	14.3-14.5 = 12	5.1-6.0 = 5
7.0-8.0 = 7	14.6-14.7 = 10	6.1-7.0 = 7
8.1-9.0 = 9	14.8-15.0 = 12	7.1-8.0 = 9
9.1-10.0 = 10	15.1-16.0 = 20	8.1-9.0 = 11
10.1-11.0 = 11	16.1-17.0 = 28	9.1-10.0 = 13
11.1-12.0 = 12	17.1-18.0 = 36	>10 = 16
>12.0 = 13	>18.0 = 44	

Source: Farmland Grain Division

Appendix Table A.7
Oklahoma Quality Characteristics For Test Weight, Dockage, and SBK
During 1995 Wheat Harvest Showing Three Different
Qualities and Discounts From NIL Buyers

		1995	
Quality	Quality Level (% bu/mi²)	Average	NIL Discounts (cents/bushel)
Test Weight	High ≥60# = 9.6%	60.59	5.5
	Middle 57#-59.9 = 59.5%	58.45	9.5
	Low <57# = 30.9%	55.29	15.5
	Total Average	57.7	11.5
Dockage	High ≤ 2.9 = 65.9%	.85	0
	Middle 3.0-4.5 = 5%	3.78	4
	Low >4.5 = 29.1%	11.21	34
	Total Average	4.0	6
SBK	High ≤ 1.4 = 56.8%	.81	0
	Middle 1.5-1.9 = 13.1%	1.69	.5
	Low ≥2.0 = 30.1%	3.25	2
	Total Average	1.7	.5

Source: Calculated from data in Kenkel, Anderson, and Attaway

Appendix Table A.8
Oklahoma Quality Characteristics For Test Weight, Dockage, and SBK During 1996 Wheat Harvest Showing Three Different Qualities and Discounts From NIL Buyers

		1996	
Quality	Quality Level (% bu/mi²)	Average (%)	NIL Discounts (cents/bushel)
Test Weight	High ≥60# = 16.5%	60.81	0
	Middle 57#-59.9 = 44.5%	58.52	1
	Low <57# = 39.0%	55.19	12
	Total Average	57.6	2
Dockage	High ≤ .9 = 64.1%	.50	0
	Middle 1.0-2.0 = 27.5%	1.37	2
	Low >2.0 = 8.4%	3.59	6
	Total Average	1.0	2
SBK	High ≤ 3= 83.6 %	1.51	0
	Middle 3.0-3.9 = 10.5%	3.46	.5
	Low >4.0 = 5.9%	4.94	1

Source: Calculated from data in Kenkel, Anderson, and Attaway

Appendix Table A.9
Oklahoma Quality Characteristics For Test Weight, Dockage, and SBK
During 1997 Wheat Harvest Showing Three Different
Qualities and Discounts From NIL Buyers

1997

Quality	Quality Level (% bu/mi^2)	Average (%)	NIL Discounts (cents/bushel)
Test Weight	High ≥60# = 38.0%	61.35	0
	Middle 59#-59.9 = 16.9%	59.4	.5
	Low <59# = 45.1%	57.31	4
	Total Average	59.2	.5
Dockage	High ≤ 1.0 = 69.2%	.56	0
	Middle 1.1-2.0 = 20.3%	1.41	2
	Low >2.0 = 10.5%	4.76	7
	Total Average	1.2	2
SBK	High ≤ 3= 95.1%	1.28	0
	Middle 3.1-4.0 = 3.7%	3.31	.5
	Low >4.1 = 1.2%	5.29	3
	Total Average	1.4	0

Source: Calculated from data in Kenkel, Anderson, and Attaway

Appendix Table A.10
Production Densities of Oklahoma Districts During 1995 Harvest

	Bushels/Total Farmland Acre	K_i (Bu/Mi^2)
Panhandle	2.4	1,556
West Central	5.5	3,512
Southwest	5.8	3,708
North Central	9.1	5,804
Central	3.0	1933
South Central	.3	208
Northeast	.6	391
East Central	.2	209
Southeast`	.1	54
OVERALL AVERAGE	3.4	2,174

Source: Calculated from data in Oklahoma Agricultural Census (1992) and Oklahoma Agricultural Statistics Service (1995)

Appendix Table A.11
Production Densities of Oklahoma Districts During 1996 Harvest

	Bushels/Total Farmland Acre	K_i (Bu/Mi^2)
Panhandle	2.1	1,352
West Central	4.2	2,699
Southwest	5.0	3,213
North Central	6.9	4,438
Central	2.9	1,830
South Central	.5	320
Northeast	1.1	686
East Central	.3	209
Southeast	.1	89
OVERALL AVERAGE	2.9	1,854

Source: Calculated from data in Oklahoma Agricultural Census (1992) and Oklahoma Agricultural Statistics Service (1996)

APPENDIX B

SENSITIVITY ANALYSIS RESULTS

Appendix Table B.1
Sensitivity Analysis: Various Price Differentials
Structure 1: Strategy 1, Results of Elevator A Maximizing Profits:
No Competition, Elevator A Grades and Segregates (Pays Different Quality Prices)

Price Differential($)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi)	Profit ($)
.10	A	4.29	4.22	4.16	17,721,557	95,612,357	42,735,987	161	153	144	94.42 M
.08	A	4.28	4.22	4.17	17,356,736	95,612,357	43,728,058	159	153	146	94.94 M
. 06	A	4.26	4.22	4.18	16,995,708	95,612,357	44,731,513	158	153	148	95.48 M
.04	A	4.25	4.22	4.20	16,638,476	95,612,357	45,746,352	156	153	149	96.05 M
.02	A	4.24	4.22	4.21	16,285,037	95,612,357	46,772,574	154	153	151	96.64 M
.00	A	4.22	4.22	4.22	15,935,393	95,612,357	47,810,179	153	153	153	97.27 M

Alternative Value = \$3.00
2,174 Production Density (bushels/ mi^2)
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.2
Sensitivity Analysis: Various Price Differentials
Structure 1: Strategy 2, Results of Elevator A Maximizing Profits:
No Competition, Elevator A Grades and Segregates (Pays One Average Price)

Price Differential($)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2 (bu.)	Quantity Q3 (bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3 (mi.)	Profit ($)
.10	A	4.21	4.21	4.21	15,589,543	93,537,258	46,772,574	151	151	151	94.11 M
.08	A	4.21	4.21	4.21	15,658,409	93,950,457	46,979,184	151	151	151	94.74 M
.06	A	4.21	4.21	4.21	15,727,428	94,364,566	47,186,250	152	152	152	95.37 M
.04	A	4.22	4.22	4.22	15,796,598	94,779,586	47,393,771	152	152	152	96.00 M
.02	A	4.22	4.22	4.22	15,865,919	95,195,516	47,601,748	152	152	152	96.63 M
.00	A	4.22	4.22	4.22	15,935,393	95,612,357	47,810,179	153	153	153	97.27 M

