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Why Don't Country Elevators Pay More for High Quality Wheat? The Effects of Risk and Information

Brian D. Adam and Seung Jee Hong*

Previous research has 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. These early-adopting elevators would pass on to producers 70% of the quality-based price differentials received from next-in-line buyers. If competing elevators also adopt 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.

An additional explanation for country elevators failing to pass on to producers quality-adjusted prices is risk aversion. 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. 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).

A simulation model is used to measure the effects of risk-averse producers and limited quality information on profits that can be earned by an elevator that pays quality-adjusted prices. Results suggest that while risk aversion is important, the amount of information producers have about the quality of their wheat is even more important.

Introduction

In the last several years, as foreign and domestic grain buyers 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 quality 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, Kenkel, Anderson, and Attaway found that most country elevators were not passing on to producers discounts for lower quality wheat, and many were not even measuring quality characteristics accurately. 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. 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.

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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. 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.[1] 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.

The work here considers an additional explanation for country elevators failing to pass on to producers quality-adjusted prices. The model used by Elliott et al. assumed that producers maximize net revenue and that they know with certainty the quality of their grain before they deliver it 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 producers believe that a competing elevator may be 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).

In order to measure the effects of producers' risk aversion and uncertainty about the quality of their wheat, 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 its competitors, which pay an average price for all qualities of wheat.

Conceptual Framework

Following Elliott et al., country elevator A is assumed to be a spatial oligopsonist, with six competitors each located a distance U away (Figure 1). It is assumed that elevator A's competitors (represented by elevator B) maximize profits, but pay the same price for each of three qualities of grain. Elevator A also maximizes profit, but pays a different price for each quality if it is profitable to do so. 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.

[1] In the long run profits should cover all costs, including cost of grading equipment. However, the model used by Elliott et al. and the one used here do not allow entry and exit of firms. Also, producers at the edge of the trade area have a competitive alternative market (as cattle feed) for their wheat.

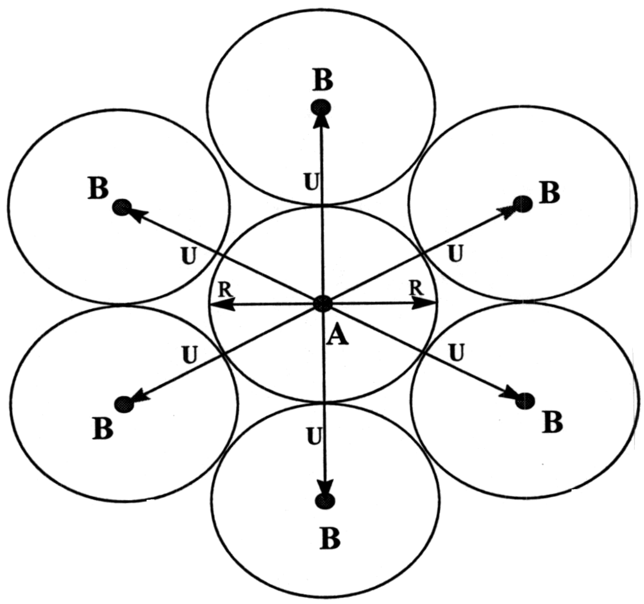


Figure 1. Spatial Competition Model (Capozza and van Order)

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

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

where

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

P_{NIL_i} = price received from NIL buyer for quality i (\$/bu)
P_{fi} = price paid to farmers by elevator for 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^B_{fi} = 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

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 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:

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

where

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

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, however, it is assumed that they 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. Based on wheat quality data from Kenkel and Anderson, it is assumed that if a producer has a prior expectation that her wheat will grade a particular quality (say high), then she has a 70% probability that her wheat will grade high quality and 30% probability that it will grade middle quality.[2] If her prior expectation is that the wheat will grade middle quality, then there is a 70% probability that the wheat will grade middle quality, a 15% probability that it will grade high quality, and a 15% probability that it will grade low quality. If her expectation is that it will grade low quality, there is a 70% chance that it will grade low quality and a 30% probability that it will grade middle quality. 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.

