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Development of a Quality Decision-Making Scenario to Measure How Employees Handle Out-of-Condition Grain

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Keywords

Grain, Moisture content, Post-harvest treatment, Decision making

Disciplines

Agriculture | Bioresource and Agricultural Engineering | Operational Research

Comments

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G. A. Mosher, N. Keren, C. R. Hurburgh, Jr.

Abstract. *Quality management systems have been shown to improve inventory management, increase internal efficiencies, and enhance the ability of businesses to meet customer specifications, but little work has explored the role of employee decisions in the success of such systems. This work used the methodology of process-tracing to examine the decision-making process of grain elevator employees (n=164) as they determined how to handle out-of-condition corn. Employees overwhelmingly chose to either follow management orders or to make a "non-choice" rather than to make a decision which would preserve the quality of the grain. Employees equally emphasized decision-making dimensions of storage risk and company policy in their decision process, suggesting a conflict in how employees approach the quality decision task.*

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Prudent post-harvest management of commodity grains such as corn helps prevent spoilage, preserve quality attributes, and establish marketability (Hellevang, 1995; Bern and Brumm, 2003; Reed, 2006). Bern et al. (2003) and Reed (2006) argue that of all quality attributes to be managed during storage, moisture is the most important. Moisture plays a critical role in the development of mold in corn and is also important in controlling insects and other foreign material in storage. Moisture levels must also be considered during aeration, fumigation, blending, and in the calculation of shrink (Hellevang 1995; Reed 2006). However, perhaps the most important effect of moisture on corn is economic. The moisture levels in corn directly influence the market price (Hellevang, 1995; Bern and Brumm, 2003).

Storage and management strategies for corn are largely determined by moisture levels. High moisture corn cannot be marketed through normal channels without extensive drying, and high moisture levels may limit handling, storage, and feeding options (Bern et al., 2003). Although high moisture corn can be dried, drying wet corn to the conventional long-term storage moisture level of approximately 14% to 15% (Hurburgh et al., 2008) uses more energy, takes more time, and reduces the capacity of grain handling systems (Roberts and Stroshine, 2009). Allowable storage time for higher moisture corn is also greatly reduced (Hurburgh and Elmore, 2009).

In most growing years, corn moisture levels at harvest are between 18% and 22%. Although it is typical for corn and other grains to be temporarily stored in outside piles while storage and rail car capacities catch up with the abundant harvest each fall (Bern et al., 2003), outdoor storage of corn is not considered a best practice in terms of long-term storage (Hurburgh and Elmore, 2009). When large portions of wet grain are stored for extended times in outdoor piles, spoilage can occur. In these cases, existing management practices of blending off out-of-condition grain are no longer an effective means of management and may have the potential to introduce both food and occupational safety hazards for humans and animals (Thakur and Hurburgh, 2009; Hurburgh, 2010).

Quality Management Systems in Agriculture

Recent food safety issues involving commodity grain have added to the concern already building concerning the safety of food and feed. The bulk commodity handling industry has not traditionally focused on food safety (Laux and Hurburgh 2010; Thakur and Hurburgh 2009), but recent food safety concerns have focused attention on this matter. Several food safety incidents have involved the adulteration of bulk agricultural commodity products (Harris, 2009; Martin and Moss, 2009; Moss, 2009; FDA, 2010).

In response to the needs of supply chain stakeholders, grain handlers have begun to recognize the potential of quality management systems (Laux and Hurburgh, 2010). The practices of quality applied to the food production and processing have the potential to address food safety as well as other important components of handling and processing organizations, including inventory management, security,

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and legislative compliance (Laux, 2007; Laux and Hurburgh, 2010; Thakur et al., 2009).

Traditionally, quality management systems have focused on improving a firm's strategic position and operating efficiency by focusing on customer needs and quality objectives (Foster, 2008; Laux and Hurburgh, 2010). The systems approach of these programs emphasize the interacting aspects of organizational components such as processes and procedures, machines and equipment, facilities, inputs, and personnel. The use of such systems in agriculture has been offered as one way to address several long-standing quality issues in the United States commodity grain market (Hurburgh and Lawrence, 2003; Thakur and Hurburgh, 2009; Thakur et al., 2009).

Laux (2007) demonstrated benefits for grain handling organizations in the areas of enhanced inventory management, increased compliance, and a better ability to add value to existing products. However, refinement and definition of procedures and processes are only one component of the quality management system. One of the most difficult elements of the quality management system to both manage and control are personnel actions (Henson and Heasman, 1998; Azanza and Zamora-Luna, 2005; Luning and Marcelis, 2007).