Alternative Value = $3.00
2,174 Production Density (bushels/ mi^2)
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.3
Sensitivity Analysis: Various Price Differentials
Structure 1: Strategy 3, Results of Elevator A Maximizing Profits:
No Competition, Elevator A Does Not Grade or Segregate (Pays One Average Price)

Price Differential ($)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1($)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
.10	A	4.17	4.17	4.17	14,524,917	87,149,504	43,578,522	146	146	146	84.63 M
.08	A	4.18	4.18	4.18	14,858,815	89,152,889	44,580,269	147	147	147	87.76 M
.06	A	4.19	4.19	4.19	15,196,507	91,179,040	45,593,400	149	149	149	99.06 M
.04	A	4.21	4.21	4.21	15,537,993	93,227,957	46,617,915	151	151	151	93.65 M
.02	A	4.22	4.22	4.22	15,883,273	95,299,641	47,653,813	152	152	152	96.79 M
.00	A	4.23	4.23	4.23	16,232,349	97,394,091	48,701,094	154	154	154	100.00 M

Alternative Value = $3.00
2,174 Production Density (bushels/ mi^2)
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.4
Sensitivity Analysis: Various Price Differentials
Structure 2: Strategy 1, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Don't Copy Each Other)
Elevator A Grades and Segregates (Pays Different Quality Prices)
Elevator B Grades and Segregates (Pays One Average Price)

Price Differential($)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
.10	A	4.81	4.74	4.67	670,845	2,169,147	441,614	31	23	15	209,102
	B	4.72	4.72	4.72	51,214	1,183,285	1,314,955	9	17	25	68,976
.08	A	4.80	4.74	4.69	567,899	2,013,971	492,861	29	22	16	174,107
	B	4.73	4.73	4.73	85,128	1,302,902	1,230,361	11	18	24	85,403
.06	A	4.79	4.75	4.71	478,290	1,887,438	555,695	27	22	17	148,679
	B	4.74	4.74	4.74	125,155	1,408,378	1,135,950	13	18	23	99,127
.04	A	4.78	4.75	4.72	400,075	1,784,764	630,594	24	21	18	131,389
	B	4.74	4.74	4.74	170,439	1,499,746	1,034,616	16	19	22	109,448
.02	A	4.76	4.75	4.74	332,159	1,702,713	718,403	22	20	19	121,340
	B	4.75	4.75	4.75	219,984	1,576,810	928,670	18	20	21	115,842
.00	A	4.75	4.75	4.75	273,193	1,639,157	820,169	20	20	20	118,042
	B	4.75	4.75	4.75	273,193	1,639,157	820,169	20	20	20	118,042

2,174 Production Density (bushels/ mi²)
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.5
Sensitivity Analysis: Various Price Differentials
Structure 2: Strategy 2, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Don't Copy Each Other)
Elevator A Grades and Segregates (Pays Different Quality Prices)
Elevator B Does Not Grade or Segregate (Pays One Average Price)

Price Differential($)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
.10	A	4.80	4.73	4.66	805,271	2,771,376	640,308	34	26	18	343,545
	B	4.68	4.68	4.68	21,901	802,541	1,022,241	6	14	22	27,485
.08	A	4.79	4.73	4.68	663,797	2,461,600	652,792	31	25	18	270,130
	B	4.70	4.70	4.70	53,185	983,356	1,006,609	9	15	22	45,262
.06	A	4.78	4.74	4.70	537,874	2,179,697	669,050	28	23	18	209,248
	B	4.72	4.72	4.72	97,318	1,175,515	986,650	12	17	22	66,646
.04	A	4.77	4.75	4.72	426,545	1,922,007	688,481	25	22	18	159,037
	B	4.73	4.73	4.73	153,862	1,378,809	963,366	15	18	22	91,902
.02	A	4.77	4.75	4.74	329,125	1,685,943	710,713	22	20	19	118,032
	B	4.75	4.75	4.75	222,466	1,593,030	937,458	18	20	21	121,346
.00	A	4.76	4.76	4.76	244,945	1,469,672	735,395	19	19	19	85,010
	B	4.77	4.77	4.77	302,982	1,817,889	909,567	21	21	21	155,333

2,174 Production Density (bushels/ mi^2)
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.6
Sensitivity Analysis: Various Price Differentials
Structure 2: Strategy 3, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Don't Copy Each Other)
Elevator A Grades and Segregates (Pays One Average Price)
Elevator B Does Not Grade or Segregate (Pays One Average Price)

Price Differential($)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
.10	A	4.72	4.72	4.72	391,357	2,348,140	1,174,771	24	24	24	274,164
	B	4.69	4.69	4.69	176,209	1,057,252	529,093	16	16	16	13,254
.08	A	4.73	4.73	4.73	359,342	2,156,055	1,078,700	23	23	23	229,146
	B	4.70	4.70	4.70	198,832	1,192,989	596,992	17	17	17	35,749
. 06	A	4.73	4.73	4.73	328,734	1,972,403	986,846	22	22	22	187,866
	B	4.72	4.72	4.72	222,788	1,336,726	668,892	18	18	18	61,005
.04	A	4.74	4.74	4.74	299,412	1,796,475	898,853	21	21	21	150,215
	B	4.73	4.73	4.73	248,175	1,489,047	745,084	19	19	19	89,291
.02	A	4.75	4.75	4.75	271,497	1,628,985	815,080	20	20	20	115,978
	B	4.75	4.75	4.75	274,894	1,649,362	825,272	20	20	20	120,666
.00	A	4.76	4.76	4.76	244,945	1,469,672	735,395	19	19	19	85,010
	B	4.77	4.77	4.77	302,982	1,817,889	909,567	21	21	21	155,333

2,174 Production Density (bushels/ mi^2)
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.7
Sensitivity Analysis: Various Price Differentials
Structure 3: Strategy 1, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Copy Each Other)
Elevators A & B Grade and Segregate (Pay Different Quality Prices)

