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The aim of AETR is to provide an outlet for research, teaching, and Extension education scholarship encompassing but not limited to research articles, case studies, classroom games, commentaries, experiential learning, and pedagogy. The goal is advancing and supporting teaching and Extension education within applied and agricultural economics, and agribusiness. The scope of the journal extends to teaching and educational contributions and materials for undergraduate and graduate education, as well as Extension and adult education.

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3. Case Studies in all areas of applied and agricultural economics, and agribusiness
4. Teaching and education commentaries (e.g. notes on pedagogy, evaluations of teaching effectiveness, evaluation and review of applied economics textbooks, and educational methodology).

Research Article

Following Along or Falling Behind? An Analysis of Internet Access During Lab-Based University Classes

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JEL Codes: A2
Keywords: Computer labs, distraction, undergraduate teaching

Abstract
Most undergraduate programs in agribusiness and applied economics include courses on data analysis, spreadsheet modeling, and other topics that are inherently computer-based. It is typical in these courses for students to have access to computers either during lecture or in lab sessions. In fact, students in some agribusiness and applied economics programs may spend a majority of their total in-class time with access to their own laptop or a desktop computer in a university lab. In this context it becomes crucially important for educators to understand how students consume and interact with course materials, including spoken lectures, while they simultaneously engage with technology. Previous research on the use of computers in the classroom show that there exists the potential for technology access to help students follow along and strengthen their understanding of course concepts during a lecture, but also that there is a risk that students are distracted by the available technology and end up falling behind. This study analyzes the effect of restricted internet access during lab-based class meetings on student learning outcomes, and provides guidance on instructor policies around technology use in the classroom.

1 Introduction

University instructors that teach in computer labs with fixed computers for student use are often unsure how to manage student computer access. The tradeoffs center around a desire to maximize student engagement with the instructor and material being presented, while avoiding restrictions that reduce student ability to follow along, take digital notes, and practice with their own machines. The instructor's computer management decision in a classroom with fixed computers is different than the issue faced regarding laptops in a typical lecture hall, as even students that do not typically use laptops to take notes have a potentially distracting screen at their desk. Some instructors choose to restrict all computer access, shutting down lab computers during lecture portions of the class, and prohibiting the use of student laptops and cell phones to prevent students from texting, emailing, web surfing, or conducting any noncourse-related activities. Other instructors take a more hands-off approach and do not limit technology access in anyway. Despite a robust literature on the use of laptops during lecture-based classes, and their impact on student performance, it is not clear which instructional approach results in the better student learning outcomes in computer lab settings with fixed student computers.

Several previous studies have explored the relationships between internet access (and computer access more broadly), distractedness, and educational outcomes. Downs et al. (2015) found, in a controlled experimental setting, that when distracted by social media sites, students performed worse on a multiple-choice exam. Similarly, Sana, Weston, and Cepeda (2013) found that multitasking on personal laptops during lectures resulted in lower test scores for the multitasking individuals, but also for those students that were sitting nearby the multitasking peers. However, not all research in this area has found internet access to be detrimental to student learning outcomes. Elliott-Dorans (2018) randomly assigned students to different sections of a large lecture course, and implemented a laptop ban in half of the sections and allowed unrestricted computer use in the other half. The author found no difference in student grade outcomes and no difference in student satisfaction as expressed on course evaluations. Despite these mixed findings, it remains unclear under which conditions the potentially detrimental distraction effects could outweigh the potentially productive uses of student computers.

In contrast to other studies that have focused on personal laptop use in the classroom or lecture hall, the present study explores whether restriction of student access to fixed lab computers during lectures improves or detracts from student learning outcomes. Using the lab management software on the instructor computer, we carry out an experiment over multiple course terms in which some course sections are granted unrestricted access to internet browsing, while others are only permitted to access relevant software and the course website. We collect student performance data, in the form of exam scores and overall course grades, in six course sections of an introductory agricultural finance course and estimate the relationship between this experimental treatment and course outcomes. We also discuss the impact of restricted web access on student comments and course ratings in end-of-term course evaluations.

This paper adds to this literature by exploring whether and how student internet access impacts student performance and satisfaction in an agricultural finance course that meets in a computer lab. Previous studies have focused primarily on the use of student-owned laptops during lecture-based courses, but it is not clear that these findings generalize to internet access in a computer lab with computer management software. As a greater number of courses in agribusiness curricula incorporate data literacy and hands-on practice during class meetings, it might be the case that more flexible policies around computer use are more helpful than harmful for student learning outcomes. This study contributes an additional point of reference that may be more useful for instructors that teach in computer labs, and more relevant for courses in which computer use is a normal and necessary component.

2 Background

Over the past twenty years, as the use of computers in university classrooms has gone from exceptional to typical, there have been many studies that have explored the ways in which computers have altered the classroom learning ecosystem. The major focus of this work has been on the ways in which access to computers has impacted student performance and how students perceive the use of technology for learning and its impact on the learning environment.

2.1 Student Performance

Since laptop computers were first introduced to university classrooms, instructors have been concerned with whether these tools were helping or hindering student learning. In a relatively early study, Hembrooke and Gay (2003) found that the retention of material presented decreased when students were able to keep laptops open during a lecture, and that this result did not depend on the way in which the student used the computer (i.e., productive vs. distractive use). Furthermore, Kraushaar and Novak (2006) examined laptop use in a lecture-style classroom with spyware installed on student computers and found a negative relationship between distractive use of the computers and academic performance. A more recent study by Zhang (2015) also showed that the use of laptop during lecture time negatively impacted student course grades.

Not all studies have found that computer access has detrimental effects on student performance in classrooms. Wurst, Smarkola, and Gaffney (2008) found that business school cohorts with access to laptops did not perform any differently (in terms of GPA) than the cohorts that were not provided laptops. In a study of the efficacy of laptop bans in an introductory politics lecture, Elliott-Dorans (2018) found that performance on both exams and writing assignments was worse than when laptop use was permitted.

