Can the Grain Marketing System Provide Sufficient Quality Incentives to Producers?

by

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Kenkel, Anderson, and Attaway found that Oklahoma country 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. 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.

Measuring quality characteristics more accurately will cost elevators more, but will help them 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 a 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.

A simulation analysis is used to determine the extent to which spatial competition limits the incentive for elevators to grade correctly and pay producers quality-adjusted prices. Results show that because of spatial monopsony early adopters of grading and quality-based pricing practices pass on to producers 70% of price differentials received from NIL buyers, and receive above-normal profits at the expense of their competitors. However, if competing elevators adopt such practices, profits of all elevators return to near normal. Then all elevators pass on to producers the full amount of price differentials received from NIL buyers, rewarding producers of high quality wheat at the expense of producers of low quality wheat. Further research is needed to explain the apparent reluctance of elevators to be first adopters.

Introduction

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. 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. In the last several years, though, next-in-line (NIL) buyers have begun to charge larger discounts for quality characteristics that are defined more precisely than standard grades (Kenkel, Anderson, and Attaway). To some extent, better grain testing technology has facilitated this. In effect, the marketing

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system has begun to impose its own system of grades and standards in response to demands for particular quality characteristics.

However, Kenkel, Anderson, and Attaway found that Oklahoma country elevators tended to overestimate desirable characteristics, such as test weight, and underestimate undesirable characteristics such as dockage, damaged kernels, shrunken and broken kernels, and foreign material in hard red winter wheat delivered to them by producers in the 1995 and 1996 harvests. They estimated that elevators lost up to 9.32 cents per bushel in the 1995 harvest and 3.75 cents per bushel in the 1996 harvest by not grading correctly. Elevators paid more than they should have for low quality wheat and less than they should have for high quality wheat. Also, because they did not know precisely the quality of grain they received, they likely received less from next-in-line (NIL) buyers than they could have. The authors noted that such grading practices fail to provide incentives to producers to deliver high quality grain.

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 consumer demand as well as increase its competitiveness (Brorsen). Similarly, Feuz, Fausti, and Wagner have found that the beef market is not effectively communicating consumer desires to producers. So, for similar reasons as those observed in the port industry, the beef industry is considering moving to a value-based marketing system.

For wheat, possible explanations for the failure of elevators to grade accurately and pay quality-adjusted prices include lack of knowledge on the part of elevator managers about the benefits of grading accurately, insufficient time for elevators to respond to market incentives (which have generally appeared only since 1992) by purchasing the appropriate testing equipment and making adjustments in grain receiving procedures, the additional costs of grading (time, labor, and equipment), and competitive pressures.

Evidence suggests that lack of knowledge may explain part of the failure to grade accurately. There appears to have been a response by elevator managers to extension programs by Kenkel and Anderson explaining the economic benefits of grading. Several elevators have purchased dockage testing machines, and have participated in grain grading schools sponsored by the Oklahoma Cooperative Extension Service.

However, even after several years of receiving quality-adjusted prices from NIL buyers, many elevators still do not grade accurately, and many (including some who grade accurately) do not pay producers quality-adjusted prices. 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.

The estimates by Kenkel, Anderson, and Attaway of loss from incorrect grading implicitly assumed that grading and pricing correctly would not cause producers to change the amount of grain delivered to a country elevator. 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 a 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.

If grain elevators seek both to maintain adequate margins on each bushel of grain they receive and to maximize the use of their fixed assets, they must pay prices that encourage producers to supply high quality grain, but that also attract a sufficient amount of 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. Also, elevators may use lenient grading as a form of nonprice competition.

Firms with more market power may have greater ability to impose discounts (Hall and Rosenfeld). 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.

The research reported 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 measures the extent to which country elevators should pass on premiums and discounts to producers for various qualities of wheat, explicitly considering 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 have important implications for the structure of the industry. If the structure of the industry causes elevators to use grading practices that appear to overvalue low-quality grain and undervalue high-quality grain, so that 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.

Conceptual Framework

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.