Price Differential($)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
.10	A	4.85	4.75	4.65	273,193	1,639,157	820,156	20	20	20	118,032
	B	4.85	4.75	4.65	273,193	1,639,157	820,156	20	20	20	118,032
.08	A	4.83	4.75	4.67	273,193	1,639,157	820,156	20	20	20	118,027
	B	4.83	4.75	4.67	273,193	1,639,157	820,156	20	20	20	118,027
.06	A	4.81	4.75	4.69	273,193	1,639,157	820,156	20	20	20	118,027
	B	4.81	4.75	4.69	273,193	1,639,157	820,156	20	20	20	118,027
.04	A	4.79	4.75	4.71	273,193	1,639,157	820,156	20	20	20	118,027
	B	4.79	4.75	4.71	273,193	1,639,157	820,156	20	20	20	118,027
.02	A	4.77	4.75	4.73	273,193	1,639,157	820,156	20	20	20	118,028
	B	4.77	4.75	4.73	273,193	1,639,157	820,156	20	20	20	118,028
.00	A	4.75	4.75	4.75	273,193	1,639,157	820,156	20	20	20	118,028
	B	4.75	4.75	4.75	273,193	1,639,157	820,156	20	20	20	118,028

2,174 Production Density (bushels/ mi^2)
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.8
Sensitivity Analysis: Various Price Differentials
Structure 3: Strategy 2, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Copy Each Other)
Elevators A & B Grade and Segregate (Pay One Average Price)

Price Differential($)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
.10	A	4.73	4.73	4.73	273,193	1,639,157	820,156	20	20	20	117,983
	B	4.73	4.73	4.73	273,193	1,639,157	820,156	20	20	20	117,983
.08	A	4.74	4.74	4.74	273,193	1,639,157	820,156	20	20	20	117,983
	B	4.74	4.74	4.74	273,193	1,639,157	820,156	20	20	20	117,983
.06	A	4.74	4.74	4.74	273,193	1,639,157	820,156	20	20	20	117,983
	B	4.74	4.74	4.74	273,193	1,639,157	820,156	20	20	20	117,983
.04	A	4.74	4.74	4.74	273,193	1,639,157	820,156	20	20	20	117,983
	B	4.74	4.74	4.74	273,193	1,639,157	820,156	20	20	20	117,983
.02	A	4.75	4.75	4.75	273,193	1,639,157	820,156	20	20	20	117,983
	B	4.75	4.75	4.75	273,193	1,639,157	820,156	20	20	20	117,983
.00	A	4.75	4.75	4.75	273,193	1,639,157	820,156	20	20	20	117,983
	B	4.75	4.75	4.75	273,193	1,639,157	820,156	20	20	20	117,983

2,174 Production Density (bushels/ mi^2)
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.9
Sensitivity Analysis: Various Price Differentials
Structure 3: Strategy 3, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Copy Each Other)
Elevators A & B Do Not Grade or Segregate (Pay One Average Price)

Price Differential($)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
.10	A	4.67	4.67	4.67	273,193	1,639,157	820,161	20	20	20	118,639
	B	4.67	4.67	4.67	273,193	1,639,157	820,161	20	20	20	118,639
.08	A	4.69	4.69	4.69	273,193	1,639,157	820,161	20	20	20	118,620
	B	4.69	4.69	4.69	273,193	1,639,157	820,161	20	20	20	118,620
.06	A	4.71	4.71	4.71	273,193	1,639,157	820,161	20	20	20	118,620
	B	4.71	4.71	4.71	273,193	1,639,157	820,161	20	20	20	118,620
.04	A	4.73	4.73	4.73	273,193	1,639,157	820,161	20	20	20	118,620
	B	4.73	4.73	4.73	273,193	1,639,157	820,161	20	20	20	118,620
.02	A	4.75	4.75	4.75	273,193	1,639,157	820,161	20	20	20	118,621
	B	4.75	4.75	4.75	273,193	1,639,157	820,161	20	20	20	118,621
.00	A	4.77	4.77	4.77	273,193	1,639,157	820,161	20	20	20	118,621
	B	4.77	4.77	4.77	273,193	1,639,157	820,161	20	20	20	118,621

2,174 Production Density (bushels/ mi^2)
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.10
Sensitivity Analysis: Various Production Densities
Structure 1: Strategy 1, Results of Elevator A Maximizing Profits:
No Competition, Elevator A Grades and Segregates (Pays Different Quality Prices)

Production Densities(bu/mi²)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
1,000	A	4.29	4.22	4.16	8,151,590	43,979,925	19,657,768	161	153	144	43.37 M
2,174	A	4.29	4.22	4.16	17,721,557	95,612,357	42,735,987	161	153	144	94.42 M
4,000	A	4.29	4.22	4.16	32,606,361	175,919,700	78,631,070	161	153	144	173.82 M

Alternative Value = $3.00
$.10 Price Differential
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.11
Sensitivity Analysis: Various Production Densities
Structure 1: Strategy 2, Results of Elevator A Maximizing Profits:
No Competition, Elevator A Grades and Segregates (Pays One Average Price)

Production Densities(bu/mi^2)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
1,000	A	4.21	4.21	4.21	7,170,903	43,025,418	21,514,523	151	151	151	43.24 M
2,174	A	4.21	4.21	4.21	15,589,543	93,537,258	46,772,574	151	151	151	94.11 M
4,000	A	4.21	4.21	4.21	28,683,612	172,101,672	86,058,094	151	151	151	173.32 M

Alternative Value = $3.00
$.10 Price Differential
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.12
Sensitivity Analysis: Various Production Densities
Structure 1: Strategy 3, Results of Elevator A Maximizing Profits:
No Competition, Elevator A Does Not Grade or Segregate (Pays One Average Price)

Production Densities(bu/mi²)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
1,000	A	4.17	4.17	4.17	6,681,195	40,087,168	20,045,318	146	146	146	38.87 M
2,174	A	4.17	4.17	4.17	14,524,917	87,149,504	43,578,522	146	146	146	84.63 M
4,000	A	4.17	4.17	4.17	26,724,779	160,348,674	80,181,273	146	146	146	155.80 M

Alternative Value = $3.00
$.10 Price Differential
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.13
Sensitivity Analysis: Various Production Densities
Structure 2: Strategy 1, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Don't Copy Each Other)
Elevator A Grades and Segregates (Pays Different Quality Prices)
Elevator B Grades and Segregates (Pays One Average Price)

Production Densities(bu/mi²)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
1,000	A	4.81	4.74	4.67	308,576	997,768	203,134	31	23	15	41,864
	B	4.72	4.72	4.72	23,558	544,289	604,855	9	17	25	-22,591
2,174	A	4.81	4.74	4.67	670,845	2,169,147	441,614	31	23	15	209,102
	B	4.72	4.72	4.72	51,214	1,183,285	1,314,955	9	17	25	68,976
4,000	A	4.81	4.74	4.67	1,234,305	3,991,071	812,537	31	23	15	469,218
	B	4.72	4.72	4.72	94,231	2,177,158	2,419,421	9	17	15	211,397

