Why Don't Country Elevators Pay Less for Low Quality Wheat? Information, Producer Preferences and Prospect Theory

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Abstract

Previous research found that country elevators that are the first in their area to grade wheat and pay quality-adjusted prices would receive above-normal profits at the expense of their competitors. Because of spatial monopsony, these early-adopting elevators would pass on to producers only 70% of the quality-based price differentials received from next-in-line buyers. If competing elevators also adopted these practices, profits for all elevators would return to near normal, and elevators would pass on to producers nearly all price differentials received from next-in-line buyers. However, that research could not explain why more elevators were not becoming "early adopters" by paying quality-adjusted prices.

More recent research found that producers' risk aversion and lack of information about the quality of their wheat could explain more of the failure of country elevators to pass on premiums and discounts. If producers are risk averse, an elevator that imposes discounts for lower quality wheat, even while paying a higher price for high quality wheat, risks losing business if producers believe that a competing elevator may be more likely to pay them a higher price net of discounts. However, even more important is the level of information producers have about the quality of their wheat before selling it to an elevator. Still, these explanations account for only part of elevators' apparent reluctance to pay quality-adjusted prices.

Since inconsistencies have been observed between expected utility and individuals' behavior, this research considers the case where producers' preferences can be more appropriately modeled by prospect theory, and whether such preferences can explain more of elevators' reluctance to pay quality-adjusted prices. A simulation model is used to measure the effects of risk-averse producers (in both expected utility and prospect theory frameworks) and limited quality information on profits that can be earned by an elevator that pays quality-adjusted prices. Results indicate that prospect theory helps to explain part, but not all, of the reluctance to pay quality-adjusted prices.

Introduction

As foreign and domestic grain buyers have increased standards for grain quality, next-in-line (NIL) buyers have begun to charge larger discounts for wheat that does not meet those higher standards (Kenkel, Anderson, and Attaway). Passing premiums and discounts on to producers should reward producers who respond to those signals and deliver higher quality grain, and will facilitate supplying products that meet consumers' needs.

However, anecdotal evidence suggests that not all elevators are passing on all or even most of those premiums and discounts to producers. Moreover, many county elevators are not measuring grain characteristics adequately (Kenkel, Anderson, and Attaway, 1997). This implies that the marketing system is not adequately transmitting price signals for quality characteristics. While extension education programs have motivated some elevator operators to grade accurately in order to increase profits, few have begun to pay quality-adjusted prices. Work by Elliott et al. (1998) explored two possible explanations for this apparent pricing inefficiency. First, grading wheat accurately costs more in labor time and equipment. Second, the spatial monopsony structure in which many country elevators operate may limit the extent to which they find it profitable to pay higher prices for higher quality grain.

In the work by Elliott et al., these explanations accounted for part, but not all, of the smaller quality differentials paid by country elevators than those paid by NIL buyers. Their results indicated that because of spatial monopsony early adopters of grading and quality-based pricing practices would pass on to producers only 70% of price differentials received from NIL buyers, and receive above-normal profits at the expense of their competitors. However, if competing elevators adopted such practices, profits of all elevators would return to near normal, except lower by the cost of grading equipment. Then all elevators would 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. These results failed to explain the apparent reluctance of elevators to be first adopters.

Adam and Hong examined an additional explanation for country elevators' failure to pay producers quality-adjusted prices. An elevator that imposes discounts for lower quality wheat, even while paying a higher price for high quality wheat, risks losing business if producers believe that a competing elevator is more likely to pay them a higher price net of discounts. Producers likely are uncertain about the quality of their grain before they deliver it to an elevator, and thus are uncertain about the net price they will receive. Risk averse producers would prefer a certain price to a quality-adjusted price that is equally likely to be higher (because of a premium) or lower (because of a discount). Also, losing a customer one year increases the chances the customer will not sell grain to the elevator in succeeding years.[1]

The results, based on an expected utility characterization of producer preferences, suggested that the amount of information producers have about the quality of their wheat before delivering it to the elevator has a greater effect than degree of risk aversion does. Still, however, the effects of risk aversion and incomplete information accounted for only a portion of elevators' apparent reluctance to pay quality-adjusted prices.

The work here builds on earlier work by considering an alternative characterization of producer risk preferences, prospect theory. Tversky and Kahneman's model of cumulative prospect theory overcomes inconsistencies between expected utility models and empirical observation of individuals' behavior. In particular, expected utility is inconsistent with: 1) framing effects; 2) nonlinear preferences; 3) source-dependence; 4) risk-seeking behavior in some circumstances; and 5) loss aversion, the tendency for individuals to be more sensitive to reductions than to increases in their levels of well-being.