The elevator's objective function can be expressed as:

$$\underset{Pfi}{\text{Max}}\ Profit = \sum_{i=1}^{n} [(P_{\text{NIL}_i} - P_{fi}) \cdot Q_i(k_i, P_{fi}, P_{fi}^C, t_i)] - C_{vi} Q_i(\cdot) - C_{fx}$$

where:

$$Q_i(\cdot) = k_i [\pi (\frac{1}{2t_i} (P_{fi} - \max(x_i, P_{fi}^C - t_i(\text{U} - \text{R})))^2)], \text{ for all } i$$

P_{NIL_i} = price received from NIL buyer for quality i (\$/bu)
P_{fi} = price paid to farmers by elevator for ith quality (\$/bu)
x_i = alternative outlet price to producer for wheat of quality i (e.g., feed value)
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)
P_{fi}^C = price paid to farmers by competing elevators for ith quality
R = radius of elevator's trade area
U = distance between elevator and competing elevators

The elevator chooses the price paid to farmers for each quality of wheat. The quantity received by an elevator from producers 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 elevator may pay different prices for, and merchandise different quantities of, each of several qualities of wheat.

Expression 2 provides a measure of the quantity of wheat available in an elevator's trade area. The expression is derived from a spatial competition model proposed by Capozza and van Order for oligopolistic firms, and is modified here for oligopsonistic country elevators.

Figure 1 illustrates this model, where firm A is surrounded by six competitors (B); the competitors are assumed to all follow the same pricing strategy. Each 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 producers by the elevator (P_{fi}) and the best competitive price by another elevator (P^C_{fi}), adjusted for transportation cost. The law of market areas asserts that the boundary between any two of the elevators is the locus of points where market price net of transportation cost for loads of wheat shipped to Elevator A and Elevator B are equal (Bressler and King).

The modified version of Capozza and Order's model is expressed as:

$P_{fi} - t_i R = \mathrm{Max}(x, P^c_{fi} - t_i(U - R))$, 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. In expression 3, x is the alternative value of wheat for use in, say, cattle feeding:

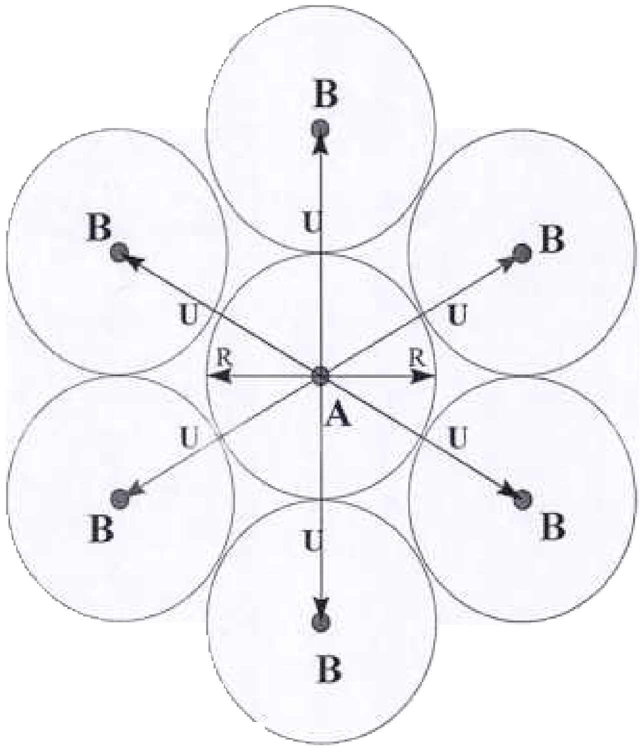
Rewriting, the radius of elevator A's trade area is

$$R = \tfrac{1}{2}\ t_i(P_{fi} - \mathrm{Max}(x, P^c_{fi} - t_i(U - R)))$$

When elevator A raises its price and the competitors' price stays the same, then elevator A's trade radius increases and the competing firms' radius decreases, as in

$$R = \tfrac{1}{2}\ t_i(P_{fi} + \Delta P_{fi} - \mathrm{Max}(x, P^c_{fi} - t_i(U - R)))$$

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



Figurel. Spatial Competition Model (Capozza and van Order)

Thus, the quantity of wheat purchased by the elevator is positively related to the price paid by the elevator, and to the density of production, but negatively related to competitors' prices and transportation cost. Since per bushel 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 a producer's alternative price (which could be a competitor's price net of transportation cost or the feed value of the grain) 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 a producer's perspective, the lower the producer's alternative market value for grain the more monopsony power that can be exerted by the elevator.

Procedures

This section describes the scenarios over which the 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 prices the elevator should pay producers for each quality of wheat. The range of parameters chosen reflects the conditions observed in the 1995, 1996, and 1997 harvests. A more detailed report available from the authors describes the results over the complete range of parameters. However, since the results did not differ qualitatively over the range of parameters, this paper focuses only on one set of parameters.