Employee decisions drive the outcomes of daily routines and processes. Consequently, the decision-making patterns of employees have the potential to work for or against organizational quality management processes (Luning and Marcelis, 2007). Quality processes in food and agricultural systems assume that employees are following procedures and behaving in predictable ways and if this does not occur, the success of such a system can be severely threatened (Luning and Marcelis, 2007). Furthermore, managing the quality of bulk raw materials such as grain involve choices on how to handle out-of-condition products. Although quality management has the potential to uncover operational efficiencies, improve inventory management, and increase legal compliance, none of these improvements can be realized if employees do not make positive quality-oriented decisions on the job.

Quality Decision Making

Several decision-making theories provide the basis for the present research. The theory of cognitive dissonance, developed by Festinger (1957), provides some of the theoretical framework for this experiment. The theory aims to explain the relationship among contradicting human cognitions or "pieces of knowledge." Operationally, the theory posits that when people are confronted with conflicting cognitions (i.e., quality or speed), they will attempt to resolve these conflicts to reduce their uncomfortable state of the mind. According to Das et al. (2008), employees will address the conflicts in one of three ways: first, ignore their own judgment and follow advice of the supervisor or manager; second, ignore the opinion of management and the supervisor and follow their own judgment; and third, delay action and do nothing until they are forced to make a decision. The third option does not solve the problem; rather, it just postpones the inevitable decision path until a later time. Additionally, the theory does not acknowledge a fourth scenario–that of no conflict between an employee's cognitions.

The work of Payne et al. (1993) provided further grounding for this work through their Accuracy Efforts framework of decision making. According to Payne and his colleagues, the goal of most decision makers is to choose a decision that is logical to them, while limiting their level of reasoning. For this reason, people tend to adopt a simplified strategy that will gain appropriate accuracy yet prevent the tedious task of processing all of the information that is relevant to the decision problem, thus, minimizing their efforts. Payne et al. (1993) classify factors that influence the decision strategy used into three categories: (1) the problem; (2) the person; and (3) the social context.

A final theoretical basis for this work was the decision-making theory of Elimination by Aspect (EBA) presented by Tversky (1972). Under EBA, the decision maker selects the most important piece of information (termed dimension by Tversky), reviews information on the available alternatives, and rejects information that he or she finds unimportant to the decision task. Keren et al. (2009, 2011) established a dimension-based framework that identified the priorities in decision-making using the method of process tracing. The present study builds on the framework first defined by Keren and his colleagues.

This work describes the development and testing of a process used to measure the decision-making process of country grain elevator employees in a quality decision scenario. The primary interest of researchers was to develop a valid quality decision-making scenario to measure both the decision choice and the decision process of grain elevator employees who were faced with a quality decision-making dilemma. To this end, the following research questions were explored:

1. Given a quality decision-making scenario, what decision choice is selected by grain elevator employees?
2. What information do employees use to select a decision choice in a quality decision task for grain elevator employees?

Methodology

The method of process tracing was used to measure the decision-making task in this work. Process tracing utilizes a linear model and measures the intervening steps between information acquisition and decision choice, considered a fundamental principle in decision-making research. Additionally, process tracing addresses a major weakness of using structural modeling approaches by studying the steps a person uses to make a decision choice rather than the outcome of the decision choice (Ford et al., 1989). Data collected can then be used to infer information on the decision-making process used by employees as they make a choice on the hypothetical scenario presented to them (Ford et al., 1989; Payne et al., 1993; Keren et al., 2009).

The software platform Decision Mind™, a computerized decision-making simulation, was used to enable the process-tracing methodology (Mintz, 2004). The primary reason for using Decision Mind™ was its ability to address the weaknesses of structural modeling described above by measuring the process of making the decision choice, rather than the outcome of the choice (Ford et al., 1989). Ease of use by research subjects and the secure data management and storage functions were also factors in the choice to use Decision Mind™. The simulation employs decision process-tracing by recording several key attributes of the decision-making process, including: 1) sequence of information gathered, 2) the number of items viewed, and 3) the decision choice.

