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Modelling the costs associated with high-moisture grain for mobile apps

J.S. Dvorak[a,*], J. Shockley[b], R. Mason[a], S. McNeill[a]

[a] Department of Biosystems and Agricultural Engineering, University of Kentucky, Lexington, KY, United States
[b] Department of Agricultural Economics, University of Kentucky, Lexington, KY, United States

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ABSTRACT

The companies that operate grain delivery locations use a variety of methods to discount grain that is delivered with high moisture levels which are often difficult for producers to determine. This project analyzed 24 grain discount schedules representing 34 locations within and near the state of Kentucky with the goal of determining the cost of delivering grain. Discounts represent a large portion of overall cost and were expressed in terms of price, percent or a combination of price and percent. All discount schedules were stepwise functions that were evaluated at the nearest tenth of a percent moisture. The step-wise functions can have constant or variable step widths and constant or variable intervals between steps. For the large number of discount schedules based on constant step widths and intervals, equations can be used to evaluate the expected discount, but the variable functions required the use of lookup tables to record the discount schedule. After establishing a method for recording and equations for evaluating the moisture discounts, these were combined with delivery and transportation cost models to provide a larger model to estimate costs associated with high moisture grain delivery to different locations. Establishing this model enabled the creation of a producer decision support tool. This tool was developed as a smart phone application which enabled automatic determination of location if used in the field during harvest and access to cloud-based mapping tools for evaluation of the transportation network for delivery to various grain delivery locations.

1. Introduction

The delivery of agricultural commodities to centralized locations for collection and/or processing is an important challenge in large scale agricultural production systems. Many researchers have modelled delivery systems for a variety of commodities such as corn stover (Sokhansanj et al., 2010), sugar (Hansen et al., 2002) and cotton (Ravula et al., 2008). The goals of these projects have been likewise varied from siting of processing facilities (Kocoloski et al., 2011) to crop feasibility within a region (Liu et al., 2007). In this project, we focus on identifying the markets with the highest price accounting for travel costs and discounts for delivering high-moisture grain, specifically soybeans, from the perspective of a producer during harvest.

In major corn and soybean producing regions in the United States, producers often harvest grain at a moisture higher than those that would permit long-term storage. Although this means that the grain must be dried or blended before storage, producers start harvesting at high moisture levels rather than waiting until it is dry to reduce the risk of weather damage and for improved machinery management at the enterprise level. Harvest timing and the benefits and costs of starting harvest early are currently an active area of research investigating various implications from the composition of machinery to the effects on grain quality to yield effects on the second crop planted in double-crop systems (e.g. wheat and soybeans) (An and Ouyang, 2016; He et al., 2018; Johnson et al., 2017; Nelson et al., 2011; Põldaru and Roots, 2014). A key question in this area is the price penalties or costs associated with harvesting high-moisture grain. A producer has many delivery options when harvesting high-moisture grain. They could transport the grain to a central storage location on their farm for drying, mixing and long-term storage or they could deliver to an acceptance facility operated by a third-party grain buyer. For most producers, more than one third party market exists.

Agricultural and biological engineers have long studied grain drying methods, efficiencies and costs and produced significant literature on the drying process (Ileleji et al., 2017; Loewer et al., 1994). Grain drying models have been developed (Lawrence et al., 2015; Moses et al., 2015), and various grain drying strategies evaluated (Chelladurai et al., 2015). This research has translated into many Extension publications for designing drying systems (Maier and Bakker-Arkema, 2002) or to help producers understand topics from grain drying system components (Sanford, 2012a,b) to energy efficiency in grain drying (Hellevang and Pederson, 2012). This information does help producers estimate costs associated with drying at their own on-farm facilities, but market pricing at third-party grain buyer locations does not follow the

* Corresponding author at: 128 C.E. Barnhart Building, Lexington, KY 40546-0276, United States.
E-mail address: joe.dvorka@uky.edu (J.S. Dvorak).

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same set of equations. Extension publications that offer advice on marketing grain generally simplify to linear equations (Fanning and McDaniel, 2014; Gessner et al., 2009; Lindquist, 2011; Sadaka et al., 2016). Other Extension publications do present the elevator discounts in table form as they are implemented, but only focus on a single discounting method without considering the variability uncovered in this project (Willcutt, 2015). As we began this project, it became apparent that current approaches to representing high moisture grain were inadequate to describe the state of the market as it actually exists.