Alternative Value = $3.00
$.10 Price Differential
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.14
Sensitivity Analysis: Various Production Densities
Structure 2: Strategy 2, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Don't Copy Each Other)
Elevator A Grades and Segregates (Pays Different Quality Prices)
Elevator B Does Not Grade or Segregate (Pays One Average Price)

Production Densities(bu/mi^2)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
1,000	A	4.80	4.73	4.66	370,410	1,274,782	294,530	34	26	18	103,705
	B	4.68	4.68	4.68	10,074	369,154	470,212	6	14	22	-41,359
2,174	A	4.80	4.73	4.66	805,271	2,771,376	640,308	34	26	18	343,545
	B	4.68	4.68	4.68	21,901	802,541	1,022,241	6	14	22	27,485
4,000	A	4.80	4.73	4.66	1,481,639	5,099,127	1,178,120	34	26	18	716,583
	B	4.68	4.68	4.68	40,295	1,476,617	1,880,848	6	14	22	134,562

Alternative Value = $3.00
$.10 Price Differential
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.15
Sensitivity Analysis: Various Production Densities
Structure 2: Strategy 3, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Don't Copy Each Other)
Elevator A Grades and Segregates (Pays One Average Price)
Elevator B Does Not Grade or Segregate (Pays One Average Price)

Production Densities(bu/mi^2)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
1,000	A	4.72	4.72	4.72	180,017	1,080,101	540,373	24	24	24	71,792
	B	4.69	4.69	4.69	81,053	486,316	243,373	16	16	16	-47,905
2,174	A	4.72	4.72	4.72	391,357	2,348,140	1,174,771	24	24	24	274,164
	B	4.69	4.69	4.69	176,209	1,057,252	529,093	16	16	16	13,254
4,000	A	4.72	4.72	4.72	720,067	4,320,405	2,161,491	24	24	24	588,928
	B	4.69	4.69	4.69	324,211	1,945,265	973,492	16	16	16	108,379

Alternative Value = $3.00
$.10 Price Differential
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.16
Sensitivity Analysis: Various Production Densities
Structure 3: Strategy 1, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Copy Each Other)
Elevators A & B Grade and Segregate (Pay Different Quality Prices)

Production Densities(bu/mi^2)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
1,000	A	4.85	4.75	4.65	125,664	753,982	377,257	20	20	20	-26
	B	4.85	4.75	4.65	125,664	753,982	377,257	20	20	20	-26
2,174	A	4.85	4.75	4.65	273,193	1,639,157	820,156	20	20	20	118,032
	B	4.85	4.75	4.65	273,193	1,639,157	820,156	20	20	20	118,032
4,000	A	4.85	4.75	4.65	502,655	3,015,929	1,509,027	20	20	20	301,656
	B	4.85	4.75	4.65	502,655	3,015,929	1,509,027	20	20	20	301,656

Alternative Value = $3.00
$.10 Price Differential
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.17
Sensitivity Analysis: Various Production Densities
Structure 3: Strategy 2, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Copy Each Other)
Elevators A & B Grade and Segregate (Pay One Average Price)

Production Densities(bu/mi^2)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
1,000	A	4.73	4.73	4.73	125,664	753,982	377,261	20	20	20	-49
	B	4.73	4.73	4.73	125,664	753,982	377,261	20	20	20	-49
2,174	A	4.73	4.73	4.73	273,193	1,639,157	820,166	20	20	20	117,983
	B	4.73	4.73	4.73	273,193	1,639,157	820,166	20	20	20	117,983
4,000	A	4.73	4.73	4.73	502,655	3,015,929	1,509,045	20	20	20	301,566
	B	4.73	4.73	4.73	502,655	3,015,929	1,509,045	20	20	20	301,566

Alternative Value = $3.00
$.10 Price Differential
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.18
Sensitivity Analysis: Various Production Densities
Structure 3: Strategy 3, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Copy Each Other)
Elevators A & B Do Not Grade or Segregate (Pay One Average Price)

Production Densities(bu/mi^2)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
1,000	A	4.67	4.67	4.67	125,664	753,982	377,258	20	20	20	570
	B	4.67	4.67	4.67	125,664	753,982	377,258	20	20	20	570
2,174	A	4.67	4.67	4.67	273,193	1,639,157	820,158	20	20	20	118,639
	B	4.67	4.67	4.67	273,193	1,639,157	820,158	20	20	20	118,639
4,000	A	4.67	4.67	4.67	502,655	3,015,929	1,509,031	20	20	20	302,279
	B	4.67	4.67	4.67	502,655	3,015,929	1,509,031	20	20	20	302,279

Alternative Value = $3.00
$.10 Price Differential
10% High Quality, 60% Middle Quality, 30% Low Quality
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.19
Sensitivity Analysis: Various Quality Levels
Structure 1: Strategy 1, Results of Elevator A Maximizing Profits:
No Competition, Elevator A Grades and Segregates (Pays Different Quality Prices)

Quality Levels(%)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
10% Q1 60% Q2 30% Q3	A	4.29	4.22	4.16	17,721,557	95,612,357	42,735,987	161	153	144	94.42 M
30% Q1 40% Q2 30% Q3	A	4.29	4.22	4.16	53,164,671	63,741,571	42,735,987	161	153	144	97.79 M
50% Q1 20% Q2 30% Q3	A	4.29	4.22	4.16	88,607,785	31,870,786	42,735,987	161	153	144	101.15 M

Alternative Value = $3.00
2,174 Production Density (bushels/ mi^2)
$.10 Price Differential
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.20
Sensitivity Analysis: Various Quality Levels
Structure 1: Strategy 2, Results of Elevator A Maximizing Profits:
No Competition, Elevator A Grades and Segregates (Pays One Average Price)

Quality Levels(%)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
10% Q1 60% Q2 30% Q3	A	4.21	4.21	4.21	15,589,543	93,537,258	46,772,574	151	151	151	94.11 M
30% Q1 40% Q2 30% Q3	A	4.22	4.22	4.22	47,806,179	63,741,571	47,810,179	153	153	153	97.27 M
50% Q1 20% Q2 30% Q3	A	4.24	4.24	4.24	81,425,185	32,570,074	48,859,168	154	154	154	100.49 M

Alternative Value = $3.00
2,174 Production Density (bushels/ mi²)
$.10 Price Differential
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.21
Sensitivity Analysis: Various Quality Levels
Structure 1: Strategy 3, Results of Elevator A Maximizing Profits:
No Competition, Elevator A Does Not Grade or Segregate (Pays One Average Price)