2.2 Students' Perceptions and Impact on Learning Environment

Studies have come to different conclusions about the ways in which students themselves feel about access to computers in the classroom. Several authors have found that students are keenly aware that their access to technology is a distraction that is not always productive. Fried (2008) showed, in a study in which student views on classroom environment were elicited, that both one's own computer use and the computer use of nearby students were seen as detriments to a student's ability to learn the material. Vahedi, Zannella, and Want (2019) found that although a majority of students acknowledged that their own use of technology distracted them from the course material, and nearly half of students reported that use of technology by nearby students was distracting, a large majority of students were against any restriction of computer use in the classroom.

Studies that include analysis of course evaluations have not found that computer access policies have much effect on end-of-term course evaluations or other modes of assessing student satisfaction. In addition to their analysis of academic performance, Wurst et al. (2008) discovered that students that were given laptops for use in their undergraduate business program found them useful and productive tools for communication, but did not rank their overall education experience higher than those that did not have access to laptops. Similarly, Elliott-Dorans (2018) concluded that while students may prefer to have access to laptops during lecture, they did not rate courses or instructors lower on course evaluations when they were prohibited from using them.

While making decisions about technology use in the classroom, instructors are often left to speculate on the applicability of past studies to their specific teaching assignment and student cohorts. For example, there may be different considerations in an agribusiness or business program than in lectures focused on liberal arts or humanities, as much of the material in modern agribusiness curriculum is engaged with electronically. These are often practical rather than theoretical courses, and the balance between productive and distractive use may not be consistent with previous studies on laptops in different subject areas. That is, in reviewing existing literature on computer use in university classrooms, we should keep in mind that the interaction between the mode of instruction and the course topic may fundamentally alter the dynamics around technology use.

3 Methods

Over the course of three academic quarters, data on student performance were collected in a total of six sections of an introductory agricultural finance class. The course was taught in a computer lab with either 28 or 40 student computers. In each 10-week quarter, two sections were taught by the same instructor, with identical materials, lectures, and in-class activities. Students in one section each quarter had open access to all websites on the lab computers, while the students in the treatment section were restricted from visiting websites other than the university's website and course management (i.e., Moodle) page. Background information on the students in all course sections was gathered through their university profile, including GPA prior to enrollment in the course, academic progress (i.e., number of course units completed), chosen major, and the level of prerequisite accounting course that had been completed. Descriptive statistics of student information is included in table 1.

Table 1 shows that a total of 76 students were enrolled in the treatment sections and 110 in the control sections. The Fall 2018 and Fall 2019 groups had a lower percentage of female students, higher degree progress percentages, and lower average GPAs than the Winter 2019 group. This can be attributed to the fact that the Winter 2019 sections are restricted mostly to students majoring in agribusiness and tend to take the course earlier in their undergraduate careers so that they can proceed to more advanced finance and management courses. The fall sections are made up of students primarily in other majors within the College of Agriculture, Food, and Environmental Sciences. These students do not typically concentrate in finance or advance to more complex business management courses.

Table 1. Descriptive Statistics for Students in Treatment (i.e., Restricted Web Access) and Control (i.e., Unrestricted Web Access) Groups

Characteristic	Fall 2018		Winter 2019		Fall 2019	
	Treatment	Control	Treatment	Control	Treatment	Control
Number of students	27	40	21	35	28	35
Gender (female = 1)	0.48	0.40	0.62	0.51	0.32	0.49
Degree progress (%)	64%	65%	55%	52%	68%	81%
GPA prior to course	2.60	2.86	3.07	3.04	2.82	2.89
Exam avg. (max = 1)	0.80	0.80	0.89	0.87	0.77	0.80
Final grade (max = 1)	0.79	0.84	0.72	0.73	0.82	0.84

3.1 Controlling Internet Access

The course in question covers finance principles including analysis of financial statements, time value of money, the relationships between risk, return, and diversification, and capital budgeting techniques. In typical class meetings, new content is presented in a lecture format, with examples or calculations projected by the instructor from their computer or demonstrated on the white board. The second half of the class meeting is typically devoted to an in-class activity in which the students use their computers to practice the new concepts and techniques, usually using Microsoft Excel. The distinction between the internet-restricted treatment group and the control group is primarily in the lecture portion of the class meeting. CrossTec SchoolVue computer lab management software, which can remotely control the lab computers, is used to restrict browser access to approved websites for the treatment group.

3.2 Performance Metrics and Model

The goal of this study is to analyze the relationship between students' internet access and their learning outcomes and satisfaction with the course. We measure learning outcomes using the average exam score and final course grade. We estimate the impact of the no-internet treatment using a simple linear regression model (OLS), in which performance is a function of the student's assignment to treatment or control, along with the students' previous success (i.e., GPA), degree progress, grade in accounting (pre-requisite course), and binary variables for course instructor.

We estimate the OLS models using two different measures of student learning outcomes. First, we use the total course grade, as a percentage of the total number of points possible. We also estimate the same models with the performance metric as the average of two exam scores, where the score is the percentage of total points possible on each exam. This measure ignores any homework or other grades in the course. We estimate models with both measures of performance because it might be the case that the exams are a more accurate reflection of learning than total course grades, or that restricted web access has an impact on retention but not on ability to complete homework assignments in an untimed setting.

A linear model risks generating biased coefficient estimates if the data set is censored. Data censoring could happen in the context of student performance, using either overall course grades or exam score averages as a dependent variable, if the true performance of students at either the top or bottom of the distribution is obscured by the limits of the grading scale. For example, if there is a cluster of students that all achieve perfect scores on their exams, the grade data do not reflect how well the best of these students would have scored if the exams were more difficult or there were more points possible. In this study, data censoring is not a concern because there were no students that achieved perfect exam scores or perfect overall course averages.

3.3 Student Satisfaction

In addition to student performance on course assessments, we compare the outcomes of voluntary course evaluations for treatment and control sections of this course to assess whether or not the restriction of internet access to lab computers was considered offensive or annoying by students in the class. This is often a key faculty concern with more restrictive computer management strategies, particularly among untenured and adjunct faculty. With only 6 course sections (3 treatments and 3 controls), we do not attempt to identify statistical relationships between experimental treatment and evaluation outcomes. Instead, we compare scores informally and search for written comments that address the computer restrictions in either a positive or negative light.

