Teaching and Educational Methods

Using Data Analytics and Decision-Making Tools for Agribusiness Education

Matthew S. Elliott[a] and Lisa M. Elliott[a]
[a]South Dakota State University

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Abstract
The agriculture sector has entered a new era wherein every stage of the supply chain involves gathering an increasing amount of data. Most of these data are generated in real-time and require rapid analysis that can support optimal decision making for agribusinesses to remain competitive. Consequently, employers desire that students gain data analysis skills in agribusiness classes to best inform optimal decision making. This paper discusses how data analytics have been incorporated into an agribusiness management course.

1 Introduction

The agriculture sector is increasingly gathering and analyzing more data. Indeed, every stage along the supply chain is generating an increasing amount of new data in real time from the sensors on planting equipment and combines to imagery from satellites and shelf scanners used by food retailers, to name a few. The gathering of real-time data has also altered the demand for high-speed analysis that can support optimal decision making in agribusinesses. Indeed, analytics plays a key role in successfully utilizing the power of big data, which includes the aggregating and combining data from other sources, and developing advanced models to make predictions that enhance decision making (Sonka 2014). Gillespie and Bampasidou (2018) identified that "there is a large gap between AEAB (agricultural economics and agribusiness) undergraduate and graduate programs in terms of analytics, with some undergraduate programs offering little or no quantitative analytic training" (343). The authors pose a question regarding agricultural economics and business undergraduates, "Is the AEAB profession missing an opportunity to brand its graduates not only in terms of their expertise in the business of agriculture, but also as strong entry-level quantitative analysts?" (Gillespie and Bampasidou 2018, 343). Without contemporary data analytics components in agribusiness courses, agribusiness students may be left with a digital skills gap. Alternatively, without agribusiness content in a data analytics course, students may not know how data analytics can inform optimal decision making in agribusinesses.

1.1 Agricultural Digital Skills Gap and Agriculture Data Analytics

> *As the agricultural industry embraces technological advances, it is demanding a new, highly skilled workforce. Many of the initial jobs are being filled by workers coming from outside the traditional farming industry: Silicon Valley entrepreneurs in software, big data, and hardware; experts in drone and satellite imagery; research scientists from leading universities. However, there is a growing need for more employees with agricultural expertise in addition to technology skills* (Pattani 2016, Opportunities Abound For High-Skilled Workers section, para. 1).

An opportunity exists to combine agribusiness education and data analytics skills for agribusiness students to serve as "links" between new agricultural data technologies and agribusiness management.

By exposing students to more concepts of data analytics in an agribusiness course, students can be better able to connect with potential employers and be able to provide a clearer vision of ways to apply the latest data analytic methods in agribusiness firms to promote optimal decision making, efficiency, and competitiveness.

Agribusiness faculties, however, are currently presented with the challenge of how to best expose students to greater data analytics topics in a way that supports their success. Traditional agribusiness courses are already content rich, and data analytics is a broad topic that is often taught through separate courses. Moreover, data analytics methods and software programs change as a result of technological advances that are as yet unknown.

We responded to the challenge by encouraging students to "learn to learn" because we believe that they will need to continue their education and remain informed of changes in data analytics throughout their careers to be successful. The learn to learn philosophy means that our course objectives are not to render students fully competent in the use of each data analytic method that we cover. Rather, we want them to gain exposure to different methods, develop an appreciation for the relevancy of data analytics in agribusiness decisions, and gain a basic understanding of data analytic methods for continued learning. The broad exposure to different data analytic methods in an undergraduate advanced agribusiness course can serve three purposes: (1) the data analytics skills the students are exposed to can be further perfected in an agribusiness capstone course where the student focuses on an agribusiness case they are interested in, where they use a single method more thoroughly, (2) exposure to data analytic methods may influence some students to decide to pursue graduate degrees, and (3) the broader knowledge of data analytics methods can be further perfected in training programs at an agribusiness firm they work for. Indeed, many firms are providing more in-depth in-firm training in data analytics and are partnering with universities to provide advanced data analytic education for their employees (McKinsey and Company 2017).