Prospect theory hypothesizes that producers dislike discounts more than they like premiums of the same magnitude. Under that hypothesis, producers would have an even greater tendency to prefer an average price than quality-adjusted prices. Under prospect theory,

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[1] A colleague (Jim Fain, Dept. of Economics, Oklahoma State University) has suggested that this risk effect can also be viewed in the context of implicit contract theory. The theory was introduced by Baily (1974), Gordon (1974), and Azariadis (1975) in an attempt to explain the industrial practice of laying off unneeded workers and paying unchanged wages to the remaining work force as product demand decreased. As explained by Azariadis, when workers are risk averse and firms are risk neutral, each wage contract offered by the firm must yield a certain level of expected utility for workers. However, workers prefer a contract that offers the same wage across all possible states of nature, which gives a wage lower than the expected value of the state contingent wages. This contract is possible because the workers are willing to pay insurance premiums to eliminate uncertainty. The firms are willing to do this because they will get higher expected profits by paying a lower wage with certainty compared to the state contingent wage contract.

This implicit contract concept can be applied to the elevator profit maximization problem. If farmers are risk averse and elevators are risk neutral, then elevators may have an incentive to provide insurance for the farmers by paying one price for a range of acceptable qualities of wheat, if the price they pay is lower than the expected value of quality-adjusted prices.

producers exhibit risk-seeking behavior for outcomes below a specified outcome, and risk-averse behavior for outcomes above the specified outcome.

To the extent that prospect theory helps explain the effect of producer preferences on elevators' grading practices, producers are making psychological "mistakes". One implication of this is that educational programs may help producers make decisions in a way that will encourage elevators to pay quality-adjusted prices.

In order to measure the effects of such preferences on elevator pricing, a simulation model is used to measure the extra profit that could be earned by an elevator that pays quality-adjusted prices. This profit is compared to that of its competitors, which pay an average price for all qualities of wheat. Prices from the elevators are evaluated by producers whose preferences are consistent with prospect theory. Producers choose the elevator to which they will sell their grain based on those evaluations.

Conceptual Framework

This problem is discussed first in the context of risk neutral producers, then in a framework in which producers maximize expected utility, and then in the context of prospect theory. Following Elliott et al., country elevator A is assumed to be a profit maximizing spatial oligopsonist, paying a different price for each quality if it is profitable to do so. Elevator A has six competitors, each located a distance U away (Figure 1). These competitors (represented by elevator B) maximize profits, but pay the same price for each of three qualities of grain. The elevators perform 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.

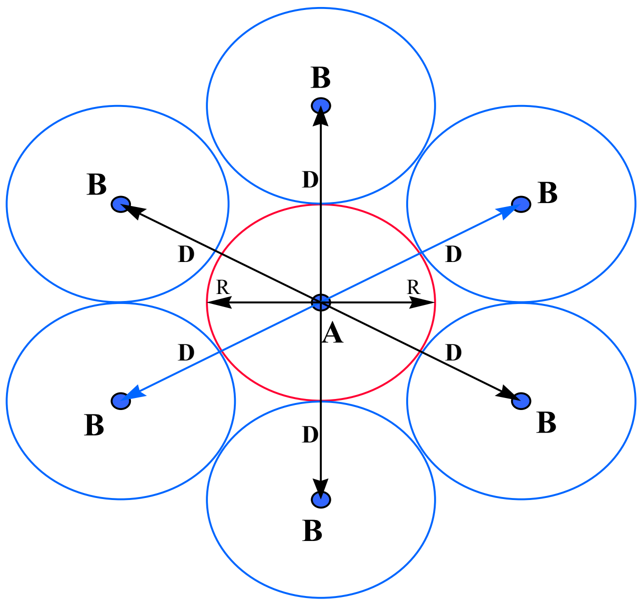

Figure 1. Spatial Competition Model (Capozza and van Order)

If producers maximize net revenue, the elevator's objective can be expressed as:

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

where

P_{NIL_i} = price received from NIL buyer for quality i (\$/bu)
P_{fi} = price paid to farmers by elevator for i^{th} quality (\$/bu)
x_i = alternative outlet price to producer for wheat of quality i (e.g., feed value)
C_{vi} = variable costs for handling i^{th} quality
Q_i = quantity of wheat of i^{th} 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 i^{th} quality (\$/bu/mi)
π = pi (circumference of a circle divided by the diameter)
P_{fi}^{B} = price paid to farmers by competing elevators for i^{th} quality
R = radius of elevator's trade area
U = distance between elevator and competing elevators

and where

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

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, competitors' 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.