Quality Levels(%)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
10% Q1 60% Q2 30% Q3	A	4.17	4.17	4.17	14,524,917	87,149,504	43,578,522	146	146	146	84.63 M
30% Q1 40% Q2 30% Q3	A	4.23	4.23	4.23	48,697,045	64,929,394	48,701,094	154	154	154	100.00 M
50% Q1 20% Q2 30% Q3	A	4.23	4.23	4.23	81,161,743	32,464,697	48,701,094	154	154	154	100.00 M

Alternative Value = $3.00
2,174 Production Density (bushels/ mi^2)
$.10 Price Differential
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.22
Sensitivity Analysis: Various Quality Levels
Structure 2: Strategy 1, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Don't Copy Each Other)
Elevator A Grades and Segregates (Pays Different Quality Prices)
Elevator B Grades and Segregates (Pays One Average Price)

Quality Levels(%)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
10% Q1	A	4.81	4.74	4.67	670,845	2,169,147	441,614	31	23	15	209,102
60% Q2	B	4.72	4.72	4.72	51,214	1,183,285	1,314,955	9	17	25	68,976
30% Q3											
30% Q1	A	4.81	4.74	4.68	1,930,642	1,366,243	403,707	31	22	14	281,392
40% Q2	B	4.72	4.72	4.72	177,356	849,808	1,382,686	9	18	26	39,973
30% Q3											
50% Q1	A	4.81	4.75	4.68	3,031,586	629,177	353,542	30	21	13	333,365
20% Q2	B	4.74	4.74	4.74	355,627	469,433	1,480,269	10	19	27	11,780
30% Q3											

Alternative Value = $3.00
2,174 Production Density (bushels/ mi²)
$.10 Price Differential
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.23
Sensitivity Analysis: Various Quality Levels
Structure 2: Strategy 2, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Don't Copy Each Other)
Elevator A Grades and Segregates (Pays Different Quality Prices)
Elevator B Does Not Grade or Segregate (Pays One Average Price)

Quality Levels(%)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
10% Q1	A	4.80	4.73	4.66	805,271	2,771,376	640,308	34	26	18	343,545
60% Q2	B	4.68	4.68	4.68	21,901	802,541	1,022,241	6	14	22	27,485
30% Q3											
30% Q1	A	4.80	4.73	4.66	2,405,156	1,836,596	634,821	34	26	18	464,256
40% Q2	B	4.68	4.68	4.68	67,473	540,965	1,029,201	6	14	22	11,563
30% Q3											
50% Q1	A	4.80	4.73	4.66	3,984,700	911,069	627,467	34	26	17	581,975
20% Q2	B	4.68	4.68	4.68	116,498	274,428	1,038,614	6	14	23	-4,376
30% Q3											

Alternative Value = $3.00
2,174 Production Density (bushels/ mi^2)
$.10 Price Differential
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.24
Sensitivity Analysis: Various Quality Levels
Structure 2: Strategy 3, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Don't Copy Each Other)
Elevator A Grades and Segregates (Pays One Average Price)
Elevator B Does Not Grade or Segregate (Pays One Average Price)

Quality Levels(%)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
10% Q1	A	4.72	4.72	4.72	391,357	2,348,140	1,174,771	24	24	24	274,164
60% Q2	B	4.69	4.69	4.69	176,209	1,057,252	529,093	16	16	16	13,254
30% Q3											
30% Q1	A	4.76	4.76	4.76	734,839	979,786	735,398	19	19	19	84,956
40% Q2	B	4.77	4.77	4.77	908,941	1,211,921	909,564	21	21	21	155,334
30% Q3											
50% Q1	A	4.77	4.77	4.77	1,391,915	556,766	835,747	20	20	20	124,155
20% Q2	B	4.77	4.77	4.77	1,340,258	536,103	804,741	20	20	20	112,484
30% Q3											

Alternative Value = $3.00
2,174 Production Density (bushels/ mi^2)
$.10 Price Differential
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.25
Sensitivity Analysis: Various Quality Levels
Structure 3: Strategy 1, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Copy Each Other)
Elevators A & B Grade and Segregate (Pay Different Quality Prices)

Quality Levels(%)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
10% Q1	A	4.85	4.75	4.65	273,193	1,639,157	820,156	20	20	20	118,032
60% Q2	B	4.85	4.75	4.65	273,193	1,639,157	820,156	20	20	20	118,032
30% Q3											
30% Q1	A	4.85	4.75	4.65	819,579	1,092,772	820,156	20	20	20	118,033
40% Q2	B	4.85	4.75	4.65	819,579	1,092,772	820,156	20	20	20	118,033
30% Q3											
50% Q1	A	4.85	4.75	4.65	1,365,964	546,386	820,169	20	20	20	118,035
20% Q2	B	4.85	4.75	4.65	1,365,964	546,386	820,169	20	20	20	118,035
30% Q3											

Alternative Value = $3.00
2,174 Production Density (bushels/ mi^2)
$.10 Price Differential
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.26
Sensitivity Analysis: Various Quality Levels
Structure 3: Strategy 2, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Copy Each Other)
Elevators A & B Grade and Segregate (Pay One Average Price)

Quality Levels(%)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
10% Q1	A	4.73	4.73	4.73	273,193	1,639,157	820,166	20	20	20	117,983
60% Q2	B	4.73	4.73	4.73	273,193	1,639,157	820,166	20	20	20	117,983
30% Q3											
30% Q1	A	4.75	4.75	4.75	819,579	1,092,772	820,169	20	20	20	117,973
40% Q2	B	4.75	4.75	4.75	819,579	1,092,772	820,169	20	20	20	117,973
30% Q3											
50% Q1	A	4.77	4.77	4.77	1,365,964	546,386	820,171	20	20	20	117,963
20% Q2	B	4.77	4.77	4.77	1,365,964	546,386	820,171	20	20	20	117,963
30% Q3											

Alternative Value = $3.00
2,174 Production Density (bushels/ mi^2)
$.10 Price Differential
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

Appendix Table B.27
Sensitivity Analysis: Various Quality Levels
Structure 3: Strategy 3, Results of Elevator A & B Maximizing Profits:
Competition (Elevators A & B Copy Each Other)
Elevators A & B Do Not Grade or Segregate (Pay One Average Price)