Wheat grown in an elevator's trade area is assumed to fall into any of three quality categories: high, middle, and low. The elevator may choose to invest in testing equipment and additional labor in order to determine whether wheat delivered is high, middle, or low quality. If it does so, it can keep the different qualities separate to receive the highest possible price from NIL buyers. The model assumes that the elevator has three bins in which to segregate the three different qualities of wheat. 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 little additional benefit in most scenarios, and is not considered.

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. To focus on the benefits to an elevator of grading correctly and of paying prices to producers that depend on quality, the simulation considers two possible grading/pricing strategies by elevator A, and two possible reactions by its competing Elevators B. Elevator A is assumed to be the leader in grading/pricing strategies, and Elevator B (representing the six surrounding competitors) is assumed to be the follower. Elevator A can choose to not grade or segregate the wheat received, in which case it does not pay producers quality-adjusted prices. Or, Elevator A can invest in testing equipment and grade and segregate the wheat, paying producers quality-adjusted prices. In response to either of A's strategies, Elevator B can choose to not grade or segregate. Or, if Elevator A chooses to grade, segregate, and pay quality-related prices, Elevator B can choose to invest in testing equipment and do the same.

Harvest-time quality data from Oklahoma country elevators have been collected for the 1995, 1996, and 1997 Oklahoma hard red winter wheat harvests (Kenkel, Anderson, and Attaway). These data provide official USDA measurements of several wheat quality characteristics, and are used to estimate the distributions of these characteristics in loads of wheat delivered to elevators at harvest.

Hard red winter wheat discount schedules implemented by NIL buyers were collected from Kenkel, Anderson, and Attaway. Data published by the Oklahoma Agricultural Statistics Service is used to estimate the density of wheat production for representative wheat-producing districts. The density of production in the elevator's trade area (bu/mi^2) is calculated by taking the harvested bushels per farmland acre times 640 acres/mi^2. 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).

NIL buyer prices are assumed to be \$5.00 for high quality wheat, \$4.90 for middle quality wheat, and \$4.80 for low quality wheat. 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. Production density is assumed to be 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, consistent with the relative proportions of test weight values observed in Oklahoma in 1995. It is also assumed that producers know whether their wheat is of high, middle, or low quality.

Choice variables for the optimization are price(s) paid to producers for wheat of different qualities. GAUSS, along with its constrained optimization module, is used to solve the simulations.

It is assumed that producers use trucks to haul their wheat to country elevators. Fuller et al. used models containing linear mileage equations to determine truck cost for both short and long hauls. The transportation cost estimated by Fuller et al. is \$.00108 per bushel per mile. NIL buyer prices are specified to be prices actually received by country elevators after paying transportation cost. These transportation costs assume a truck with a hopper and bottom dump that can hold 833 bushels. It is assumed that each of the six competing elevators is located a distance of 40 miles from Elevator A.

Data for fixed and variable elevator operating costs is taken from Kenkel and Anderson (1992). Fixed costs include depreciation, administrative overhead, market information, and interest and is assumed to be \$100,000. Variable costs include labor, utility, chemical, and repairs. Variable costs 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 estimates 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. The machine is amortized over a 20-year life at 10% interest, for an annual cost of $587. 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. Thus, for an elevator handling 1,500,000 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, it is assumed that elevators that grade correctly segregate the three different qualities of wheat into three bins for sale directly to NIL buyers. It is assumed that no additional investment is needed for these facilities.

Results

In the case where none of the elevators invests in testing equipment to correctly grade wheat received from producers, the elevators receive equal profits of $118,639, receive the same price from NIL buyers ($4.80/bu.), pay producers the same price for all qualities of wheat ($4.67/bu.), and have the same trade area radius (Table 1).

Table 1. Neither Elevator Grades and Segregates (results are same for each elevator): P_{NIL1}=$5.00, P_{NIL2}=$4.90, P_{NIL3}=$4.80; high quality = 10%; mid quality = 60%; low quality = 30%

Price ($/bu)	Quantity (bu)	Trade Area Radius	Price Received from NIL buyers ($/bu)	Elevator Profit ($)
P_{f1} = $4.67	Q_1 = 273K	$Radius_1$ = 20 miles	P_{NIL1} = 4.80	Profit =
P_{f2} = $4.67	Q_2 = 1,639K	$Radius_2$ = 20 miles	P_{NIL2} = 4.80	$118,639
P_{f3} = $4.67	Q_3 = 820K	$Radius_3$ = 20 miles	P_{NIL3} = 4.80	

The second case is where elevator A invests in testing equipment, correctly grades wheat received, segregates it for sale to NIL buyers, and pays producers prices that differ according to the quality of wheat they deliver, while elevator B does no grading and pays producers one price for all qualities of wheat (Table 2).[1] Elevator A achieves a profit of $343,545 while elevator B achieves a profit of only $27,485. Elevator A receives more of the high quality and middle quality wheat while elevator B attracts more of the low quality wheat. Elevator A passes on to producers 70% of the price differential received from NIL buyers for each quality of wheat. Elevator A has a trade area radius of 34 miles for high quality wheat, 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. Elevator receives 97% of the high quality wheat available, 77.5% of the middle quality wheat, and 38.5% of the low quality wheat. The results show that an elevator that grades correctly and pays different prices for different qualities of wheat can substantially increase profits relative to its competitors that do not grade accurately.