4 Results

Our regression results for the four estimated models are presented in table 2. The variable of interest, which takes the value of 1 if students had unrestricted access to the internet on lab computers, is not found to have a significant effect on student performance in any model. Unsurprisingly, a student's prior success, in terms of GPA before enrolling in the course in question, has a strong and statistically significant impact on exam and final course grades. Two independent variables indicating the strength of a student's accounting preparation and the percentage of their course program that had been completed at the start of the course are not found to impact the performance metrics. These variables are removed from models 2 and 4. The course instructor also appears to have a strong impact on student scores, likely because of differences in grading habits. Comparing models 1 and 2 to models 3 and 4 suggests that one instructor tends to award lower course grades and higher exam grades than the other instructor. It should be noted that it is not clear whether either of these performance metrics more accurately measures student learning of the finance concepts presented in the course.

Although it appears that granting full student access to the internet during class lectures has no net-effect on exam or overall course scores, it might still be the case that the policy of restricting internet access reduces student satisfaction in the course or instructor. Although student satisfaction is not necessarily reflective of learning, it can be an important consideration, particularly for untenured faculty

Table 2. Estimates from the OLS Models of Student Performance Measures

	Final Course Score				Exam Average (%)			
Independent Variables	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
Web access	0.012		0.012		-0.011		-0.009	
	(0.96)		(0.97)		(-0.91)		(-0.73)	
GPA	0.113	***	0.112	***	0.096	***	0.099	***
	(7.12)		(7.26)		(7.40)		(7.99)	
Gender (female = 1)	-0.027	*	-0.028	*	-0.036	**	-0.034	**
	(-2.17)		(-2.22)		(-3.13)		(-2.93)	
Financial accounting	0.003				0.016			
	(0.24)				(0.94)			
Degree progress percent	-0.021				0.015			
	(-0.54)				(0.36)			
Instructor binary	-0.128	***	-0.124	***	0.061	***	0.064	***
	(-8.08)		(-8.39)		(4.08)		(5.51)	
Constant	0.524	***	0.516	***	0.527	***	0.535	***
	(11.2)		(11.9)		(13.8)		(15.5)	
N	184		184		184		184	
Adjusted R-squared	0.411		0.416		0.324		0.326	

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; t statistics are in parentheses; p values were calculated using the heteroskedasticity-robust standard errors.

that are often assessed based on student course evaluations. An analysis of course evaluations for these six course sections shows that there is no evidence that students are bothered by restrictions to their computer usage during lectures. No students in any of the treatment sections commented on being frustrated that they could not search for complementary material as the lecture was proceeding, or expressed that they felt overly controlled by the restrictive web access policy. Nobody in the control sections commented on distraction caused by off-topic use of computers by those nearby. The numerical ratings for the course and instructor were higher for the treatment section in two of the three course terms for which data was collected. While this is far too few observations for any statistical claims at the section level, it does not appear that faculty face much risk of alienating students by restricting internet access in this course format.

5 Conclusions

Although there has been significant research focused on the impacts of computer access in university classrooms, much of this work has been specific to a particular content area or classroom format. Many instructors still struggle with the best way to manage their classrooms with respect to student access to computers and internet connection. This study explores this issue in an agricultural finance course that meets in relatively small groups in a computer lab setting. We conduct an experiment in which two sections of the same course are taught in a single term by the same instructor. Results indicate that student internet access has no discernable net impact on the exam scores or course grades that the students earn. Furthermore, students make no mention of the restrictions in course evaluations and rate overall class quality similarly as the control group. The general recommendation based on these results is that faculty should think twice before spending valuable time or mental energy in restricting student access to fixed computers in a lab setting, at least if the goal of such restriction is to improve student learning outcomes or satisfaction with the course.

There are a couple of issues to keep in mind when interpreting the results of this analysis. First, literature on student access to computers in the classroom has found both positive and negative effects on student performance measures. In some cases, technology access serves a productive role and allows students to either practice in real time or supplement the instructor-provided material with additional contextual information. Perhaps more frequently, technology access acts as a distraction from course content and may detract from student learning outcomes. It is not clear if the results from this experiment indicate that these effects offset one another, or if neither is significant in this context. A study that more carefully monitors how students use their computers in these computer lab–based courses is necessary to learn more about the underlying drivers of these results.

Second, in this experiment, the instructors restricted access to the internet using computer lab management software in which student computers can be controlled remotely. Students are likely aware that their computers are not as private as their laptops or phones would be, and may behave differently than they would with laptops in a lecture hall. Instructors in these computer labs do not actively monitor what students are doing on their computers during a lecture, but the students may not know this. We acknowledge that the results of this study are less relevant for different classroom formats, but this point highlights a key risk with moving to a “bring-your-own-computer” system that some universities are considering.

Third, the lack of statistical association between internet access and student performance in our models could be attributed to the fact what we don’t have an accurate measurement of student’s attention level. Farley, Risco, and Kingston (2013) indicated that college students’ minds wander frequently during lectures regardless of computer use. The frequency of mind wandering could largely depend on individual student’s learning motivation and self-regulation (May and Elder 2018; Zhang 2015). This could partially explain why students’ GPAs prior to taking the agricultural finance course have a significantly positive impact on their exam grade and overall course grade in the course. Future research focused on tracking the time students actually spend on task in the control and treatment groups could help instructors better understand the impact of computer/internet use on student attentiveness during lectures and its relationship with subsequent learning outcomes.

Fourth, we make no attempt to formally analyze the more subjective considerations that may lead instructors to choose different technology policies. Some instructors may find that classroom policies requiring that computers be locked or turned off results in more attentive and engaged students, even if this is not reflected in student scores or success on assessments. Others may decide that the hassle of managing student computers or restricting use is not worth the potential benefits in classroom environment. A more robust study design that elicits student opinions on these specific issues would be helpful for instructors that are weighing these issues.

Finally, the culture of a classroom, program, and university can have significant impacts on the way that students interact with technology during lectures. In some classes, the student use of technology for distractive purposes may be excessive and cause serious difficulty for instructors. Other classes or departments may not have a culture of laptop use and distractive use is less of a problem. This culture can be influenced and shaped by instructors to some degree, by walking the room to the extent possible, engaging students more actively, or avoiding a long lecture format. This study does not take into consideration the degree to which these techniques might alter the impact of web access on student performance, and different results might be found in other situations.