Quality Levels(%)	Elevator	Price Q1($)	Price Q2($)	Price Q3($)	Quantity Q1(bu.)	Quantity Q2(bu.)	Quantity Q3(bu.)	Radius Q1(mi.)	Radius Q2(mi.)	Radius Q3(mi.)	Profit ($)
10% Q1	A	4.67	4.67	4.67	273,193	1,639,157	820,158	20	20	20	118,639
60% Q2	B	4.67	4.67	4.67	273,193	1,639,157	820,158	20	20	20	118,639
30% Q3											
30% Q1	A	4.77	4.77	4.77	819,579	1,092,772	820,161	20	20	20	118,621
40% Q2	B	4.77	4.77	4.77	819,579	1,092,772	820,161	20	20	20	118,621
30% Q3											
50% Q1	A	4.77	4.77	4.77	1,365,964	546,386	820,171	20	20	20	118,621
20% Q2	B	4.77	4.77	4.77	1,365,964	546,386	820,171	20	20	20	118,621
30% Q3											

Alternative Value = $3.00
2,174 Production Density (bushels/ mi^2)
$.10 Price Differential
Q1= High Quality
Q2= Middle Quality
Q3= Low Quality

APPENDIX C

GAUSS PROGRAM FOR SIMULATION

GAUSS PROGRAM FOR SIMULATION SOLVING ELEVATOR PROFITS FOR THREE DIFFERENT COMPETITIVE STRUCTURES

```
/*******************************************************************************
** GAUSS program c:\projects\grades\PROFITEL.GAU
This program numerically calculates a continuous, rather than integer,
solution using the Constrained Optimization routine
*******************************************************************************/
new;
ts = hsec;
outwidth 120;
let vnames = meanret stdret def_pay fut_opt util1 util2 util3
        ce1 ce2 ce3 beta fut put1 put2 put3
        call1 call2 call3 target G_part strat;
format /rd 8,3;
disable;
screen on;

output file = c:\projects\grades\ncr13497\profitel.out reset;

/*
output file = c:\windows\desktop\mybrie~1\profitel.out reset;
*/
/*
output file = p:\elliott\profitel.out reset;
*/
output on;

beg_date = datestr(0);
beg_time = timestr(0);
print "        ";;
print "                    BEGIN_DATE:";;
print beg_date;
print "        ";;
print "                    BEGIN_TIME:";;
print beg_time;
print;
/*
output off;
screen off;
*/
/* declaring variables */
declare
  pNIL1,pNIL2,pNIL3,pfarm,pfarm1,pfarm2,pfarm3,prodden1,prodden2,altprice,
  transport,varcost,fixcost,QUANTITY,radius,radiusa,discount,ii,profblnd,
  radiusb,prof,profa,profb,OPTA,OPTB,firmA,firmB,grade,bgrade,sumQ,blend;

library optmum,quantal,pgraph,co;
#include optmum.ext;
#include co.ext;
optset;
graphset;
```

```
COset;
nvars = 10;  /* # of variables allowed to affect price paid to farmers */
/* density of production of quality characteristic i,
  prices paid by NIL buyers, transport rate, alternative price,
  variable costs, fixed costs */
nvals = 10;  /* # of possible values for exogenous variables */
qchars = 3;  /* number of quality grades */
pfarm = ones(qchars,1);
start = pfarm * 4.79;
estim1a = start;
estim2a = start;
/*
start[3] = 0;
*/
/* exogenous variables */
distance = 40;     /* distance from elevator to competing elevators */
print "There are ";; print distance;; print "miles between elevators.";
discount = 0.10;    /* discount from one grade to the next */
transport = ones(qchars,1)*.004;
              /* transport cost from farm
              to country elevator, $/bu/mi .00108*/
compete = 1;        /* 1 if firm A has competition from firm B, or else 0 */
gradeA = 1;         /* does elevator A grade wheat? yes=1,no=0 */
gradeB = 0;         /* does elevator B grade wheat? yes=1,no=0 */
onepricA = 1;       /* 1 if elevator A pays one price for all qualities */
onepricB = 1;       /* 1 if elevator B pays one price for all qualities */
if (gradeb eq 1);
  print "firm B grades";
elseif (gradeb eq 0);
  print "firm B does not grade";
  onepricB = 1;
endif;
if (gradea eq 1);
  print "firm A grades";
elseif gradea eq 0;
  print "firm A does not grade";
  onepricA = 1;
endif;
if onepricA eq 1;
  print "firm A pays one price for all qualities";
elseif onepricA eq 0;
  print "firm A pays different prices for each quality";
endif;
if onepricB eq 1;
  print "firm B pays one price for all qualities";
elseif onepricB eq 0;
  print "firm B pays different prices for each quality";
endif;
varcosta = ones(qchars,1)*.05;
              /* variable cost, $/bu. */
varcostb = varcosta;
/*variable costs includes (depending on grading or not) cost of grading)*/
```

```
varcosta[1] = .05+(gradea*.017);
varcosta[2] = .05+(gradea*.017);
varcosta[3] = .05+(gradea*.017);
varcostb[1] = .05+(gradeb*.017);
varcostb[2] = .05+(gradeb*.017);
varcostb[3] = .05+(gradeb*.017);
let proddens[3,3] =  .1 .6 .3,
               .3 .4 .3,
               .5 .2 .3;
/*
   /************* 1995 test weight values *********************/
   print "1995 test weight values for production density";
   prod_den[1] = .096*prod_den[1];
   prod_den[2] = .595*prod_den[2];
   prod_den[3] = .309*prod_den[3];
   print prod_den;
   /************************************************************/
*/
i = 2;
do until i gt 2;  /* rows(proddens); */
   let product = 1000, 2174, 4000;   /* 2174 is 1995 average */
   ii = 2;
   do until ii gt 2;  /* rows(product); */
      print "production density is ";; print product[ii];
      prod_den = proddens[i,.]'.*product[ii];
               /* production density, bu/square mile */
print "prod_den = ";; print prod_den;
   pNIL = ones(qchars,1);
   zero = zeros(qchars,1);
   altprice = ones(qchars,1);
               /* alternative market price for wheat,
                  e.g. for cattle feed */
   altprice[1] = 3.00;
   altprice[2] = 3.00;
   altprice[3] = 3.00;
   comprice = 4.59;   /* price at competing elevators */
   comprice = comprice*ones(qchars,1);
   /* fixcost includes a yearly cost of owning a grading machine */
   fixcosta = 100000+(gradea*587);  /* dollars */