Continuing education in data analytics also corresponds well with land-grant universities' missions for extension. The continuing education of data analytics methods provides an immense opportunity for land-grant universities to provide relevant agribusiness education not only to students, but to existing extension audiences and to a growing number of nontraditional clients. The primary purpose in this paper is to provide a discussion on how we incorporated data analytics into an agribusiness management course with the ability to use similar techniques and problems developed here for extension education and agribusiness industry clients.

2 Incorporating Data Analytics into an Agribusiness Course

The first step in developing an undergraduate data analytics curriculum involves finding a data analytics textbook or data analytics resource that could be coupled with traditional agribusiness course content. We identified a textbook, entitled *Business Analytics: Data Analysis & Decision Making* (Albright and Winston 2014), that outlined many of the data analytics concepts we were seeking to teach in the course. As an added bonus of utilizing this textbook, the students were given a free 2-year academic license to use the Palisade Software Suite,1 which includes a number of Excel-based decision tools, including @RISK, PrecisionTree, TopRank, BigPicture, StatTools, NeuralTools, and Evolver. The agribusiness course was a 3-credit course held three days a week. The third class of each week was set aside to focus exclusively on data analytics. Our goal was to connect data analytics concepts to a traditional agribusiness topic covered in that week. Data analytics and agribusiness content were paired, as illustrated in Table 1.

For the data analytics lectures, outlines and exercises provided by the textbook were utilized with slight changes made for applications to agribusiness problems. To connect the data analytics assignments to real agribusiness management cases, agricultural data was collected and connected to past

[1] The Palisade Software Suite's tools can be viewed in detail at the Palisade's website at https://www.palisade.com/products.asp.

agribusiness decisions or to potential problems that could be analyzed in an agribusiness setting. Each assignment was developed like a separate case study. In connecting each assignment to real agribusiness decision-making scenarios using real data, students developed an appreciation of the relevance of the data analytic methods covered. The data collected for each assignment mostly included information from annual reports obtained from the Securities and Exchange Commission (SEC), datasets from Kaggle.com, and data and information from Bloomberg terminals. Table 2 shows the specific data analytic assignments given to the students throughout the semester. Each of these assignments have been made available as Excel workbooks, where the analysis is partly set up to use with the corresponding Palisade Decision Tool. In addition, in association with this article are teaching notes online.[2] The teaching notes covers the background of the case, assignment questions that could be asked, and the authors' answers to the questions asked.

The data analytics content was delivered through a live webinar. The webinar also served as a means to provide a hands-on data lab experience to a traditional lecture class of 90 students. The webinar was recorded and allowed students the freedom to follow along at their own pace. The students could pause or rewatch parts that they may have failed to grasp because they were unfamiliar with the software or data analytics concepts. As an added benefit, the recorded webinars could be further used to develop a short course on data analytics that could be made available as continuing education material for agribusiness firms.

The data assignments allowed students to work in groups of five or less to develop a PowerPoint presentation with text and visuals using data analytics to answer the questions asked. After each assignment was graded, a representative from the group with the top score presented the group's PowerPoint presentation to the class so that the students could see the quality of work done by their peers and to create an opportunity for the students to present and discuss their findings and recommendations using the data analytics concepts they learned.

Table 1. Agribusiness Content Connected to Data Analytics Concepts for an Agribusiness Management Course

Agribusiness Content	Data Analytics Concept
Decision Rights	Decision Making Under Uncertainty
Pricing with Market Power	Time Series Analysis and Forecasting
Economics of Strategy	Optimization and Simulation
Divisional Performance Evaluation	Portfolio Risk Analysis
Understanding the Business Environment	Neural Network Analysis

[2] The data analytics assignments and teaching notes are available by request through the AETR website at https://www.aaea.org/publications/applied-economics-teaching-resources.