The decision-making task investigated in this work was employee decisions concerning the management and storage of wet corn. When a load of wet corn is delivered, the employee is confronted with an important quality-oriented choice at the scale. The scenario asks employees to make a decision–do they follow direct orders from management and dump the wet corn onto an unmanaged pile on the ground or do they take action to better preserve the quality of the product before it is stored? The four dimensions for the quality decision-making choice included: storage risk, customer service, cost to company, and company policy, shown on the left side of the matrix in table 1. All were hypothesized to have significant impact on the decision outcome and were drawn from previous studies on grain quality and feedback from grain handling professionals (Bern et al., 2003; Hurburgh, 2010).

The decision-making scenario was created using the framework from the decision-making theories of Cognitive Dissidence (Festinger, 1957), Accuracy Efforts (Payne et al., 1993), and Elimination by Aspects (Tversky, 1972). The decision-making task in this work examined how employees would make a decision when they were presented with a conflict to their cognitive "pieces of knowledge." Although employees may know that dumping wet grain into an unmanaged pile is a poor quality practice, they also must consider company policy and their management's directive. Making the choice introduces a clear conflict to the employee in terms of quality, represented in the decision-making scenario as storage risk. The dimensions of company policy, cost to company, and customer service, along with the management's demand to accept all incoming grain, add social context factors to the decision-making task, as outlined by Payne et al. (1993). Given the social context, employees are asked to complete a quality decision-making task. The primary interest of the research was to determine the information employees selected as most important in making their decision choice.

Decision choices were presented in a matrix format as shown in table 1. With each decision simulation, employees read the hypothetical situation and then were presented four decision choices, located on the top of the matrix. Each square of the matrix represents the potential outcome of a given choice on a given dimension and a weighted numerical score representing a numerical evaluation of the decision choice.

Weighted scores less than zero denote a negative evaluation of the decision choice on that specific dimension and scores greater than zero designate a positive evaluation on that particular dimension. There is not necessarily a "best" decision choice among the decision choices. All choices force employees to determine which dimension will have the strongest influence on their decision. For example, a choice which is positive in terms of storage risk may be less positive in terms of customer service or company policy.

Table 1. Decision Mind™ decision simulation matrix.

	Dump the Corn (Choice 1)	Do Not Accept Corn (Choice 2)	Dry Corn First (Choice 3)	Check Moisture Levels (Choice 4)
Storage risk (Dimension1)	Outcome ^{11} (-10)	Outcome ^{12} (+10)	Outcome^{13} (-7)	Outcome ^{14} (+7)
Customer service (Dimension 2)	Outcome^{21} (+8)	Outcome^{22} (-8)	Outcome$_{23}$ (+4)	Outcome^{24} (-3)
Costs to company (Dimension 3)	Outcome^{31} (-6)	Outcome^{32} (+7)	Outcome^{33} (+3)	Outcome^{34} (+5)
Company policy (Dimension 4)	Outcome^{41} (+4)	Outcome^{42} (-7)	Outcome^{43} (-3)	Outcome^{44} (-5)

Matrix squares and the numerical evaluations showing the outcomes of each decision choice were not seen by employees unless they chose to read them. Figure 1 illustrates the decision matrix as employees viewed it. The square in the bottom of the figure displays how selected outcomes were presented to employees in the Decision Mind™ decision-making simulation. In the case shown, the employees choose "Do Not Accept Corn" and selected the "Customer Service" dimension.

The scenario was developed and critiqued by a panel of experts in grain elevator operations using a modified Delphi method (Linstone and Turoff, 2002). The scenario was purposely ambiguous so that employees would not attempt to link the scenario to specific events occurring within their work environment. The scenario was also designed to be straightforward because of the difficulty in quantitatively accounting for all of the detail presented in the scenario. In addition, the employees often make decision choices without having all of the relevant information. The scenario was designed with this assumption in mind.

Decision choices and dimensions were presented in random order in each decision scenario. Using the information contained within the matrix squares, employees viewed the information and then selected a decision choice. Scenarios were pilot tested on a small group with a moderate knowledge of grain elevator operations. Slight modifications were made to improve the clarity of the decision scenarios as a result of the pilot tests. The text of the scenario presented to participants and the decision choice options and dimensions are shown in figure 2.