   fixcostb = 100000+(gradeb*587);
/*
   print "varcosta = ";; print varcosta;
   print "varcostb = ";; print varcostb;
   print "fixcosta = ";; print fixcosta;
   print "fixcostb = ";; print fixcostb;
*/
   capacity = 3000000000;  /* bushels merchandised per year */
   /*************************************************************************/
   proc elprofit(pf);
      local Q_AVAIL,check,rel_price,pfgt0,pff,yyy,sumQ,ycap,
            zeroQ,comprnet;
        if compete eq 0;
```

```
    comprice = 0;
    endif;
    comprnet = maxc(altprice'|(comprice-transport*distance)');
    rel_price = (pf-comprnet) .ge 0.0;          /* relevant prices */
    radius = (pf-comprnet)./(2*transport);
    Q_AVAIL = prod_den.*(pi.*
      (rel_price.*(radius.^2)));
          /* positive quantities */
        /* from (pf - (transport rate/mi)*radius of circle =
           altprice
        ---> radius = (pf - altprice)/transport rate/mi.) */
    yyy = 1;
    check = 1;
    QUANTITY = Q_AVAIL;
    /*****************************************************
    capacity constraint ********************************
    *****************************************************/
    sumQ = sumc(QUANTITY);
    if sumQ gt capacity;
      QUANTITY = QUANTITY .* (1-((sumQ-capacity)/sumQ));
    endif;
    sumQ = sumc(QUANTITY);
    blend = (QUANTITY[1]/sumQ)*1 + (QUANTITY[2]/sumQ)*2 +
         (QUANTITY[3]/sumQ)*3;
    if blend ge 2.1;
      bgrade = 3;
    elseif blend ge 1.1;
      bgrade = 2;
    elseif blend lt 1.1;
      bgrade = 1;
    endif;
    profblnd = -(((pNIL[bgrade]*sumQ - sumc(pf.*QUANTITY))
         - sumc((varcosta*firmA+varcostb*firmB).*QUANTITY)
         - fixcosta*firmA-fixcostb*firmB));
    prof = -(sumc((pNIL - pf).*(QUANTITY)
         - (varcosta*firmA+varcostb*firmB).*QUANTITY)
         - fixcosta*firmA-fixcostb*firmB);
    if ((firmB eq 1) and (gradeb eq 0))
      or ((firmA eq 1) and (gradea eq 0));
      prof = profblnd;
    endif;
    if (profblnd gt prof);
      prof = profblnd;
    endif;
          /* positive for graphing,
             negative for optimization */
  retp(prof);
 endp;
/*************************************************************************/
/* To print out the results *************************************/
 let top1[1,9] =
   "disc" "pr1 A" "pr2 A" "pr3 A" "prof A"
```

```
    "pr1 B" "pr2 B" "pr3 B" "profB";
  let top2[1,7] =
    "disc" "rad1 A" "rad2 A" "rad3 A" "rad1 B" "rad2 B" "rad3 B";
  let top3[1,7] =
    "disc" "Q1 A" "Q2 A" "Q3 A" "Q1 B" "Q2 B" "Q3 B";
  tab1 = ones(6,cols(top1));
  tab2 = ones(6,cols(top2));
  tab3 = ones(6,cols(top3));

  xxx = ones(qchars,1);
  yyy = ones(qchars,1);
  discount = .10;
  tabrows = 1;
  pNIL[2] = 4.90;
  do until discount lt -0.010;
    pNIL[1] = pNIL[2] + discount;
    pNIL[3] = pNIL[2] - discount;
    ubound = .000001.*ones(qchars,1);
    estim1a = 4.69.*ones(qchars,1);
    estim1b = 4.69.*ones(qchars,1);
    estim2a = 4.29.*ones(qchars,1);
    estim2b = 4.29.*ones(qchars,1);
    xxx = abs(estim1a - estim2a);
    yyy = abs(estim1b - estim2b);
    do until ((xxx le ubound) and (yyy le ubound));
/*
      print "xxx = ";; print xxx;
      print "yyy = ";; print yyy;
*/
      if (compete eq 0);
        yyy = ubound;
      endif;
        COSet;
        _co_A = zeros(3,3);
    /*****************************************************************/
    /** Optimization for first elevator, A ********************/
    /*****************************************************************/
        print "Optimizing A";
        firmA = 1;
        firmB = 0;
        if (onepricA eq 1);
          /* These constraints set the prices
          for each quality to be equal */
          _co_A = { 1 -1 0, 0 1 -1, 1 0 -1 };
          _co_B = zero;
        endif;
        _co_Bounds = { 0 5,
                0 5,
                0 5 };
/*
        _co_LineSearch = 2;
```

```
        _co_Options = { dfp half forward screen };
*/
/*
        print "comprice = ";; print comprice;
        start = estim1a;
        print "start = ";; print start;
*/
        { estim,f_value,grad_vec,retcode } = CO(&elprofit,start);
          QUANTA = QUANTITY;
          radiusa = radius;
          profa = prof;
/*
          call coprt(estim,f_value,grad_vec,retcode);
          print;
          print "Equality Lagrangeans";
          print vread(_co_Lagrange,"nlineq"); print;
          print "Inequality Lagrangeans";
          print vread(_co_Lagrange,"nlinineq"); print;
          print "boundary Lagrangeans";
          print vread(_co_Lagrange,"bounds"); print;
*/
          estim2a = estim1a;
          estim1a = estim;
          comprice = estim;
          xxx = abs(estim1a - estim2a);

      if compete eq 1;  /* run this section only if A has competitor B */
      /*****************************************************************/
      /**    Optimization for second elevator, B *********************/
      /*****************************************************************/
        COSet;
        print "Optimizing B";
        firmA = 0;
        firmB = 1;

      /* These constraints set the prices for each quality to be equal */
        if (onepricB eq 1);
          _co_A = { 1 -1 0, 0 1 -1, 1 0 -1 };
          _co_B = zero;
        endif;
/*
        _co_LineSearch = 2;

        _co_Options = { dfp half forward screen };
*/
        _co_Bounds = { 0 5,
                   0 5,
                   0 5 };
        start = estim1b;
        { estim,f_value,grad_vec,retcode } = CO(&elprofit,start);
          QUANTB = QUANTITY;
          profb = prof;
```

```