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). 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.

For the case where producers maximize expected utility, producers at each point in the production area determine whether to sell their grain to elevator A or to elevator B by evaluating their expected utility of selling to either elevator. At some distance D_A from elevator A, producers' expected utility from selling to elevator A equals their expected utility from selling to elevator B. This distance defines the boundary of each elevator's trade area. In turn, this determines the quantity of the i^{th} quality purchased using the formula for the area of a circle, $k_i \pi D_{A(B)i}^2$, where k_i is the production density of wheat of quality i, $D_{A(B)i}$ is the radius of the trade area surrounding each elevator, and $\overline{D}$ is the distance between elevator A and its competitors.

This situation can be represented mathematically as follows:

(3) $$EU^A = \sum_{i=1}^{n} p_i U[(P_i^A - t_i D_i^A)Q_i^A] = U\{\sum_{i=1}^{n}[(P^B - t_i(\overline{D} - D_i^A)Q_i^B]\} = EU^B.$$

where

(4) $$Q_i^{A(B)} = k_i \pi (D_i^{A(B)})^2$$

Prospect Theory

For the case where producers' preferences are consistent with prospect theory, producers at each point in the production area determine whether to sell their grain to elevator A or to elevator B by evaluating their "prospect value" resulting from selling to either elevator. Following Kahneman and Tversky (1979), value is treated as a function of two arguments: the asset position that serves as a reference point, and the magnitude of the change (positive or negative) from that reference point. They hypothesized that the value function for changes in wealth is normally concave above the reference point and often convex below it. That is, the marginal value of both gains and losses generally decreases with their magnitude. Also, losses loom larger than gains. The aggravation that one experiences in losing a sum of money appears to be greater than the pleasure associated with gaining the same amount.

They proposed the following value function for a set of possible outcome x_i:

(5) $$v(x_i) = \begin{cases} x_i^{\alpha} & \text{if } x_i \geq 0 \\ -\gamma(-x_i)^{\beta} & \text{if } x_i < 0, \end{cases}$$

where γ is the loss aversion coefficient. Tversky and Kahneman (1992) have estimated α and β to be 0.88 and γ to be 2.25. The above value function is (i) defined on deviations from the reference point; (ii) generally concave for gains and commonly convex for losses; and (iii) steeper for losses than for gains.

In order to complete evaluation of an outcome, the value calculated by equation (5) should be combined with a decision weight, which is transformed by a weighting function. The weighting function has the following properties: 1) Decision weights measure the impact of events on the desirability of prospects, and not merely the perceived likelihood of these events. 2) π is an increasing function of *p* (the probability of the event occurring), with π(0) = 0 and π(1) = 1. That is, outcomes contingent on an impossible event are ignored, and the scale is normalized so that π(*p*) is the ratio of the weight associated with the probability *p* to the weight associated with the certain event. 3) Subadditivity: π(*rp*) > *r*π(*p*) where *r* is a constant for 0 < *r* <1. 4) Subcertainty: π(*p*) + π(1-*p*) < 1 for all 0 < *p* < 1. 5) Subproportionality: for a fixed ratio of probabilities, the ratio of the corresponding decision weights is closer to unity when the probabilities are low than when they are high (Kahneman and Tversky, 1979).

The weighting function has been developed further by Prelec (1998). Following his results, the weighting function $\pi(p)$ is regressive (first $\pi(p) > p$, then $\pi(p) < p$), s-shaped (first concave, then convex), and asymmetrical (intersection the diagonal at about 1/3).

For calculating π_i, a decision weight is assigned to outcome x_i using the $w(p)$ approximation for w proposed by Tversky and Kahneman (1992),

(6) $$w(p) = \frac{p^r}{(p^r + (1-p)^r)^{1/r}},$$

where r is estimated at 0.61 in the domain of gains and 0.69 in the domain of losses. If 0.61 is used for r in the domain of gains, then the weighting function has an invariant fixed point and inflection point at 0.34, and if 0.69 for r in the domain of losses, then it has an invariant fixed point and inflection point at around 0.37. The above approximation $w(p)$ for $\pi(p)$ is also consistent with regressive (first $\pi(p) > p$, then $\pi(p) < p$), and s-shaped (first concave, then convex) properties.