Table 2. Agribusiness Management Data Analytics Assignments: Problem Types, Data Analytics Methods, Software Programs, and General Case Study Questions

Problem Type	Data Analytics Method	Software	Case Study Question
Decision-Making Problem	Decision Analysis	Precision Tree	Should CHS develop a fertilizer plant in Spiritwood, North Dakota? Does being a cooperative change the decision?
Forecasting Problem	Forecasting	StatTools	Do markdown events affect meat demand at Walmart Super Centers? What federal/state food policies appear to affect meat demand most?
Optimization Problem	Linear Optimization	Risk Optimizer	What dairy ration ingredient mix has the lowest cost given changes to the price of commodities? How can the risk be mitigated through contracts?
Portfolio Risk Analysis	Simulation	@Risk	Should Green Plain Inc. expand its feedlot investments to complement its ethanol facilities? Is diversification to reduce risk a viable strategy for a public corporation?
Machine Learning Problem	Neural Network	NeuralTools	Are there advantages in using machine learning to detect borrower default? How do changes in the broader economy affect the default rate?

2.1 Overview of Data Analytics Assignments

Data Assignment #1: In data assignment 1, the students had to perform a decision (tree) analysis using the Precision Tree software. The analysis explored the feasibility of building a nitrogen plant given base case assumptions on exploratory costs, fixed costs of the plant, the plant life in years without reinvestment, a discount rate, expected nitrogen product margins (with associated probabilities of occurrence), plant utilization, and the subjective probability of the CEO to whether the plant would be found to be technologically feasible. The students were asked whether they would recommend to the CEO to further pursue development of the plant to determine if the plant could be built with the estimated amount of fixed costs and obtain the expected product margins. Most of the values used in the analysis were based off of a farmer-owned cooperative, CHS Inc. (formally known as Cenex Harvest States), decision to explore building a nitrogen manufacturing plant in Spiritwood, North Dakota, and were found in their annual and quarterly SEC reports. Figure 1 shows the expected monetary value of the decision to pursue building the nitrogen plant given the uncertainty of the product market and whether the plant would be found to be feasible using the base case assumptions from the decision analysis. The initial branch of the tree indicates the expected monetary value of choosing to explore the feasibility of the plant was greater ($169,723 greater than $0) than not choosing to explore the plant given the assumed probabilities, costs, and payoffs. Using expected monetary value alone, the students would recommend to the CEO to explore the feasibility of the plant. However, students were asked to perform a number of analyses to determine the sensitivity of the decision to the assumptions used and were asked to reevaluate the decision. Further discussion was connected to decision rights (control and residual rights) in agribusinesses. Specifically, should being organized as a cooperative versus a corporation require an alternative design of the decision analysis?

Data Assignment #2: In data assignment 2, the students explored the factors that influence fresh and frozen meat department weekly sales at Walmart Supercenter stores. The students performed a multiple regression analysis using the StatsTools software to make out-of-sample forecasts of weekly fresh and frozen meat department sales in 2012 (see figure 2). The data used was gathered from a data analytics competition on Kaggle.com that Walmart sponsored to recruit data analytics employees. The students evaluated the same question asked in the Kaggle.com competition—do holiday markdown events affect demand in the stores? The students were also asked to evaluate the model specification given to them, and determine what variables may be missing to better understand the effect of markdown events on weekly meat sales. This data assignment was connected to the agribusiness topic of using market power and discriminatory pricing strategies to affect demand and maximize profit. Further discussion was focused on how to measure spatial market power in the model. Specifically, how could the level of competition be measured at each supercenter store to understand consumer responsiveness to markdown events?