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Teaching and Educational Methods

Developing R Shiny Web Applications for Extension Education

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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, extension audiences are demanding more sophisticated, rapid analysis to aid their decision making using the data they have at their disposal. This paper discusses using R Shiny web applications to meet the new demand.

1 Introduction

> *All producers are realizing that agriculture is now a data-driven industry, said Daniel Schmoldt, a program leader at the National Institute of Food and Agriculture. They need to adopt as much technology as they can to both collect and analyze data.* (Pattani 2016, para. 5)

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 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 (Pattani 2016). To help agribusinesses remain competitive, extension educators can harness the recent developments in web applications to meet the new demand.

Although some of the same techniques for educating students to develop their own data analytics can be applied to extension audiences, many want extension educators to provide the latest data analytic methods and only the results. Indeed, many do not have the time to learn to code, understand application programming interfaces (APIs), or how to build, estimate, and test the latest data analytic models using the data extension audiences have at their disposal. This article discusses using R shiny web applications to disseminate real-time data analytics to an extension audience. We outline some strategies and resources to begin developing and using web applications for extension education.

To meet the new demand for data analytics across a broad extension audience, we have focused our efforts on developing R shiny web-based applications (https://shiny.rstudio.com/) that incorporate contemporary, sophisticated methods and models. R is a common, open-source programming language used by many agricultural and applied economists. With the Shiny package in R, the data analytics that are done can be disseminated to a broad audience. Extension specialists can also use R markdown (https://rmarkdown.rstudio.com/) to disseminate analytics with limited interactivity in web pages and documents. As an example, we used Shiny web applications for agricultural producers to analyze policy and marketing decisions (e.g., Elliott et al. 2018; Elliott and Elliott 2020) and to understand the nuances of measuring tariff impacts (Elliott and Elliott 2019). By developing web applications, we can empower agricultural producers to use the latest data analytics methods and avoid having to teach complex topics and jargon.

2 Strategies and Resources for Developing Agricultural Data Analytics via Web Applications for Extension Audiences

2.1 Degree of User Interactivity

Web applications can range in complexity and interactivity for the user. The developer of a web application can choose to allow a limited amount of user input, or interactivity, and design the web application to focus on clear communication of results of a predetermined analysis. The results in a web application of this type do not have to be a static analysis, however. Rather, the web application can update in real-time to maintain relevancy to the user (e.g., flex dashboards in R Markdown). An extension product with limited user interactivity can be developed in R Shiny, but it may be easier to implement this type of product using R markdown. This type of web application is often designed so a broad extension audience can understand how to use and interpret the application without additional education or supplementary resources. However, HTML text, logos, figures, and data tables can accompany the analytics to communicate the analytics extensively.

Alternatively, web applications can also allow users to input their data and change modeling assumptions, conduct sensitivity analyses, or change the model itself. This type of web application can allow the user to understand the effect better, and the impact that modeling assumptions have on firm specific results. These types of web applications often require users to gain additional education to best use the web application. Additional training can be delivered through articles, workshops, webinars, or help videos that accompany the web applications.

2.2 Enable Contemporary Methods, Models, and Visualizations

Web applications and web computing can be a game-changer for extension educators. Specifically, web applications enable the sharing of applied research that allows for more flexibility in methods used and to communicate the complexity of analysis better. This same flexibility is not generally available when publishing extension articles or when developing Excel\macro workbooks. Web applications can also provide more transparency in research to stakeholders, fostering trust, and the use of applied research to make management and policy decisions. Moreover, user-friendly web applications can better reach a broader audience with limited attentiveness.

Web applications empower users to have access to the latest data and analytic methods and allow them to interact with a model in real-time to generate firm-specific results. For example, web applications can employ deep learning image recognition to identify plant species from smartphone photos (e.g., Lam n.d.), assess pasture potential using quantile regression (e.g., Woodward n.d.), or provide a learning application to teach the basics of machine learning and multivariate methods to analyze data (e.g., Nijs n.d.).

There are numerous new machine learning and visualization packages that are available through R and Python that can be incorporated into R shiny web applications for users to apply the latest data analytics to their particular problem. A summary of the latest machine learning methods available for R has been described by Lesmeister (2019). Also, R shiny can use the latest mapping and plotting javascript tools available through data analytics firms such as Plotly (https://plotly.com/r/), Leaflet (https://rstudio.github.io/leaflet/), and Mappbox (https://plotly.com/r/mapbox-layers/).

2.3 Reaching Mobile and Tablet Users

Web applications are beneficial in that they can be used on PCs, Macs, tablets, and smartphones. A recent study by the Pew Research Center found that 37 percent of Americans now go online, mostly using a smartphone (Anderson 2019). Indeed, 35 percent of the users visiting our web applications have used a mobile phone or a tablet. As extension audiences continue to view more of their content on mobile phones and tablets, it becomes increasingly necessary to optimize extension educational materials to be delivered through these devices. R shiny web applications automatically scale to various screen sizes. However, some web applications are more challenging to navigate and use on small mobile screens. A promising recent package, *shinyMobile* (https://rinterface.github.io/shinyMobile/), has been made available to provide shiny Apps with a more user-friendly mobile look and standalone capabilities. A shiny application using the shinyMobile framework can appear similar to native iOS and Android applications (e.g., Granjon, Coene, and Rudolf 2019).

2.4 Resources to Get Started Developing Web Applications

Developing web applications using R and Shiny is not difficult for extension professionals with a background in R already. However, for users with no background using R, the learning curve to develop a basic application applied to an extension problem may be steep.

There is an increasing amount of resources available to help extension educators begin developing web applications. Some resources reduce the need for extension educators to become proficient coders to develop interactive web applications or dashboards (e.g., Plotly Dash). Other open-source resources allow for extension educators access to web application codes to use as templates that can be adapted to their particular problem (e.g., github.com). There are several recent books on web application development using R Shiny. For example, *Web Application Development with R Using Shiny* by Chris Beeley and Shitalkumar Sukhdeve (2018), *Interactive Web-Based Data Visualization with R, Plotly, and Shiny* by Chris Sievert (2020), and *Hands-on Dashboard Development with Shiny: A Practical Guide to Building Effective Web Applications and Dashboards* by Chris Beeley (2018) . Updates and other information can be found on R pubs (rpubs.com) to gain ideas and view web application designs from other developers. There are also online training courses that developers can enroll in to learn R and web application development using Shiny (e.g., Udemy and Datacamp).