To provide a way to quantitatively present the information gathering process completed by participants, Keren et al. (2006) introduced the search index metric. The measurement calculates the ratio between the number of times information squares of one dimension have been reviewed as compared with the other dimensions, giving researchers an idea of the employee's focus while making the decision. Index values which equal one indicate the dimension has equal importance to others in the decision process. Values less than or greater than one represent a dimension of less importance as compared with others or

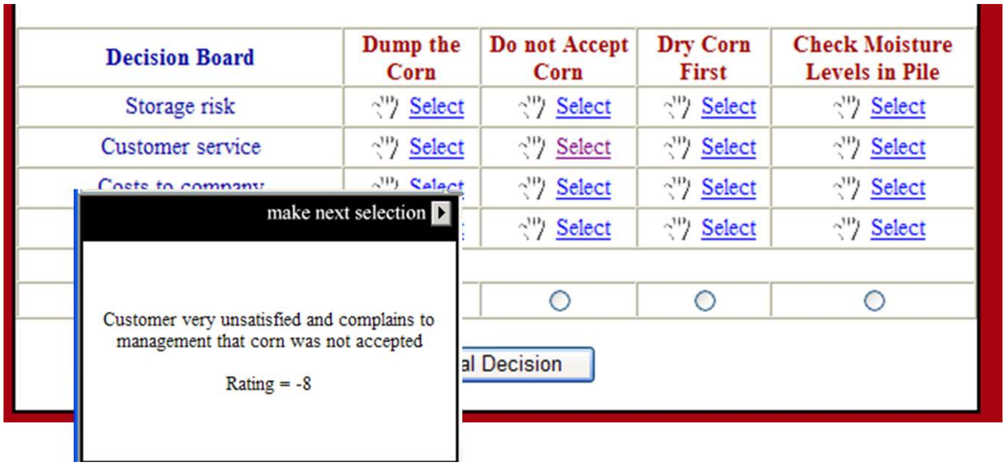

Figure 1. Decision-making matrix as presented to employees.

greater importance in relation to others, respectively.

In this study, four dimensions were used: storage risk, customer service, costs to company, and company policy. The orientation most affiliated with quality in this decision scenario is the storage risk index. Employees who viewed storage risk dimensions were assumed to be considering quality management as a primary source of information in their decision process. The search indices are shown below with the appropriate equation. They include: Storage Risk Search Index (SR_SI), Customer Service Search Index (CS_SI), Cost to Company Search Index (CC_SI), and Company Policy Search Index (CP_SI). Calculations are shown below.

$$S\_SI = N_{storage} / 1/(n-1) \sum N_{i\text{-}storage} \quad (1)$$

where $N_{storage}$ denotes the number of times storage risk squares were viewed, and $N_{i\text{-}storage}$ denotes the number of times squares other than storage risk were viewed.

$$P\_SI = N_{customer} / 1/(n-1) \sum N_{i\text{-}customer} \quad (2)$$

where $N_{customer}$ denotes the number of times customer service squares were viewed, and $N_{i\text{-}customer}$ denotes the number of times squares other than customer service were viewed.

$$SO\_SI = N_{cost} / 1/(n-1) \sum N_{i\text{-}cost} \quad (3)$$

where N_{cost} denotes the number of times cost to company squares were viewed, and $N_{i\text{-}cost}$ denotes the number of times squares other than cost to company were viewed.

$$PP\_SI = N_{policy} / 1/(n-1) \sum N_{i\text{-}policy} \quad (4)$$

where N_{policy} denotes the number of times company policy squares were viewed, and $N_{i\text{-}policy}$ denotes the number of times squares other than company policy were viewed.

RESULTS

Participants in the study were employees of three large Midwestern grain handling facilities. Employees who would be subject to quality-related decisions in their daily jobs were offered the opportunity to participate in the project. Of the 410 invitations extended, 197 responded. Of these 197, 164 provided usable data, for a response rate of 40%. Data was collected over a three month period in 2010. The decision scenario was presented to employees in a Web-based format. The grain handling facilities in the study represent approximately one-third of the state's

Long-term storage of wet corn has been a continuing problem at the grain cooperative where you work. The policy of the cooperative is that no member of the cooperative should be turned away from delivering corn – all loads are received and stored somewhere.

A member of the cooperative pulls in with a load of very wet corn. You are directed to dump the load directly on a large uncovered pile of corn on the ground near the storage bins. You do not know the moisture levels of the corn in the pile.

You must decide on the next step. The following four items are your options.

Dump the corn
Do not accept corn
Dry corn first
Check moisture levels in pile

These four dimensions could impact your decision.

Storage risk
Customer service
Costs to company
Company policy

When you are ready, follow the steps below in order to initiate and complete the simulation.

Figure 2. Text of decision-making scenario.

service area and approximately 20% of the state's grain handling capacity (AgClassroom, 2010).