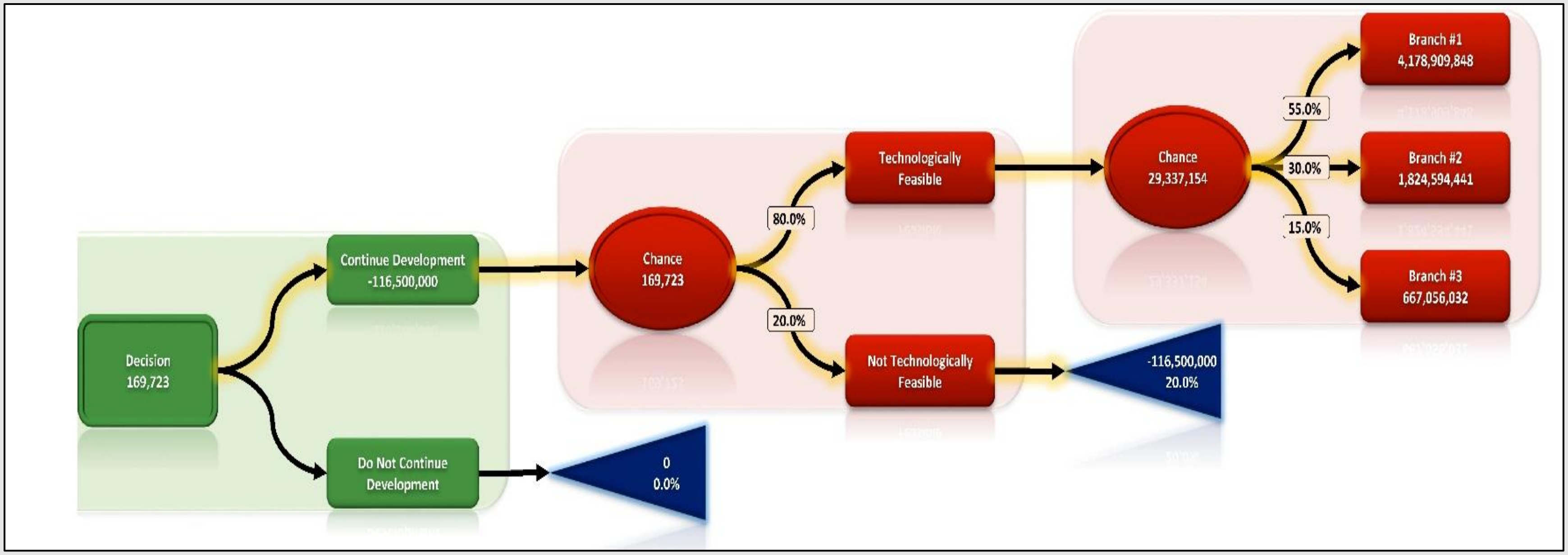

Figure 1. Decision Analysis of Building a Nitrogen Plant

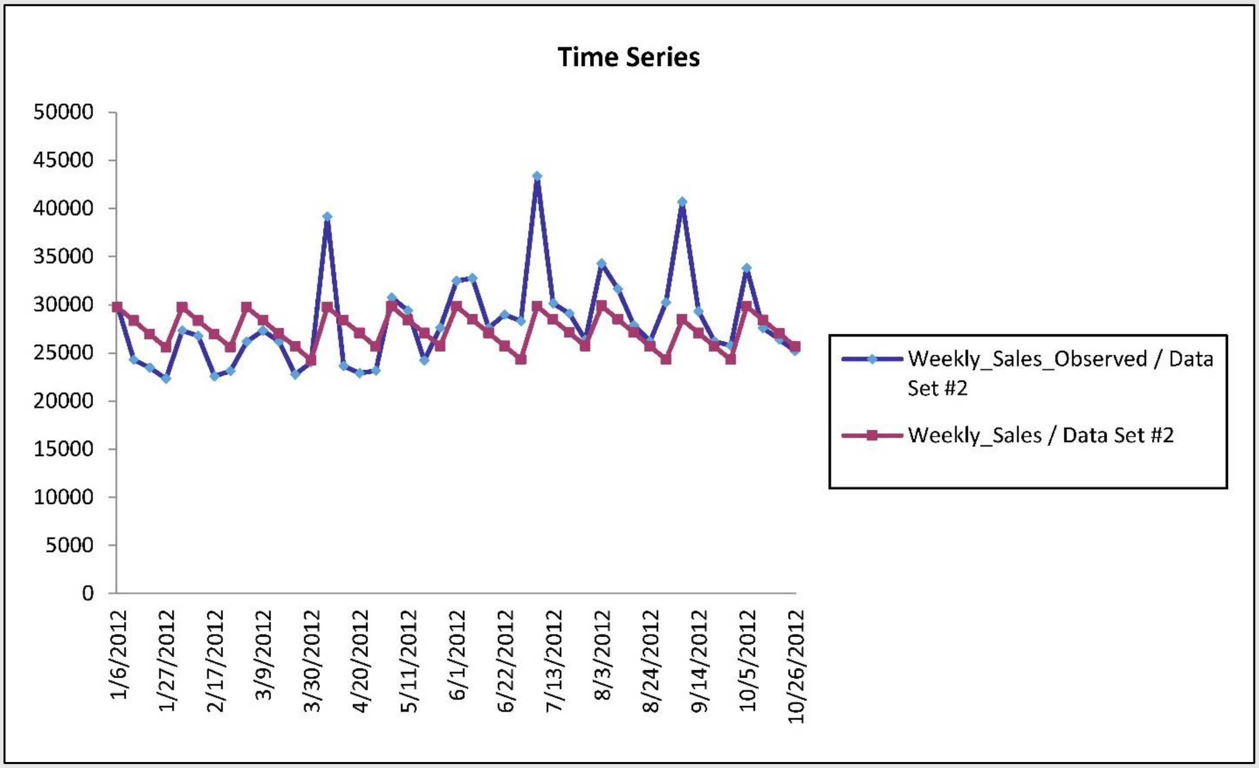

Figure 2. Forecast of Walmart Fresh and Frozen Meat Department Weekly Sales at a Supercenter Store

Data Assignment #3: In data assignment 3, students had to determine the lowest cost dairy feed ration a feed mill should acquire, mill, and blend, given assumptions on the feed nutritional composition, commodity availability, commodity prices, and milling capacity. To find the lowest cost ration mix, students performed linear optimization and simulation using Excel's data solver and the @Risk software and risk optimization tool. The students then simulated the change to the lowest cost ration if the prices of the ingredients changed. The students also examined the risk to the feed mill's income over the ingredient cost, given the uncertain nature of the price of the ingredients and the inability of the feed mill to change their feed price with the same frequency that ingredient prices change (see figure 3). The students were asked to explain what strategies (e.g., contracts and hedging) are available to the feed mill to mitigate the risk to net income.