2.5 Publishing Web Applications

Once a developer has created a web application, it can be hosted on a server. Numerous cloud computing services allow web applications to be hosted with generally reasonable rates based on use. The default publishing site for R Shiny apps is shinyapps.io (https://www.shinyapps.io/). Developers can register and host five apps, with 25 active hours per month for free. Additional abilities, like faster servers, custom URLs, more active user time, and hosting more applications, requires a paid subscription. Developers can also purchase the Rstudio connect server software (https://rstudio.com/products/connect/) and host their applications on their server or a university server.

3 Examples of Shiny Web Applications We Have Developed

3.1 Ag Land Highest and Best-Use Web Application

We have developed several R Shiny applications in the past for extension education. For example, the Ag Land Highest and Best Use Web Application was developed to disseminate ag land assessment analyses to policy makers and stakeholders. Specifically, we quantified the probability of cropland or noncropland use of agricultural land for property tax assessment (see http://agland.sdstate.edu/HBU/; see Figure 1). The analysis explored what the impact would be on the state and county if there were a change in assessment policy for ag land. A specific policy impact we explored was the change to ag land assessments if the highest and best use was determined by how the property was used rather than basing the assessment using the USDA-NRCS land capability classification system. The layout of this application was a fluid page design with a navigation bar (i.e., Navbar Page) at the top to allow users to move between different web pages with different content. The maps used in this web application were soil raster maps with high resolution (10 square meters) and were displayed using R leaflet. The raster maps

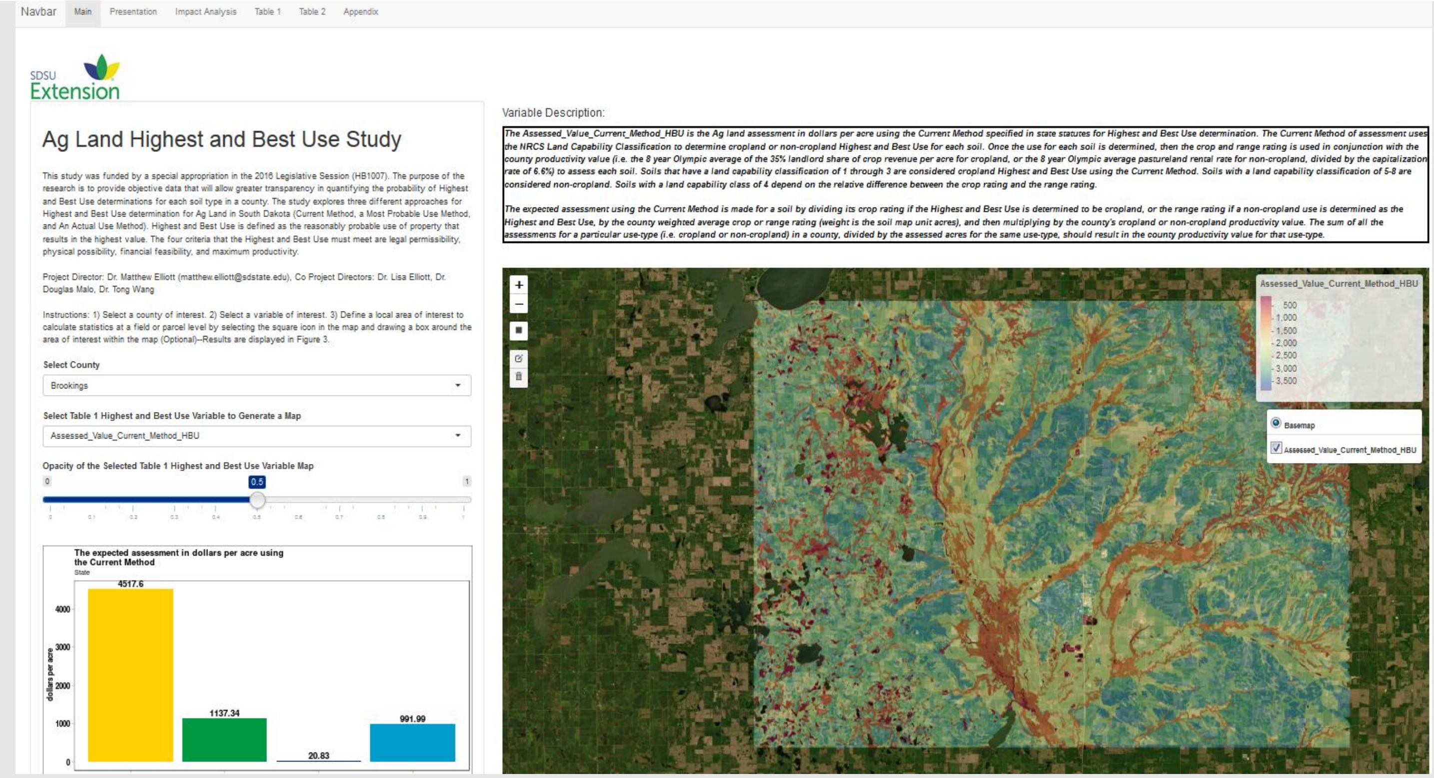

Figure 1. South Dakota State University Ag Land Highest and Best Use Study Web Application

were large files, and loading times took longer for this application to begin. One of the policies explored in the study and reported in the web application used a random forest regression (a machine learning technique) to determine the probability of cropland use based on soil, climate, topography, and location.

A recent web application we developed following the Ag Land Highest and Best Use was targeted to county assessors and stakeholders who use the soil data to make ag land assessments. This application allows users to view baseline ag land assessment data. Users are also provided with additional data and automated notes on soil attributes to study areas where adjustments to baseline assessments may be necessary (see https://agland.sdstate.edu/Soil_Tables/). In this application, spatial points were used instead of raster maps to decrease the loading time for users. Further, we have made this application more mobile- and tablet-friendly by using the *shinyMobile* package (see Figure 2). The ag land assessment data associated with each point is displayed when the user hovers their finger or mouse pointer over the map points. This web application also has an embedded interactive document made using R markdown explaining the data and methods in more detail (see Figure 3).