The sample consisted of 120 males and 34 females and 10 participants choosing not to identify their gender, for a total of 164. The age of participants ranged from below 21 to over 61, but the majority responding were aged 21 to 40 (33%) or 41 to 60 years (56%). Most participants belonged to one of two groups: those with less than three years on the job (38%), and those who had been with the organization more than 10 years (34%). Nearly all (98%) had completed high school, with the majority (62%) completing at least some college.

Results were calculated using Statistical Package for the Social Sciences (SPSS 19.0). Two important components of data are taken from the decision-making scenario: the decision choice and information on the decision-making process. The decision-making process is reflected by the search index values, which represent the information acquired by respondents in one dimension as compared with others. A value of 1 for a particular dimension indicates that no emphasis was given to that dimension above the others and therefore, represents the benchmark. A paired sample t-test was performed on each index to compare its value with 1. Values for the search indices and their respective paired sample t-tests are shown in table 2.

Two search dimensions were significantly higher than the average. Storage risk and company policy were both given significantly more emphasis by decision makers. A third search dimension, cost to company, was given significantly less emphasis by decision makers. No significant difference between the benchmark value of 1 and mean search index value for customer service was observed.

The storage risk dimension represents a higher emphasis toward quality in this decision scenario; therefore, the higher mean value suggests that employees are thinking about quality while making their decision choice. However, the mean for company policy is also significantly greater than one, providing evidence that employees are also thinking about the expectations of their managers and supervisors. The cognitive conflict between the two pieces of knowledge as described in the Cognitive Dissonance Theory (Festinger, 1957) seems to be playing out in the employees' minds during this decision-making process.

Cost to company was the only dimension significantly lower than one. According to the search indices, one area employees are not considering as much when making quality decisions is the cost of poor quality to the company. This was not an unexpected finding, considering many employees' general indifference to their company's financial bottom line, particularly if they do not see a clear connection between company expenses and their work tasks.

Table 2. Information acquisition within a quality decision task as compared with 1.

Search Index	Mean	S.D.	T	P-value
Storage risk	1.19	1.08	2.06	0.041
Customer service	1.03	1.11	0.277	0.782
Company policy	1.32	1.85	2.03	0.043
Cost to Company	0.893	0.543	-2.36	0.020

The second piece of information contained with the decision-making simulation was the distribution of decision choices made by employees, shown in figure 3. Numbers within each bar reflect the number of employees who made that decision choice. Numbers shown at the top of each histogram bar indicate the numerical rating of each decision choice in terms of the dimension of storage risk reflecting the evaluation of the decision choice from a quality preservation perspective.

In the decision scenario, the most quality-oriented choice was to not accept the corn. However, very few respondents chose this alternative. Rather, many chose to follow the orders given by management in dumping the corn. Because dumping corn on an unmanaged pile is fairly typical practice (Bern et al., 2003), it was not unexpected that many employees chose this option.

However, an unanticipated number of employees chose options which were in effect "non-choices." The decision alternatives of checking the moisture content in the dump pile and drying the corn first are considered "non-choices" because they do not require an employee to make a decision about what to do with the wet corn at the scale, which was the focus of the decision-making scenario. Furthermore, it is assumed that employees who receive grain at the scale do not have the authority to dry corn or to delay the receipt of the grain by checking the moisture content of an adjacent grain pile. A second assumption is that employees working at the scale do not have access to the weighted average of the scale tickets of loads already in the pile. In the rush of receiving the grain during harvest season, the employee must make a quick decision to accept or reject the load. Because the decisions to check the moisture content in the pile or dry corn are not feasible options for employees, they were classified as "non-choices."

While drying the corn before storage is normally considered a valid quality management choice, it is not the best quality practice in this scenario. The decision choice posed to employees was a two-step sequential decision. Before employees could make a decision whether to dry the corn or to test the moisture content of the pile, they must accept or reject the load of grain on the scale. The decision-making scenario asked the employee to follow management orders to accept all loads (even those loads out-of-condition) or take action they knew would protect the quality of corn the grain elevator already had in its possession. Therefore, the decision to dry the corn was not a feasible choice for employees to make. Instead, employees were to accept or reject the load. For this reason, when the option to dry the corn was selected, the choice was not considered the best quality choice in the given circumstance.