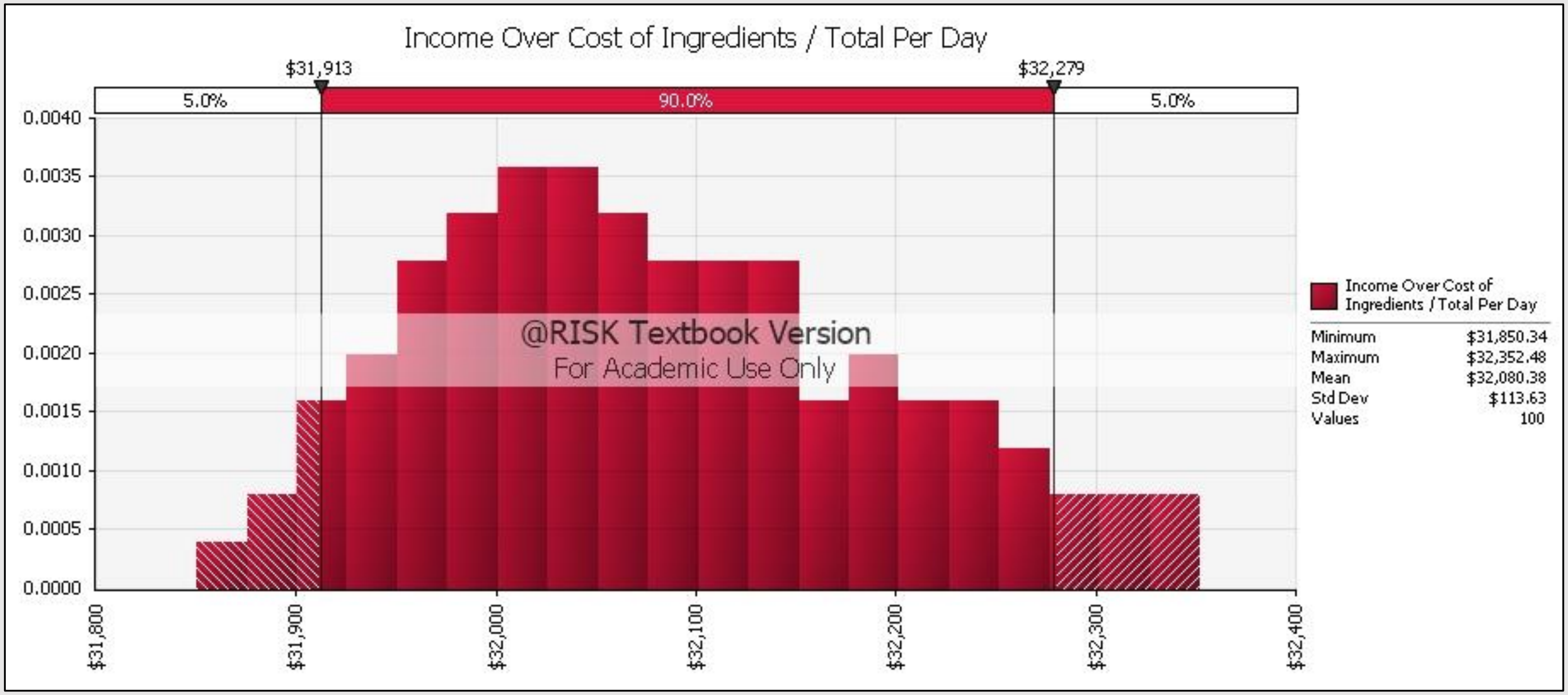

Figure 3. Risk Simulation Results for a Feed Mill's Income over Ingredients Cost for a Dairy Ration Using @RISK

Data Assignment #4: In data assignment 4, the students examined an agribusiness firm mainly focused on producing ethanol, but also had a separate division engaged in feeding cattle. The students allowed prices of outputs and inputs in the firm to be unknown and simulated the effects to net income for the firm. The students learned how to model more accurately multiple input and output prices using a correlation matrix. The price distributions and correlations of unknown inputs were based off historical price data gathered from the Bloomberg terminal to more accurately reflect the risk to the firm. The students then explored the changes to risk and return if the firm decided to expand the cattle feeding operation to complement the existing ethanol facility investment (see figure 4). The case this assignment was based on was Green Plains Inc.'s recent expansion of their cattle feeding operations to complement the multiple ethanol facilities they own. The students were further asked if investment in a separate business segment for the sole purpose of risk reduction is a viable strategy for a public corporation.

Data Assignment #5: In data assignment 5, the students examined a machine learning model (neural networks) compared with a logistic regression to identify the credit risk of customers seeking loans. The assignment was based on the types of credit risk determinations that are common in a multitude of agribusinesses involved in lending or providing credit to their customers. The students were asked to compare the performance of identifying borrower default using the machine learning technique versus logistic regression. Also, students were asked to determine the relative variable importance of credit indicators to default risk. For example, students found that the number of accounts past due over 120 days was the most important variable found by the neural net, followed by the total number of credit accounts opened and number of financial inquiries on the customer's credit report (see figure 5). The data used was gathered from Kaggle.com and was provided by Lending Club, based on their customer loan data during the 2007–2015 period. Further discussion was focused on how borrower defaults rates and demand for loans increased after 2008 as a result of the financial crisis.

Name	Cell	Sim#	Graph	Min	Mean	Max
Net Income	B30	1	-0.80b … 1.00b	-$660,901,400	$143,060,300	$933,830,100
Net Income	B30	2	-0.80b … 1.00b	-$625,872,900	$173,048,400	$973,987,900
Net Income	B30	3	-0.60b … 1.20b	-$590,844,500	$203,036,600	$1,014,146,000
Net Income	B30	4	-0.60b … 1.20b	-$555,816,100	$233,024,800	$1,054,303,000

Figure 4. Net Income Risk Analysis for a Firm with Ethanol Production and Cattle Feedlot Production (Each risk analyis explores an increasing capacity of cattle feeding to complement ethanol production of the firm.)