Both applications allows users to select a county and variable of interest such as the assessed value; the percent soil that has been cropped; representative yields; the percent of sand, silt, and clay in the topsoil; and the expected animal units monthly the ag land can support. Spatial maps are displayed with color-coded results for each county. The web application allows the users to pan in and out and to select different base maps such as a satellite map, a road map, or a topography map.

3.2 "Nowcast" Tariff Impact Estimates Web Application

Another web application we have developed examines real-time Chinese tariff impact estimates on the prices of U.S. agricultural commodities that can be monitored with changes in market events (see http://agland.sdstate.edu/Tariff/). Market data are collected using an API license with Thomson Reuters Eikon. The data are periodically updated for users to generate new "nowcasts" of tariff impacts using commodity prices in alternative markets; latest supply and demand estimates from USDA; and relevant currency and transportation rates. The application allows users to examine a certain commodity and

Figure 2. South Dakota State University Ag Land Soil Tables App Map Tab on an iPad Mini

market (e.g., futures or cash markets), and user specified date range, as well as the ability to change model variables to analyze the tariff impact using a Bayesian Structural Time Series model. The layout of this application uses *shinyDashboard* (https://rstudio.github.io/shinydashboard/). Results are shown in a graph, and quantified loss values are provided in information boxes above the chart (see Figure 4). Below these results is a description of the method used, an explanation of what is being reported, a detailed analysis, and model reports that are provided by the R packages used to do the analysis. Users can make changes to the model and perform sensitivity analyses of variables used in the model. For

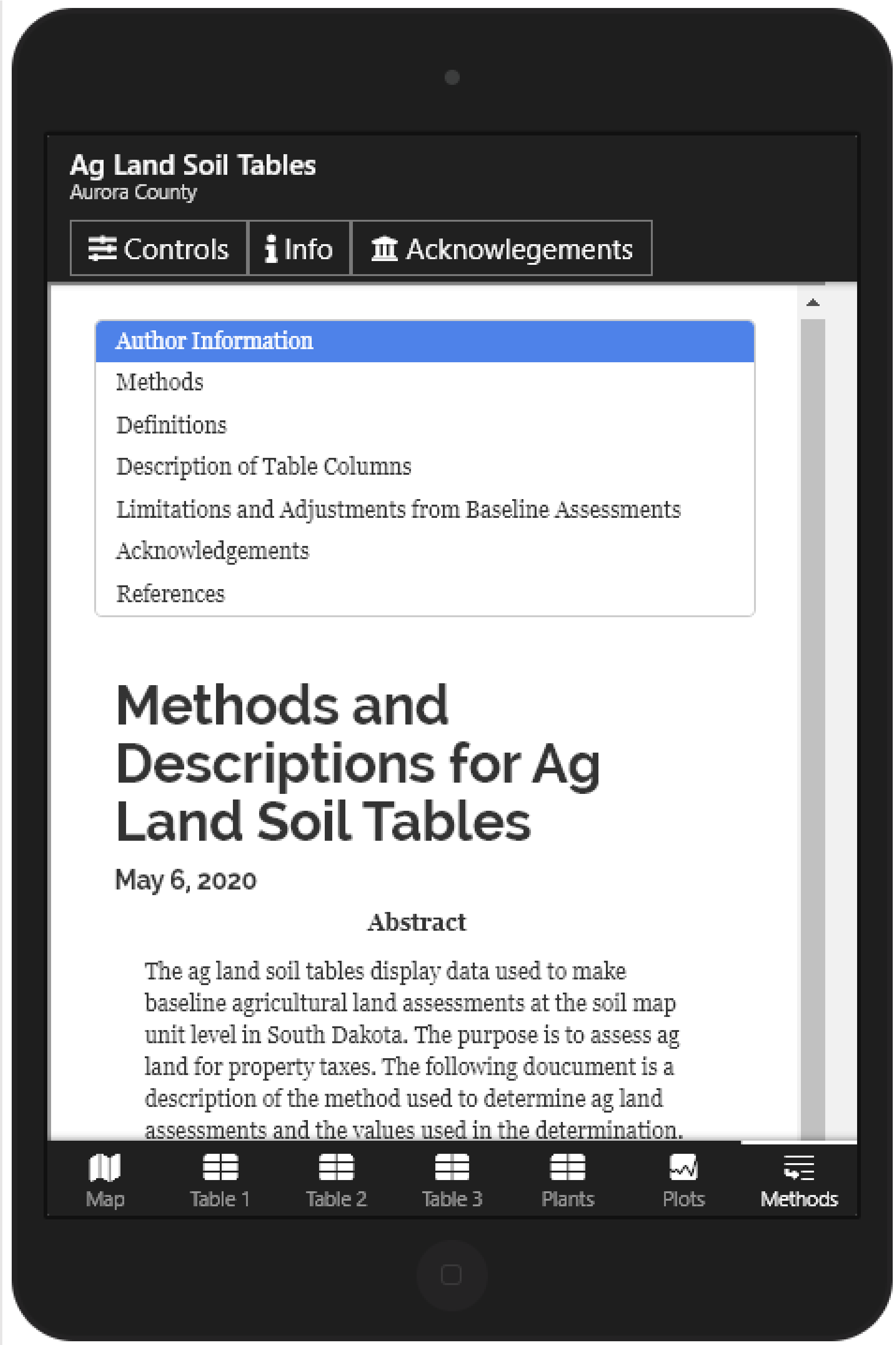

Figure 3. South Dakota State University Ag Land Soil Tables App Methods Tab on an iPad Mini

example, users can include different world grain prices in the model to understand the impact on U.S. prices from tariffs. We advise that discretion must be applied when determining which components to make interactive for users. This particular application is more flexible than most and allows the user to engage in model building and testing. This web application can easily be redesigned to limit user flexibility, but we were using the application to understand the sensitivity of different models on tariff impact estimates. We found the application useful for explaining the complicated nature of understanding tariff impacts to multiple users, including students, and to allow sensitivity testing of models.