Table 2. Elevator A grades and segregates, Elevator B does neither: P_{NIL1}=$5.00, P_{NIL2}=$4.90, P_{NIL3}=$4.80; high quality = 10%; mid quality = 60%; low quality = 30%

Price ($/bu)	Quantity (bu)	Trade Area Radius	Price Received from NIL buyers ($/bu)	Elevator Profit ($)
Elevator A				
P_{f1} = $4.80	Q_1 = 805K	$Radius_1$ = 34 miles	P_{NIL1} = $5.00	Profit =
P_{f2} = $4.73	Q_2 = 2,771K	$Radius_2$ = 26 miles	P_{NIL2} = $4.90	$343,545
P_{f3} = $4.66	Q_3 = 640K	$Radius_3$ = 18 miles	P_{NIL3} = $4.80	
Elevator B				
P_{f1} = $4.68	Q_1 = 22K	$Radius_1$ = 6 miles	P_{NIL1} = $4.80	Profit =
P_{f2} = $4.68	Q_2 = 803K	$Radius_2$ = 14 miles	P_{NIL2} = $4.80	$27,485
P_{f3} = $4.68	Q_3 = ,022K	$Radius_3$ = 22 miles	P_{NIL3} = $4.80	

The third case is where 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 (Table 3). Since the elevators are using the same strategy, the elevators pay the same prices and have the same trade area radii for all qualities (20 miles, half the distance between the two elevators). They each pay prices of $4.85, $4.75, and $4.65 for the different qualities, passing on to producers the full price differentials received from NIL buyers for the different qualities. The profit for each elevator is $118,032. This is $607 less than the profit received when neither elevator graded accurately, approximately the annualized equipment cost and labor cost of grading accurately. Sensitivity analysis (results of which are available from the authors) shows that these results are robust across a range of parameters consistent with conditions observed in crop years 1990-1997.

Table 3. Both Elevator A and Elevator B grade and segregate (results are same for each elevator): P_{NIL1}=$5.00, P_{NIL2}=$4.90, P_{NIL3}=$4.80; high quality = 10%; mid quality = 60%; low quality = 30%

Price ($/bu)	Quantity (bu)	Trade Area Radius	Price Received from NIL buyers ($/bu)	Elevator Profit ($)
	Q_1 = 273K	$Radius_1$ = 20 miles	P_{NIL1} = $5.00	Profit
P_{f2} = $4.75	Q_2 = 1,639K	$Radius_2$ = 20 miles	P_{NIL2} = $4.90	$118,032
P_{f3} = $4.65	Q_3 = 820K	$Radius_3$ = 20 miles	P_{NIL3} = $4.80	

Thus, while an early adopter receives above normal profits, when other elevators copy the innovator's grading and pricing practices, all elevators receive slightly lower profits than before. However, if all elevators adopt grading and pricing practices that reflect quality differences, the quality of U.S. wheat might be improved because elevators would pass on the full price differentials received from NIL buyers. The prices producers received for their wheat would more nearly reflect its value. To the extent producers can control the quality of their wheat through cultural and harvesting practices, the increased financial incentive would tend to increase quality of wheat delivered to country elevators. These results are shown graphically in Figure 2.

The model does not explain why more elevators do not become early adopters and, at least until competitors copy, achieve above normal profits.

Conclusions

The results from the simulation and sensitivity analysis showed that a country elevator that adopts accurate grading and pricing practices will pass on 70% of price differentials, and will receive above normal profits. Producers of high and middle quality wheat would benefit from higher prices, while producers of low quality wheat would receive a lower price. To the extent producers can control wheat quality, this would increase the overall quality of wheat entering the marketing system. If competitors of the early adopting elevator began to grade accurately and price accordingly, profits to all elevators would return to near normal.

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. If producers do not receive these signals, U.S. wheat will become less competitive in world wheat markets. 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.