The large number of "non-choices" made by employees and the high selection of two non-feasible options suggests the phenomenon known as "free ride" in the safety decision-making literature could be occurring in this case. Free ride is when employees fail to correct an obvious safety issue because they figure someone else will take care of it. In this case, the employees are tasked with a quality decision to accept or reject the load. When they fail to make the decision posed to them, this suggests that

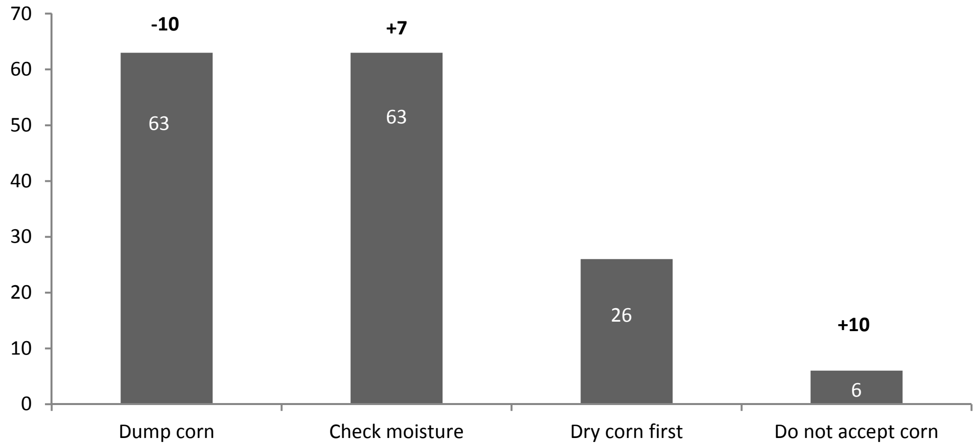

Figure 3. Distribution of frequency of decision choices in a quality decision task.

employees are passing along the inevitable choice of balancing company policy and quality concerns to someone else, either inside or outside of the organization. The tendency of workers to behave in the "free ride" manner was noted with respect to safety by Zohar and Erev (2007), and, given the observations in this case, is worthy of further investigation in the quality domain.

CONCLUSION AND SUMMARY

This work describes the development and measurement of a quality decision-making scenario to be used in a grain quality decision task. Several significant findings emerged from this study.

- A large number of employees chose to follow the orders from management to dump the corn rather than take steps to better preserve and manage the quality of the grain.
- An equally large number of employees selected a "non-choice" by choosing to dry the corn or check the moisture in the pile, effectively passing the choice to someone else.
- Employees gave a significantly higher emphasis to the dimensions of storage risk and company policy when compared with the average emphasis value of 1, suggesting that employees' are conflicted in their decision-making process between preserving the quality of the corn and following company policy and their management's orders.
- Cost to the company was significantly under-emphasized in the quality decision, indicating that employees' are not considering the costs of their quality decision choice to their company.
- The search index of customer service was found to have no significant difference from the average emphasis value of 1, suggesting that customer service did not play a major role in the quality decision process.

Several limitations to the study are acknowledged. The small sample size was cross-sectional and from a limited number of grain handling organizations, limiting the generalization of the findings to other organizations within the grain handling industry. In addition, the data collection procedures were relatively new to the participants, introducing potential measurement error. The study examined one decision-making scenario which was framed as a choice between accepting a high moisture load of corn and not accepting such a load. The scenario examined did not include specific details such as the moisture content of the corn in the pile, the aeration options on the pile, or other specific factors that could influence the decision choice. Other factors such as the perceived competence of the management and the culture of the work environment were explored in other portions of the study and are published elsewhere (Mosher et al., 2012; Mosher et al., 2013).

This was the first attempt at using the process-tracing method to create a decision-making scenario for a decision task in grain quality management. Therefore, the decision-making scenario was designed to be fairly straightforward. However, the investigation raised several questions which could be addressed by future research. High priority needs for future research in this area include:

- development of other quality decision scenarios to reflect other quality tasks in the grain elevator work environment,
- further refinement and testing of the existing decision-making scenario with grain handling professionals in other grain handling facilities and in other parts of the country, and
- expansion of the project to include larger and more diverse grain handling facilities.

The management of out-of-condition grain is an important component of quality management systems in the grain handling system. A quality management program within a grain handling environment cannot be successful if employees are not making positive quality-oriented decisions. As the importance of quality management increases in the grain handling industry, continued research on the quality decision-making processes of employees will play an important role in improving existing methods for managing grain quality and may also increase the likelihood of the successful implementation of new quality management systems within the grain handling environment.

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