Two levels of producer risk aversion are considered. 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.

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.

These probabilities can be thought of as posterior probabilities based on empirical observation

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.

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, a sub-optimization routine solves for the distances to the boundaries of the trade areas surrounding elevators A and B, given the prices paid by each elevator, using equations (3) and (4). From this result, quantities of each quality of wheat purchased by each elevator are calculated.

Then, for either of these cases, 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.

Choice variables for the elevators' optimizations are price(s) paid to producers for wheat of different qualities. GAUSS, along with its optimization and constrained optimization modules, is used to solve the simulations (Aptech Systems, 1984-1992; 1995).

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

Results

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.

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	Profit =
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	Profit =
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	

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.

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.

Table 2. 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} = \$4.65	Q_1 = 913K	$Radius_1$ = 20.02	Profit =
P_{f2} = \$4.62	Q_2 = 913K	$Radius_2$ = 20.02	\$502,089
P_{f3} = \$4.57	Q_3 = 913K	$Radius_3$ = 20.02	
Elevator B			
P_{f1} = \$4.60	Q_1 = 909K	$Radius_1$ = 19.98	Profit =
P_{f2} = \$4.60	Q_2 = 909K	$Radius_2$ = 19.98	\$500,786
P_{f3} = \$4.60	Q_3 = 909K	$Radius_3$ = 19.98	

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.

In contrast, results for the case where producers have additional, but still incomplete, information about the quality of their wheat are very similar to those for the case where producers maximize expected revenue (tables 4 and 5).[4] Prices paid (rounded to the nearest cent) are the same as for that case, although elevator A's trade area radius is 0.01 miles smaller for each quality. Profits at each elevator decline by about 2/10 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 (table 5). Figure 2 summarizes results from tables 1, 3, 4, and 5 graphically.

[4] As explained above, this incomplete information takes the form that if, for example, a producer has a prior expectation that her wheat will grade high quality, then she has a 70% (posterior) probability that her wheat will grade high quality and 30% probability that it will grade middle quality.

Table 3. 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} = \$4.62	Q_1 = 911K	$Radius_1$ = 20.00	Profit =
P_{f2} = \$4.62	Q_2 = 911K	$Radius_2$ = 20.00	\$500,592
P_{f3} = \$4.61	Q_3 = 911K	$Radius_3$ = 20.00	
Elevator B			
P_{f1} = \$4.61	Q_1 = 910K	$Radius_1$ = 19.99	Profit =
P_{f2} = \$4.61	Q_2 = 910K	$Radius_2$ = 19.99	\$500,483
P_{f3} = \$4.61	Q_3 = 910K	$Radius_3$ = 19.99	