Finally, the overall value of a prospect can be calculated as

(7) $$V(G) = \sum \pi_i v(x_i) .$$

In the elevator profit maximization problem, there are two possible prospects observed by a producer, one from elevator A (prospect A) and one from elevator B (prospect B). The producer selling wheat to elevator A faces three possible outcomes, with each outcome assigned a probability that depends on the proportion of wheat quality. The producer selling wheat to elevator B faces only one outcome, so its probability is one. In either case, the outcomes are the net prices adjusted by transportation costs and distances from each elevator. Thus, outcomes applying to prospect A are $P_1^A - tD_1^{\,A} = x_1$ for high quality, $P_2^A - tD_2^{\,A} = x_2$ for middle quality, and $P_3^A - tD_3^{\,A} = x_3$ for low quality, and the outcome of prospect B is $P^B - t(U - D^A) = x$. Define p_h, p_m, and p_l as probabilities for high, middle, and low quality, then two prospects are represented as follows: $(x_3, p_l; x_2, p_m; x_1, p_l)$ for prospect A and (x, 1) for prospect B. These prospects will be reformulated through editing to simplify evaluation.

The editing phase for these prospects is coding. Coding is the process that transforms an outcome of a prospect into gains and losses relative to some neutral reference point, which is usually defined as the current asset position. However, the location of the reference point, and the consequent coding of outcomes as gains and losses, can be affected by the expectations of the decision maker (Kahneman and Tversky, 1979). In the elevator problem, a producer can expect that the net price paid by elevator B, which is adjusted by transportation costs, is a certain outcome when she decides to sell her wheat to elevator B. Therefore, the producer's expectation makes her consider the net price paid by elevator B as a reference point. In this case, comparing the net prices of elevator A with the price of elevator B gives gains and losses of prospect A. After coding, prospect A is reformulated as $(x_l, p_l; x_m, p_m; x_h, p_h)$ and prospect B is described as $(0,1)$, where $x_l = x - x_3$, $x_m = x - x_2$, and $x_h = x - x_1$.

In the evaluation phase, the reformulated prospect A is evaluated by the value function for outcomes (5), the weighting function (6), and the overall value function (7). Calculating the prospect for producers selling to elevator B does not need this evaluation process because its value should be always zero. Therefore, the decision problem of the producer is reduced to selling to elevator A if its prospect value is positive, and selling to elevator B if the prospect value from selling to elevator A is negative.

The results from the prospect theory specification are compared to results using an expected utility specification as used in Adam and Hong. The analysis in an expected utility framework considers three levels of producer risk aversion. The Arrow-Pratt risk aversion parameter associated with the "medium risk aversion" level is adapted (using the procedure suggested by Raskin and Cochran) from literature that either elicited producers' risk aversion levels or estimated the level based on production responses. The "low" and "high" levels are simple adjustments of this estimated level to capture a broader range of producer risk preferences.

Producer Information about Wheat Quality

For the case where producers maximize expected revenue, it is assumed that they know with certainty the quality of their wheat, whether high, medium, or low, as in the analysis by Elliott et al. For the case where producers maximize expected utility or prospect value, however, it is assumed that they may have less than perfect information about the quality of their wheat. First, an extreme case is considered in which the only information producers have about the quality of their wheat is the relative proportion of each quality of wheat grown in the elevators' trade areas. They have no information about how the quality of their wheat might differ from that of other producers in their area. Then, more realistically, it is assumed that producers have more, but still incomplete, information about the quality of their wheat. Thus, elevators select prices knowing the proportion of each quality of wheat in their trade area, and producers select the elevator to which they will sell their wheat with prior, but incomplete, information about the quality of their wheat.

For the case of more but still incomplete information, it is assumed that producers of high-quality wheat are 70% certain that they will deliver high-quality wheat to the elevator, but believe there is a 30% probability that they will in fact deliver middle-quality wheat. Similarly, producers of middle-quality wheat are 70% certain they will deliver middle-quality wheat, but believe there is a 15% probability that will deliver high-quality wheat and a 15% probability that they will deliver low-quality wheat. Producers of low-quality wheat are 70% certain they will deliver low-quality wheat, but believe there is a 30% probability that they will deliver middle-quality wheat.

Procedures

This section describes the procedures used to simulate elevators' pricing decisions and producers' choice of elevator to which to sell their grain. A profit-maximizing algorithm chooses the prices the elevator should pay producers for each quality of wheat, while simultaneously an expected utility maximizing algorithm chooses the optimal market (elevator A or elevator B) for producers at different locations within the elevators' trade area.