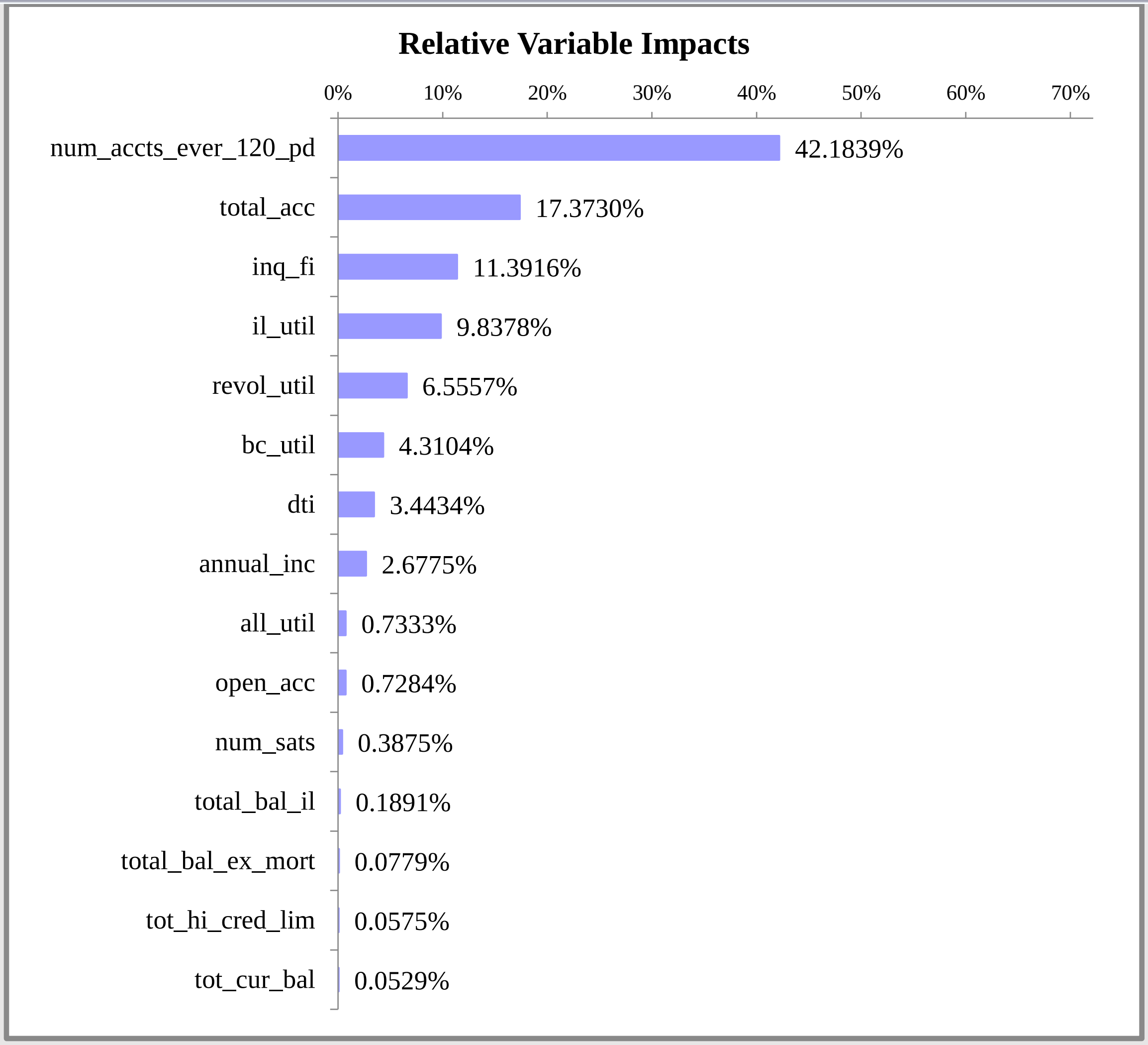

Figure 5. Relative Variable Impacts to Loan Default Risk Using a Neural Network

2.2 Data Analytics Case Study

The groups completed a final project for which they were given the opportunity to select an agribusiness problem on their own to examine using one of the data analytics concepts used in the course. The grading rubric used for the final project is shown in table 3. The groups largely chose to do a decision analysis or measure risk of returns. The agribusinesses students chose to focus on problems ranging from the decision to expand a family farm to should large multinational agribusinesses such as Cargill, ADM, Bunge, Dupont, and so on expand to improve performance. Many students utilized the Bloomberg terminals financial analysis data on companies' net income and growth rates compared with companies in the same business segment but operate at different scales.