Producers typically focus on the market prices when choosing a buyer. However, each grain buyer will post a discount schedule that provides the price reductions associated with various levels of moisture. While all buyers that accept high-moisture grain use discount schedules, there are differences in these discount schedules and how they are applied that make price comparisons between different buyers and locations difficult. In addition to differences in discount schedules, each grain buyer will have a local basis, and transport costs vary by field location and buyer. Currently, marketing decision support tools often only focus on presenting the cash price (adjusted for basis) at multiple elevators in a region for comparison (DTN, 2018; Successful Farming, 2018). More advanced versions also incorporation of simple transportation costs, but they do not include the ability to include tolls or, often more importantly, the effects of discount schedule variations (Growers-Edge, 2018). However, any research effort that considers the harvest of high-moisture grain should consider these complex discount schedules within its model.

The goal of this project was to develop a model that would enable evaluation of the costs and final prices to be received by producers when selling high-moisture grain. Achieving this goal would then allow the development of a producer decision support tool, within a mobile app framework, that would enable the producer to determine the optimum third-party delivery location for high-moisture grain while working in the field. Such a tool must consider field location, offering price, transport costs, moisture level and the moisture discount schedule. To achieve the goal of modelling this complex system within a mobile app, the following objectives had to be met:

- Identify the types of discount schedules used by grain buyers.
- Create a method to encode various discount schedules for evaluation within the model.
- Provide versatility to add future markets and associated discount schedules.
- Incorporate into a total cost model to determine the maximum price received by producers.

2. Methods

An Extension effort associated with this project identified several important aspects of the high-moisture grain delivery system. Producers reported that understanding the discounts from high moisture was one of the most complicated factors in selecting delivery locations of for their grain. While they generally appreciated that certain delivery points were more strict regarding moisture levels, they were often surprised by the variation in local markets when discounts were all represented the same way. In general, producers were aware of the moisture level of the grain as they were harvesting and loading transport trucks. There was more variety in knowledge of transport costs. Producers knew the locations of several nearby delivery points, but they were also interested in evaluating delivery to other locations. Some producers had already determined transportation costs for their enterprise for delivery to a wide variety of locations. Others wanted the ability to calculate costs automatically to each delivery location based on transport times and distances, labor costs, and depreciation costs. Producers indicated that the price offered by each buyer was a vital piece of information, but this varied between producers as each producer often had business agreements with buyers that meant that any publicly posted price would not be accurate for their operation. However, since this was only one piece of information for each location, producers felt that they would be able to easily provide this information to any system built around a high-moisture grain delivery model. Finally, producers had the discount schedules for many buyers, but could not see themselves entering the information on discount schedules into a system themselves. Fortunately, they indicated that the discount schedules were consistent between producers and generally lasted an entire harvest season so once encoded into a model, they would be broadly applicable.

2.1. Types of moisture discount schedules

In previous Extension work, a list of the grain delivery locations in Kentucky has been compiled (Shockley, 2017). The operators of these grain delivery locations were contacted and their high moisture discount schedules were requested. Because of the funding source, this effort was specifically focused on soybean discount schedules. Therefore, the data consist mostly of soybean discount schedules, but during this process discount schedules for corn and soft red winter wheat were also obtained. Some locations on the previously mentioned list did not accept high moisture grain and others did not want to release their discount schedules to non-customers. Certain larger grain companies operated multiple delivery locations, and the same discount schedule was used at several different locations. In the end, we obtained 24 moisture discount schedules (11 soybean, 7 wheat, and 6 corn) representing 34 different delivery locations within the state of Kentucky and surrounding areas.

2.2. Schedule encoding

In this project, two separate encoding methods were utilized. The first was by creating an equation to represent the discounts and recording the coefficients and form of the equation within the model. The second method relied on a look-up table and a variable describing the type of discount table used.

3. Results and discussion

Grain delivery locations provided moisture discounts in a variety of forms. Some provided a reduction in price per grain volume, while others expressed the reduction in terms of a percentage discount per grain volume. These penalties can be provided as a simple equation (e.g. “12¢ per bushel for each ½% or fraction over 13%”) or as a table (Table 1). In all cases, the discount was a stepwise function. All moisture readings are rounded to the nearest tenth of a percentage point before using for calculating moisture discounts. If in table form,

Table 1
Example discount schedule in table form for a percent discount with variable increments between steps.

Moisture level	Discount
13.1–13.5	1.00%
13.6–14.0	2.00%
14.1–14.5	3.00%
14.6–15.0	4.00%
15.1–15.5	5.25%
15.6–16.0	6.50%
16.1–16.5	7.75%
16.6–17.0	9.00%
17.1–17.5	10.50%
17.6–18.0	12.00%
18.1–18.5	13.50%
18.6–19.0	15.00%
19.1–19.5	16.50%
19.6–20.0	18.00%