            radiusb = radius;
/*
            call coprt(estim,f_value,grad_vec,retcode);
            print;
            print "Equality Lagrangeans";
            print vread(_co_Lagrange,"nlineq"); print;
            print "Inequality Lagrangeans";
            print vread(_co_Lagrange,"nlinineq"); print;
            print "boundary Lagrangeans";
            print vread(_co_Lagrange,"bounds"); print;
*/
            estim2b = estim1b;
            estim1b = estim;
            yyy = abs(estim2b - estim1b);
            comprice = estim;
/*
            print "compriceb = ";; print comprice;
            print "profa = ";; print -profa;
            print "profb = ";; print -profb;
            print "pfa = ";; print estim1a;
            print "pfb = ";; print estim1b;
            print "radiusa = ";; print radiusa;
            print "radiusb = ";; print radiusb;
            print "QUANTITYA = ";; print QUANTA;
            print "QUANTITYB = ";; print QUANTB;
*/
         endif;
      endo;
      tab1[tabrows,1] = discount;
      tab1[tabrows,2] = estim1a[1];
      tab1[tabrows,3] = estim1a[2];
      tab1[tabrows,4] = estim1a[3];
      tab1[tabrows,5] = -profa;
      if compete eq 1;
         tab1[tabrows,6] = estim1b[1];
         tab1[tabrows,7] = estim1b[2];
         tab1[tabrows,8] = estim1b[3];
         tab1[tabrows,9] = -profb;
      endif;
      tab2[tabrows,1] = discount;
      tab2[tabrows,2] = radiusa[1];
      tab2[tabrows,3] = radiusa[2];
      tab2[tabrows,4] = radiusa[3];
      if compete eq 1;
         tab2[tabrows,5] = radiusb[1];
         tab2[tabrows,6] = radiusb[2];
         tab2[tabrows,7] = radiusb[3];
      endif;
      tab3[tabrows,1] = discount;
      tab3[tabrows,2] = QUANTA[1];
      tab3[tabrows,3] = QUANTA[2];
      tab3[tabrows,4] = QUANTA[3];
```

```
  if compete eq 1;
    tab3[tabrows,5] = QUANTB[1];
    tab3[tabrows,6] = QUANTB[2];
    tab3[tabrows,7] = QUANTB[3];
  endif;
  tabrows = tabrows + 1;
  discount = discount - .02;
endo;

print "production = ";; print product[ii];;
print "bushels per square mile";
print;
mask1 = zeros(1,cols(top1));
let fmt1[9,3] =
"*.*s" 8 8
"*.*s" 8 8
"*.*s" 8 8
"*.*s" 8 8
"*.*s" 8 8
"*.*s" 8 8
"*.*s" 8 8
"*.*s" 8 8
"*.*s" 8 8;
r = printfm(top1,mask1,fmt1);
print;
mask1 = ones(rows(tab1),cols(top1));
let fmt1[9,3] =
"*.*lf" 8 2
"*.*lf" 8 2
"*.*lf" 8 2
"*.*lf" 8 2
"*.*lf" 8 0
"*.*lf" 8 2
"*.*lf" 8 2
"*.*lf" 8 2
"*.*lf" 8 0;
r = printfm(tab1,mask1,fmt1);
print;
mask2 = zeros(1,cols(top2));
let fmt2[7,3] =
"*.*s" 10 10
"*.*s" 10 10
"*.*s" 10 10
"*.*s" 10 10
"*.*s" 10 10
"*.*s" 10 10
"*.*s" 10 10;
r = printfm(top2,mask2,fmt2);
print;
mask2 = ones(rows(tab2),cols(top2));
let fmt2[7,3] =
"*.*lf" 10 2
```

```
    "*.*lf" 10 0
    "*.*lf" 10 0
    "*.*lf" 10 0
    "*.*lf" 10 0
    "*.*lf" 10 0
    "*.*lf" 10 0;
    r = printfm(tab2,mask2,fmt2);
    print;
    mask3 = zeros(1,cols(top3));
    let fmt3[7,3] =
    "*.*s" 10 10
    "*.*s" 10 10
    "*.*s" 10 10
    "*.*s" 10 10
    "*.*s" 10 10
    "*.*s" 10 10
    "*.*s" 10 10;
    r = printfm(top3,mask3,fmt3);
    print;
    mask3 = ones(rows(tab3),cols(top3));
    let fmt3[7,3] =
    "*.*lf" 10 2
    "*.*lf" 10 0
    "*.*lf" 10 0
    "*.*lf" 10 0
    "*.*lf" 10 0
    "*.*lf" 10 0
    "*.*lf" 10 0;
    r = printfm(tab3,mask3,fmt3);
    ii = ii + 1;
  endo;
  i = i + 1;
endo;

graphset;
xx = tab1[.,1];
yy = tab1[.,2:4]~tab1[.,6:8];
if (compete eq 1) and (gradeA eq 1) and (gradeB eq 1) and
  (onepricA eq 0) and (onepricB eq 0);
  title("Elevator Prices vs. Buyer Prem/Disc\LA & B Grading");
elseif (compete eq 1) and (gradeA eq 1) and (gradeB eq 1) and (onepricB eq 1)
  and (onepricA eq 0);
  title("Elevator Prices vs. Buyer Prem/Disc\LA & B Grading, B One Price");
elseif (compete eq 1) and (gradeA eq 1) and (gradeB eq 1) and (onepricA eq 1)
  and (onepricB eq 1);
title("Elevator Prices vs. Buyer Prem/Disc\LA & B Grading, Both Pay One Price");
elseif (compete eq 1) and (gradeA eq 1) and (onepricA eq 1) and (gradeB eq 0);
 title("Elevator Prices vs. NIL Buyer Prem/Disc\LOnly A Grades, A One Price");
elseif (compete eq 1) and (gradeA eq 1) and (onepricA eq 0) and (gradeB eq 0);
  title("Elevator Prices vs. NIL Buyer Prem/Disc\LOnly A Grades");
elseif (compete eq 0) and (onepricA eq 0);
  title("Elevator Prices vs. NIL Buyer Prem/Disc\LA is Monopsony");
```

```
elseif (compete eq 0) and (onepricA eq 1);
  title("Elevator Prices vs. NIL Buyer Prem/Disc\LA is Monopsony, A One Price");
endif;
```

VITA

JOHN WESLEY ELLIOTT

Candidate for the Degree of

Master of Science

Thesis: EFFECTS OF COMPETITION AND SPACE ON COUNTRY ELEVATOR GRADING PRACTICES AND PRICES FOR WHEAT

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Elk City, Oklahoma, August 21, 1973, the son of Bobby and Debbie Elliott.

Educational: Graduated from Canute High School in May 1991. In August 1991, I began the pursuit of a Bachelor of Science degree in Agricultural Economics where I went to Southwestern Oklahoma State University in Sayre , Oklahoma for a year and a half and attended Redlands Community College in El Reno, Oklahoma for a semester and then transferred to Oklahoma State University where I received the degree in December 1995. I continued at Oklahoma State University in pursuit of a Master of Science degree in Agricultural Economics. Completed the requirements of the Master of Science degree at Oklahoma State University in December 1997.

Professional Experience: Research Assistant, January, 1996 through December, 1997, for the Oklahoma State University, Department of Agricultural Economics.