Table 3. Case Assignment Grading Rubric

Grading Category	Elements Necessary for Full Credit
Describe the agribusiness's current business environment.	Provide a brief but comprehensive discussion of how changes to technology can affect the current business environment the agribusiness operates in. Also, provide an accurate description of the competitors, customers, and suppliers. Identify important laws and regulations that can influence firm value for the agribusiness.
Describe the agribusiness's current strategy.	Describe the industries the current agribusiness is engaged. Define the level of competition the firm experiences. Describe whether the agribusiness firm competes for price, quality, or service. Describe if the firm has market power.
Describe the agribusiness's current organizational architecture.	Describe the units, divisions, or hierarchy of the firm. Describe decision rights of the owner(s) and parties that transact with the firm (employees, suppliers, lenders, shareholders, etc.). Discuss any known incentive payment schemes and reward systems. Discuss any known performance evaluation systems.
Describe a potential change to the business environment that would necessitate a change to the organizational architecture.	Describe changes to the business environment, strategy, or organizational architecture that can affect firm value.
Describe a change to strategy or organizational architecture that would adapt to the new business environment.	Describe actions the agribusiness could do to adapt to the change in their business environment to protect firm value.
Develop a data analysis that can inform on the agribusiness's current or future firm value.	Perform a data analysis that informs on potential changes to firm value that you previously discussed.
Interpret the data analysis performed.	Interpret the analysis accurately.
Make a recommendation to the agribusiness firm given that your data analysis could improve firm value.	Make recommendations that fit the analysis findings.

3 Discussion and Concluding Remarks

A few insights arose from the develop of the methods, materials, and assignments for the agribusiness management course.

1. *Mac users beware—Palisade Software Suite is not Mac friendly*. As an alternative for students with Mac computers, students were made aware of computer labs on campus labs where the Palisade Software Suite was installed, which they could use to work on their assignments.
2. *Having good teaching assistants is critical*. Students will have many functional questions about the assignments and software, even with the recorded webinars and textbook. Having teaching assistants (TAs) watch the recorded data analytics webinar and work through the assignment problems beforehand to ensure that they understand the assignment is important. Our TAs also provided feedback on areas that had not been effectively covered. A large majority of the students sought help from the TAs outside of class during the TAs' office hours.
3. *Combining traditional agribusiness concepts with data analytics creates a considerable amount of content.* There was much material to cover, and full competency was not our goal. Rather, we wanted the students to gain hands-on experience to examine agribusiness issues using data analytics that could create a basis from which to connect with potential employers. The broad knowledge of data analytic concepts would allow them to demonstrate they are familiar with data analytics. We set a course goal for the students to develop a "learn to learn" approach for them to become fully competent with contemporary data analytic methods and to examine real-world agribusiness issues.
4. *Students need to have a good understanding of statistics, preferably a basic econometric class, and proficiency using Excel*. The students that had a good understanding of statistics and had studied econometric models previously were able to complete the assignments and understand the results. However, a portion of the students were deficient in basic statistics and were not proficient using Excel to achieve the assignment objectives. Changes to the agribusiness curriculum may be necessary to achieve a minimum level of competency of data analytics for a broader group of students.

This agribusiness content could be extended to extension audiences through various means of dissemination. The student webinar recordings could be packaged together with supplementary materials and offered as a self-paced course for an agribusiness audience to learn to develop their own firm-specific analyses. Further, the materials could provide a base to offer to an agribusiness firm a short course to improve the data analytic skills of their employees. The material could also serve as a base to develop a webinar and/or workshop series focused on agribusiness data analytics for extension clients. Some extension clients may not have the time to learn data analytic skills or how to use the above decision tools, but could gain from a more generic risk analysis done by an extension specialist. For example, the optimized feed rations done in data assignment 3 could be disseminated in webinars, workshops, or extension publications to regional dairy farmers and updated with the latest prices and distributions for ingredients.

About the Author: Matthew S. Elliott is an Assistant Professor in the Ness School of Management and Economics at South Dakota State University (corresponding author email: matthew.eliott@sdstate.edu). Lisa M. Elliott is an Assistant Professor in the Ness School of Management and Economics at South Dakota State University.

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