Wheat grown in an elevator's trade area is assumed to fall into any of three quality categories: high, middle, and low. Both elevator A and its competitors are assumed to have invested in testing equipment and additional labor in order to determine whether wheat delivered is high, middle, or low quality. They 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 categories, blending provides little additional benefit in most scenarios, and is not considered.[2]

Next-in-line (NIL) buyers are assumed to pay $5.00 for high quality wheat, $4.90 for middle quality wheat, and $4.80 for low quality wheat. These are prices actually received by country elevators after paying transportation cost. 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 1/3 is high quality, 1/3 is middle quality, and 1/3 is low quality.[3]

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. Based on their models, the transportation cost is assumed to be $0.011 per bushel per mile. It is assumed that each of the six competing elevators is located a distance of 40 miles from Elevator A.

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[2] Hennessey and Wahl show that the elevator's decision on blending or segregating grain depends on the convexity/concavity of the price schedule from NIL buyers. Here, the schedule is linear so that this decision can be ignored.

[3] Changing these assumptions within reasonable ranges does not change the results qualitatively.

Elevator fixed and variable costs used are an average of the estimates by Kenkel and Anderson's of grain handling cost at Oklahoma elevators, adjusted to include costs of grading and segregating grain. Fixed costs include depreciation, administrative overhead, and interest (including amortized cost of a Carter-Day Dockage Tester) and are assumed to be $100,587. Variable costs include labor, utility, chemical, and repairs. Variable costs are assumed to be $0.067/bushel. Also, it is assumed that elevators correctly segregate the three different qualities of wheat into three bins for sale directly to NIL buyers.

Optimization

Several steps are used to solve for producers' and elevators' choices. Elevator A chooses profit-maximizing prices for each of the three qualities of wheat, given elevator B's price (equation (1)). For the case where producers maximize net revenue, the quantities purchased by the elevator and radius of the trade area are given by equation (2). For the case where producers maximize expected utility (prospect value), a nonlinear constraint is included in which the distance to the boundary of the trade area between elevators A and B is such that, at the boundary, the expected utility (prospect value) of producers is the same for selling to elevator A as it is for selling to elevator B for each quality of wheat. From this constraint, quantities purchased by the elevators and the radii are calculated.

This problem is solved with the objective that the equilibrium solution satisfy the Nash criterion, that each player's strategy is a best response to the strategies actually played by its rivals. Thus, elevator B chooses its profit maximizing price for the three qualities, given elevator A's prices, and trade areas and quantities are recalculated for each elevator. Then the process is repeated, with elevator A choosing prices, given B's prices, and so on, until elevator A's and elevator B's prices stabilize. GAUSS, along with its optimization and constrained optimization modules, is used to solve the simulations (Aptech Systems).

Results

Producers Maximize Expected Net Revenue

For the case where producers maximize net revenue (table 1), elevators pass on to producers 70% of the price differentials received from next-in-line buyers, so that they receive a margin of 32¢/bu. for high quality, 29¢/bu. for middle quality, and 26¢/bu. for low quality wheat. Quantities received and trade area radius vary directly with their prices. Elevator B pays an average price for all qualities that is just lower than elevator A's price for middle quality wheat.

The trade area boundary for high quality wheat is 23.35 miles from elevator A, or 3.35 miles beyond the midpoint between the elevators. For middle quality wheat the boundary is just 0.32 miles beyond the midpoint, and for low quality wheat, is 2.71 miles less than the midpoint. These radii are consistent with the prices paid and quantities received: higher prices relative to elevator B's prices result in a larger trade area and high quantities received. By pricing according to quality, elevator A achieves a profit of $557,851, about 20% higher than elevator B's profit.

Producers Maximize Expected Utility

For the case where producers maximize expected utility and have no information about the quality of their crop (Tables 2 and 3), the probability a producer will deliver a particular quality of wheat is equal to its proportion of total production in the trade area. In this simulation, producers have a 1/3 chance that their wheat will grade high quality, 1/3 that it will grade middle quality, and 1/3 that it will grade low quality. Because they don't know the quality of their wheat, producers select an elevator that will pay the highest risk-adjusted price for an evenly-weighted portfolio of all the possible qualities. As tables 2 and 3 indicate, this implies that elevators have little incentive to pay quality-adjusted prices, since risk averse producers prefer a certain average price than a random price with an expected value equal to the average price. In table 2, Elevator A pays prices that reflect 30% of the price differences paid by NIL buyers by setting those prices high enough so that the average of the three prices is $4.613/bu, which is $0.013/bu higher than Elevator B's price. This results in margins of $0.35/bu. for high quality wheat, $0.28/bu. for middle quality wheat, and $0.23/bu. for low quality wheat. The radius of elevator A's trade area is slightly bigger than elevator B's (20.02 miles compared to 19.98 miles), and its profits are 3/10 of a percent higher than elevator B's profits.