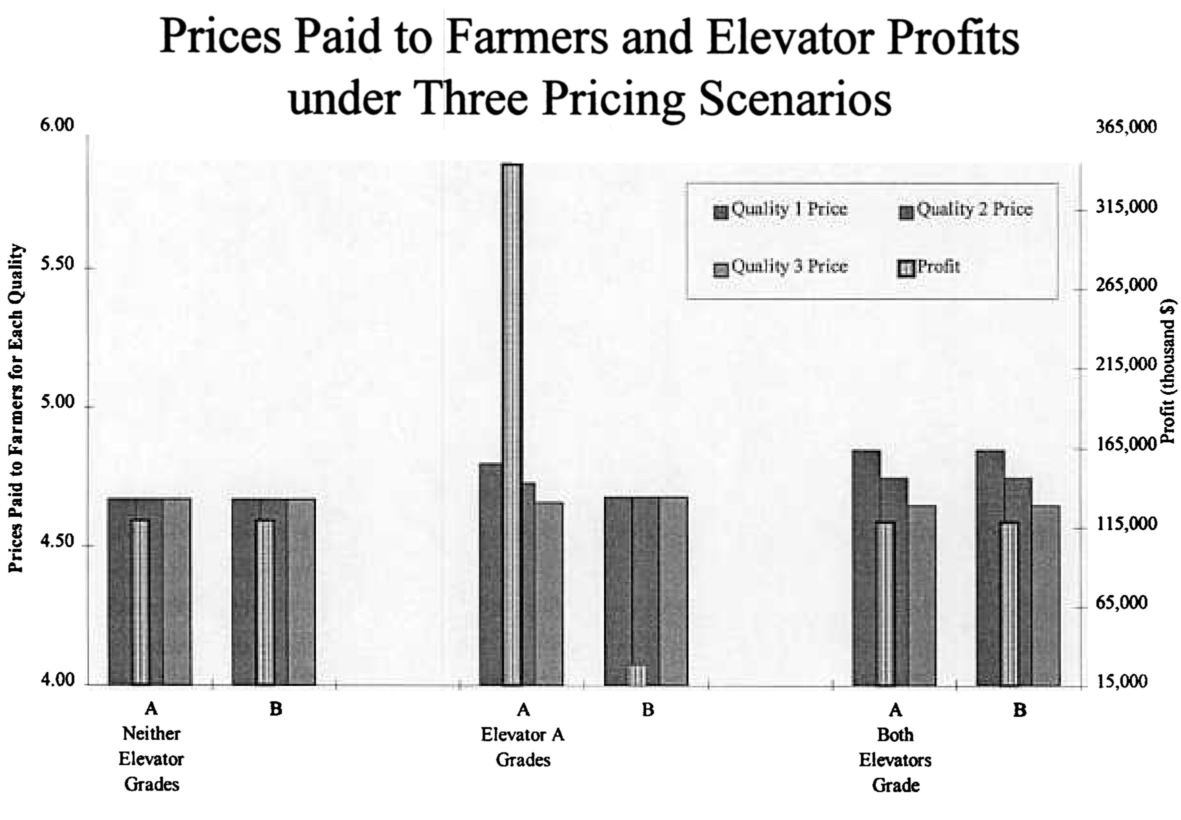


Figure 2. Prices Paid to Farmers and Elevator Profits under Three Pricing Scenarios

Further work is needed to fully answer the question of why elevators do not grade accurately and pay producers prices based more closely on the quality of wheat they deliver. If one elevator becomes an early adopter, the model suggests that it will greatly increase profits at the expense of its competitors. They would be forced to change their grading and pricing practices in response.

Several factors may help explain why more elevators do not become first adopters. First, most producers do not know the quality of wheat they have produced until it is graded at the elevator. They face price risk if an elevator that grades accurately finds that the quality is less than average and imposes a discount. A producer in that situation would prefer to receive an average price from an elevator that does not grade accurately and price accordingly. This is particularly true to the extent that quality is related to weather and not controllable by the producer. Compounding this risk is the possibility that producers' preferences are consistent with prospect theory. Prospect theory suggests that producers dislike discounts more than they like premiums of the same magnitude. If producers behave as prospect theory suggests, the effect of the risk that their wheat might grade lower than expected and receive a discounted price is magnified. This would lead producers to prefer selling to an elevator that pays an average price rather than one that pays according to quality.

Second, the model used here assumes that elevators have linear cost functions. If elevators have nonlinear cost functions (e.g., if they have greater economies of size than those modeled here), the optimization may have understated the role of capacity utilization in an elevator's optimal pricing decisions. Research in progress is examining these complications.

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