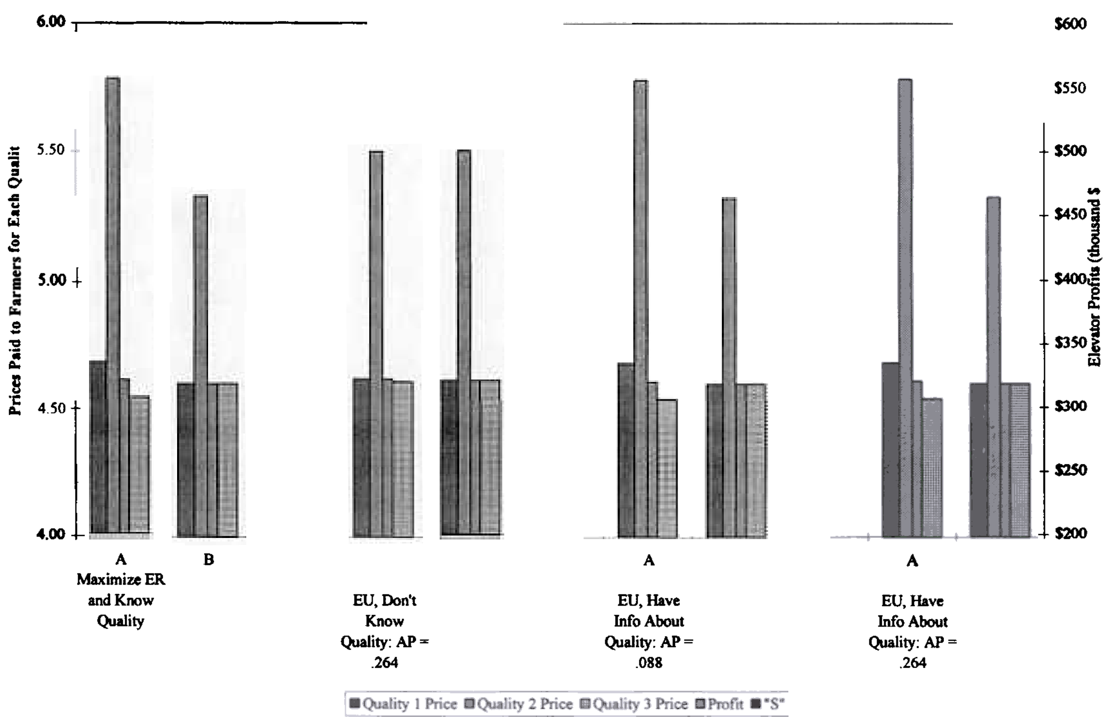
Table 4. Producers maximize expected utility and have some information about crop quality (AP = 0.088): P_{NIL1}=\$5.00, P_{NIL2}=\$4.90, P_{NIL3}=\$4.80

Price (\$/bu)	Quantity (bu)	Trade Area Radius (miles)	Elevator Profit (\$)
Elevator A			
P_{f1} = \$4.68	Q_1 = 1,240K	$Radius_1$ = 23.34	Profit =
P_{f2} = \$4.61	Q_2 = 939K	$Radius_2$ = 20.31	\$556,487
P_{f3} = \$4.54	Q_3 = 680K	$Radius_3$ = 17.28	
Elevator B			
P_{f1} = \$4.60	Q_1 = 632K	$Radius_1$ = 16.66	Profit =
P_{f2} = \$4.60	Q_2 = 882K	$Radius_2$ = 19.69	\$463,661
P_{f3} = \$4.60	Q_3 = ,176K	$Radius_3$ = 22.72	

Table 5. 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} = \$4.68	Q_1 = 1,240K	$Radius_1$ = 23.33	Profit =
P_{f2} = \$4.61	Q_2 = 938K	$Radius_2$ = 20.30	\$556,275
P_{f3} = \$4.54	Q_3 = 679K	$Radius_3$ = 20.02	
Elevator B			
P_{f1} = \$4.60	Q_1 = 632K	$Radius_1$ = 17.28	Profit =
P_{f2} = \$4.60	Q_2 = 883K	$Radius_2$ = 19.70	\$464,158
P_{f3} = \$4.60	Q_3 = 1176K	$Radius_3$ = 22.73	

Prices Paid to Farmers and Elevator Profits



Conclusions

The results indicate that while risk aversion affects prices elevators pay for different qualities of wheat, the amount of information producers have about the quality of their wheat is more important. However, risk aversion is more important the less information producers have. This is good news for the grain marketing system. Since producers are not likely to alter their levels of risk aversion, little could be done to promote quality-adjusted pricing if producers' risk aversion were the major factor inhibiting elevators from paying quality-adjusted prices. However, it is conceivable that producers can take steps to enhance the quality of information about their crop quality. Future work should examine more carefully the effects of alternate levels of information to determine the level producers need in order for elevators to pay quality-adjusted prices. Also, further work is needed to determine if non-expected utility characterizations of producer preferences, such as prospect theory, can better explain producer response to quality-adjusted prices.

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