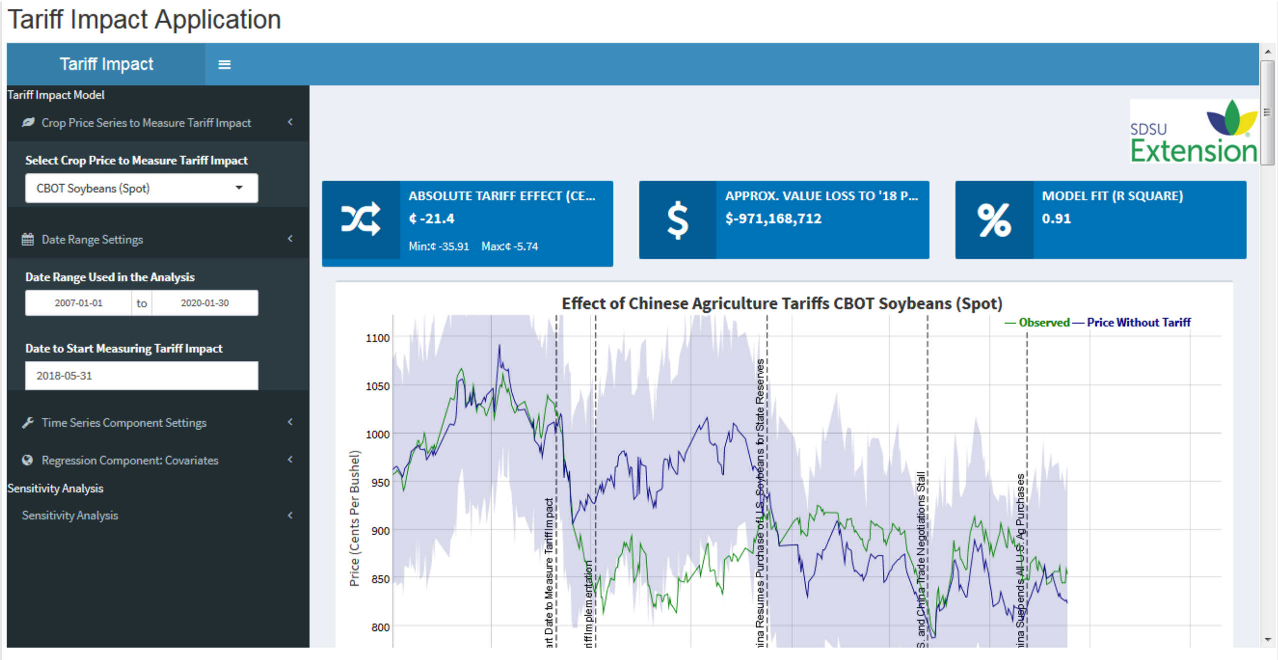

Figure 4. South Dakota State University Tariff Impact Web Application

Web applications can also be embedded in a web page to allow developers to write an accompanying article using common web formatting languages. For example, we created a separate webpage using R markdown where we described the context of the tariff web application we described above. The article was written using HTML and the web application was embedded into the report to allow users to interact with the web application without having to leave the article (see http://agland.sdstate.edu/Tariff_web/).

3.3 Interactive Charts—Web Documents and PowerPoint Presentations

In addition to interactive web applications, interactive charts are becoming more widely available to include in extension products so users can further interact with the chart as they are listening to an extension presentation or while reading a web article. Numerous firms are offering interactive chart hosting where the charts can easily be embedded. Some examples of these types of charting services are Plotly, Tableau, and Google Charts. For instance, we have created interactive grain basis charts and maps for South Dakota that can be found at http://agland.sdstate.edu/Basis/ and http://agland.sdstate.edu/Basis2/ using R Shiny and Plotly. These charts are standalone applications viewable on a smartphone (see Figures 5 and 6), and are embedded in HTML presentations we have given, and in extension articles on the web (e.g., see https://extension.sdstate.edu/south-dakota-grain-basis-tools).

3.4 Challenges with Excel

We initially tried to accomplish real-time data analytics products for extension audiences using Excel workbooks coupled with macros to feed in real-time data. However, we quickly realized the many issues associated with Excel when hosting producer workshops. Some problems emerged because producers experienced trouble utilizing the tool on their home computers (e.g., because of limited memory space, compatibility issues across different Excel versions, and an inability to use the decision tool on Macs). Also, as the Excel-based decision tools became more complex, increasing issues emerged because of the number of complicated steps that were conditional on the user entering accurate input in the previous