As table 3 indicates, for producers that are more risk averse, elevator A optimizes profits by paying nearly the same price for all three qualities. Its profits are only 2/100 of a percent higher than elevator B's profits. Because of producers' risk aversion, elevator A does not find it profitable to pay quality-adjusted prices. These results indicate the risk aversion is very important when producers have no information about the quality of their wheat compared to the overall quality of wheat in their region.

Results for the case where producers have additional, but still incomplete, information about the quality of their wheat indicate that elevators pay nearly the same high price for high- and middle quality wheat and a much lower price for low quality wheat (tables 5 through 7). Thus, the prices for high- and middle quality wheat are higher than those paid by Elevator B, and the price for low quality wheat is lower than Elevator B's price. Profits at each elevator decline by slightly more than 1/10 of one percent, compared to the expected revenue case. Increasing producers' level of risk aversion changes those results very little, except that elevator A's profits are very slightly reduced and elevator B's profits are slightly enhanced as level of risk aversion increases.

Producers Maximize Prospect Value

Table 8 indicates than when producers' preferences can be characterized by prospect theory, Elevator A's prices differ across qualities by $0.05/bu. compared to the risk neutral case in which there was a difference of $0.07/bu. Thus, prospect theory helps explain part of country elevators' reluctance to pass premiums and discounts on to producers.

Comparing Table 8 with the expected utility results when producers have "some information" (Tables 5-7) shows that the prices seem to be more related to quality differences than prices under expected utility. However, Elevator A achieves only a 1.5% profit advantage over Elevator B by paying quality-adjusted prices, whereas under the expected utility specification, the advantage from paying quality-adjusted prices is approximately 20%. Thus, if producers' preferences can be characterized more appropriately by prospect theory than by expected utility, elevators face a much smaller potential gain from paying quality-adjusted prices. This provides a better, though still partial, explanation of why more elevators do not become "early adopters" in paying quality-adjusted prices to producers.

Conclusions

A cursory review of the results suggests that prospect theory does not provide any advantage over expected utility theory to explain why elevators do not pay quality-adjusted prices. The optimal price structure for a profit-maximizing elevator is to pass on to producers roughly half of the premiums/discounts it receives from NIL buyers. Presumably, an elevator would choose to do this, and its competitors would be forced to follow. As Elliott et al. showed, if this happened, elevators would pass on all quality-based premiums/discounts to producers.

Further review of the prospect theory results, though, suggests that an elevator's potential profit gain from paying quality-adjusted prices is relatively small, representing only a 1.5% advantage over its competitors that do not pay quality-adjusted prices. If other factors, such as producer loyalty, are important to the elevator's management, this potential gain may be too small to risk losing that loyalty.

Further research should examine the effects of alternative levels of information producers have about the quality of their wheat in a prospect theory context. Adam and Hong found in an expected utility framework, and the current results are consistent with their findings, that the level of information producers have has a bigger effect on elevators' incentive to pay quality-adjusted prices than level of risk aversion does. Also, the incentive by elevator managers to promote producer loyalty should be examined more carefully.

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Table 1. Producers maximize expected revenue and know crop quality: P_{NIL1}=$5.00, P_{NIL2}=$4.90, P_{NIL3}=$4.80

Price ($/bu)	Quantity (bu)	Trade Area Radius (miles)	Elevator Profit ($)
Elevator A			
P_{f1} = $4.68	Q_1 = 1,241K	$Radius_1$ = 23.35	
P_{f2} = $4.61	Q_2 = 940K	$Radius_2$ = 20.32	$557,851
P_{f3} = $4.54	Q_3 = 681K	$Radius_3$ = 17.29	
Elevator B			
P_{f1} = $4.60	Q_1 = 631K	$Radius_1$ = 16.65	
P_{f2} = $4.60	Q_2 = 882K	$Radius_2$ = 19.68	$464,605
P_{f3} = $4.60	Q_3 = 1,174K	$Radius_3$ = 22.71	(Diff = $93,246)

Table 2. Producers maximize expected utility but don't know crop quality (AP = 0.00176): P_{NIL1}=$5.00, P_{NIL2}=$4.90, P_{NIL3}=$4.80

Price ($/bu)	Quantity (bu)	Trade Area Radius (miles)	Elevator Profit ($)
Elevator A			
P_{f1} = $4.68	Q_1 = 911,452	$Radius_1$ = 20.01	
P_{f2} = $4.62	Q_2 = 911,452	$Radius_2$ = 20.01	$500,370
P_{f3} = $4.54	Q_3 = 911,452	$Radius_3$ = 20.01	
Elevator B			
P_{f1} = $4.61	Q_1 = 909,834	$Radius_1$ = 19.99	
P_{f2} = $4.61	Q_2 = 909,834	$Radius_2$ = 19.99	$500,000
P_{f3} = $4.61	Q_3 = 909,834	$Radius_3$ = 19.99	(Diff = $370)

Table 3. Producers maximize expected utility but don't know crop quality (AP = 0.088): P_{NIL1}=$5.00, P_{NIL2}=$4.90, P_{NIL3}=$4.80

Price ($/bu)	Quantity (bu)	Trade Area Radius (miles)	Elevator Profit ($)
Elevator A			
P_{f1} = $4.62	Q_1 = 910,763	$Radius_1$ = 20.00	
P_{f2} = $4.61	Q_2 = 910,763	$Radius_2$ = 20.00	$500,389
P_{f3} = $4.61	Q_3 = 910,763	$Radius_3$ = 20.00	
Elevator B			
P_{f1} = $4.61	Q_1 = 910,523	$Radius_1$ = 20.00	
P_{f2} = $4.61	Q_2 = 910,523	$Radius_2$ = 20.00	$500,328
P_{f3} = $4.61	Q_3 = 910,523	$Radius_3$ = 20.00	(Diff = $61)

Table 4. Producers maximize expected utility but don't know crop quality (AP = 0.264): P_{NIL1}=\$5.00, P_{NIL2}=\$4.90, P_{NIL3}=\$4.80

Price (\$/bu)	Quantity (bu)	Trade Area Radius (miles)	Elevator Profit (\$)
Elevator A			
P_{f1} = \$4.61	Q_1 = 910,724	$Radius_1$ = 20.00	
P_{f2} = \$4.61	Q_2 = 910,724	$Radius_2$ = 20.00	\$500,415
P_{f3} = \$4.61	Q_3 = 910,724	$Radius_3$ = 20.00	
Elevator B			
P_{f1} = \$4.61	Q_1 = 910,562	$Radius_1$ = 20.00	
P_{f2} = \$4.61	Q_2 = 910,562	$Radius_2$ = 20.00	\$500,373
P_{f3} = \$4.61	Q_3 = 910,562	$Radius_3$ = 20.00	(Diff = \$42)

Table 5. Producers maximize expected utility and have some information about crop quality (AP = 0.00176): P_{NIL1}=\$5.00, P_{NIL2}=\$4.90, P_{NIL3}=\$4.80

Price (\$/bu)	Quantity (bu)	Trade Area Radius (miles)	Elevator Profit (\$)
Elevator A			
P_{f1} = \$4.66	Q_1 = 1,137K	$Radius_1$ = 22.35	
P_{f2} = \$4.66	Q_2 = 1,022K	$Radius_2$ = 21.30	\$551,006
P_{f3} = \$4.51	Q_3 = 696K	$Radius_3$ = 17.48	
Elevator B			
P_{f1} = \$4.61	Q_1 = 709K	$Radius_1$ = 17.65	
P_{f2} = \$4.61	Q_2 = 796K	$Radius_2$ = 18.70	\$457,304
P_{f3} = \$4.61	Q_3 = 1,154K	$Radius_3$ = 22.52	(Diff = \$93,702)

Table 6. Producers maximize expected utility and have some information about crop quality (AP = 0.088): P_{NIL1}=\$5.00, P_{NIL2}=\$4.90, P_{NIL3}=\$4.80

Price (\$/bu)	Quantity (bu)	Trade Area Radius (miles)	Elevator Profit (\$)
Elevator A			
P_{f1} = \$4.66	Q_1 = 1,137K	$Radius_1$ = 22.35	
P_{f2} = \$4.66	Q_2 = 1,022K	$Radius_2$ = 21.30	\$551,009
P_{f3} = \$4.51	Q_3 = 696K	$Radius_3$ = 17.48	
Elevator B			
P_{f1} = \$4.61	Q_1 = 709K	$Radius_1$ = 17.65	
P_{f2} = \$4.61	Q_2 = 796K	$Radius_2$ = 18.70	\$457,513
P_{f3} = \$4.61	Q_3 = 1,154K	$Radius_3$ = 22.52	(Diff = \$93,496)

Table 7. Producers maximize expected utility and have some information about crop quality (AP = 0.264): P_{NIL1}=\$5.00, P_{NIL2}=\$4.90, P_{NIL3}=\$4.80

Price (\$/bu)	Quantity (bu)	Trade Area Radius (miles)	Elevator Profit (\$)
Elevator A			
P_{f1} = \$4.66	Q_1 = 1,138K	$Radius_1$ = 22.31	
P_{f2} = \$4.66	Q_2 = 1,031K	$Radius_2$ = 21.28	\$550,069
P_{f3} = \$4.51	Q_3 = 699K	$Radius_3$ = 17.52	
Elevator B			
P_{f1} = \$4.61	Q_1 = 712K	$Radius_1$ = 17.69	
P_{f2} = \$4.61	Q_2 = 798K	$Radius_2$ = 18.72	\$458,069
P_{f3} = \$4.61	Q_3 = 1,150K	$Radius_3$ = 22.48	(Diff = \$92,000)

Table 8. Producers maximize expected utility and have more information about crop quality (AP = 0.00176): P_{NIL1}=\$5.00, P_{NIL2}=\$4.90, P_{NIL3}=\$4.80

Quality	Price (\$/bu)	Quantity (bu)	Trade Area Radius (miles)	Elevator Profit (\$)
Elevator A				
High	4.67	1,169K	22.66	
Middle	4.63	998K	20.94	\$550,372
Low	4.54	680K	17.28	
Elevator B				
High	4.60	685K	17.34	
Middle	4.60	827K	19.06	\$465,180
Low	4.60	1,175K	22.72	(Diff = \$85,192)

Table 9. Producers maximize expected utility and have more information about crop quality (AP = 0.088): P_{NIL1}=\$5.00, P_{NIL2}=\$4.90, P_{NIL3}=\$4.80

Quality	Price (\$/bu)	Quantity (bu)	Trade Area Radius (miles)	Elevator Profit (\$)
Elevator A				
High	4.67	1,169K	22.65	
Middle	4.63	997K	20.93	\$549,825
Low	4.54	681K	17.29	
Elevator B				
High	4.60	685K	17.35	
Middle	4.60	828K	19.07	\$464,955
Low	4.60	1,174K	22.71	(Diff = \$84,870)

Table 10. Producers maximize expected utility and have more information about crop quality (AP = 0.264): P_{NIL1}=\$5.00, P_{NIL2}=\$4.90, P_{NIL3}=\$4.80

Quality	Price (\$/bu)	Quantity (bu)	Trade Area Radius (miles)	Elevator Profit (\$)
Elevator A				
High	4.67	1,167,122	22.64	
Middle	4.63	996,106	20.92	\$549,760
Low	4.54	681,803	17.31	
Elevator B				
High	4.60	685,945	17.36	
Middle	4.60	829,012	19.08	\$465,130
Low	4.60	1,172,540	22.69	(Diff = \$84,630)

Table 11. Producers maximize prospect value and have some information about crop quality: P_{NIL1}=\$5.00, P_{NIL2}=\$4.90, P_{NIL3}=\$4.80 (B's prices used as reference points)

Quality	Price (\$/bu)	Quantity (bu)	Trade Area Radius (miles)	Elevator Profit (\$)
Elevator A				
High	4.65	1,085,859	21.84	
Middle	4.60	874,914	19.60	\$534,081
Low	4.55	683,505	17.33	
Elevator B				
High	4.60	750,834	18.16	
Middle	4.60	947,087	20.40	\$525,763
Low	4.60	1,170,310	22.67	(Diff = \$8,318)

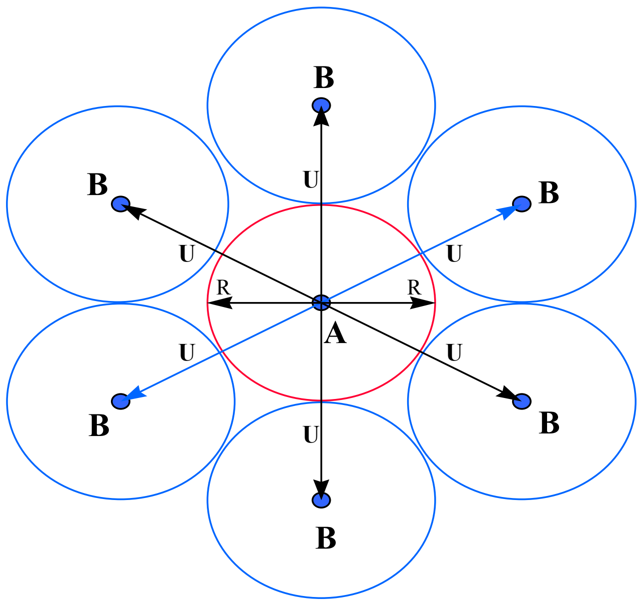

Figure 1. Spatial Competition Model (Capozza and van Order, 1978)