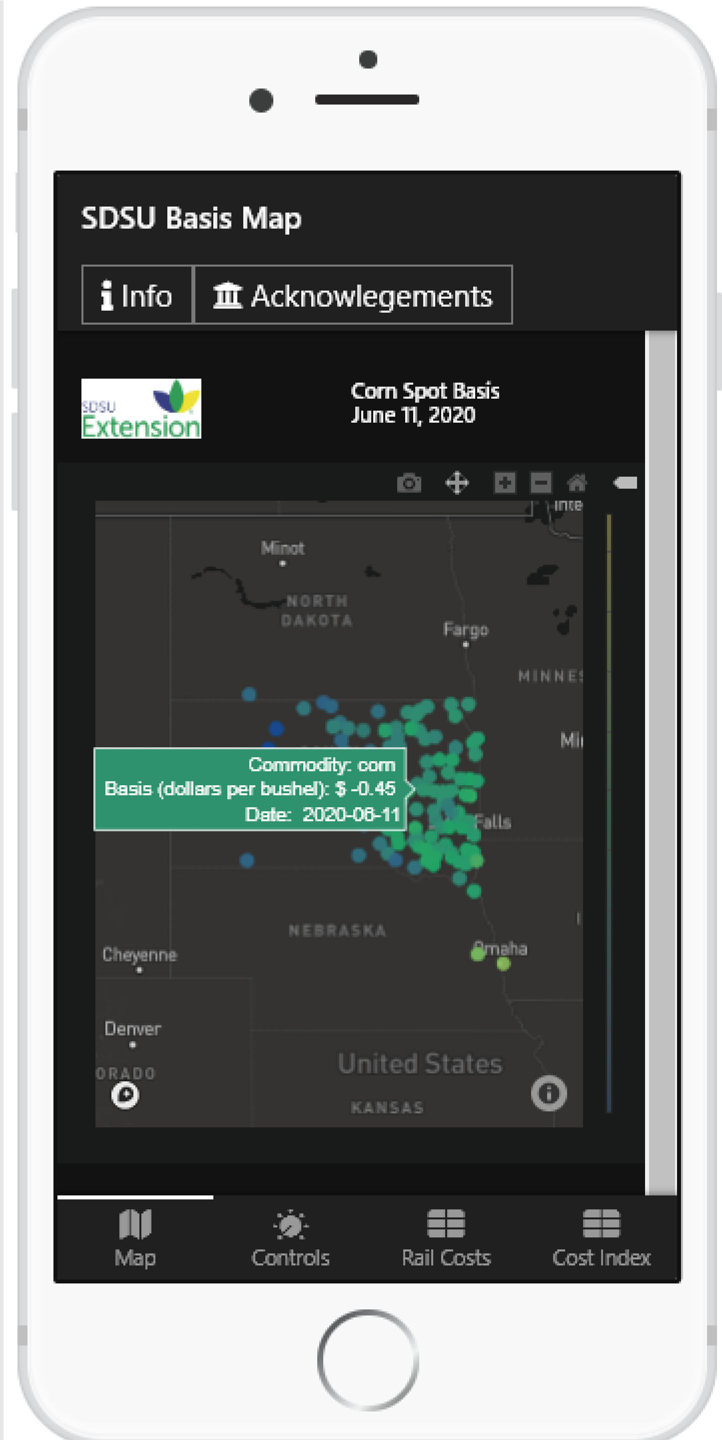

Figure 5. South Dakota State University Basis Map on an iPhone 8+

step. Given web applications functionality, user-friendliness, and compatibility with smartphones and tablets, we determined web applications were a more viable vehicle for disseminating applied research to extension clients that use more sophisticated, real-time data analytics.

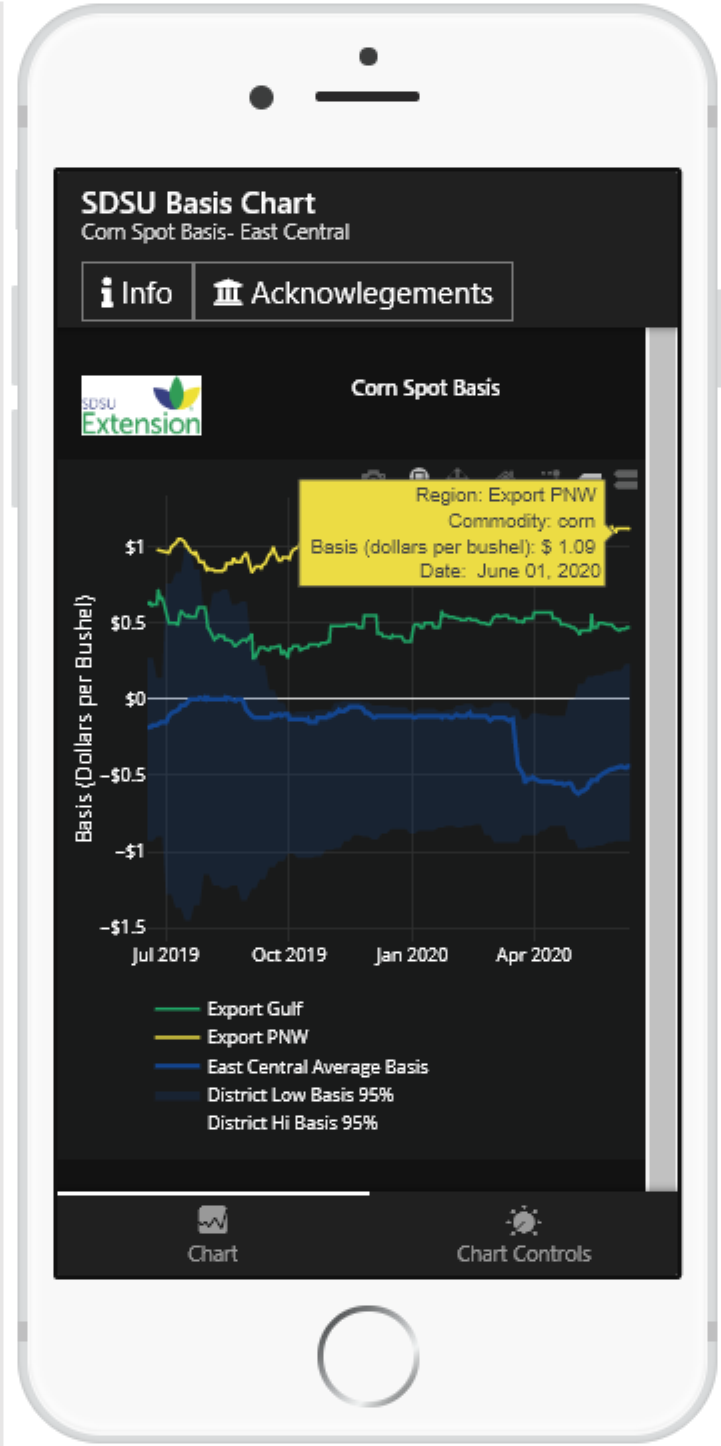

Figure 6. South Dakota State University Interactive Corn Basis Chart on an iPhone 8+

4 Takeaways from Agricultural Data Analytics via Web Applications for Extension Audiences

1. Spend adequate time designing the web application based on different requirements: educational learning, accessibility; whether the tool will be accessed mostly on a desktop, mobile, or tablet; and the degree of user-friendliness that is needed. Designing the application is often the most cumbersome, time-consuming process that requires a lot of trial and error.

2. Take plenty of time to beta test the web applications. As applications become more complex, bugs and glitches are common. Also, be aware if the application does not have the same performance and display across all types of devices.
3. It takes resources to design and develop a real-time web application, as most real-time data requires expensive APIs from vendors. Finding sources of funding is often imperative to provide real-time data analytics to extension audiences.
4. When considering developing web applications, strategize on how it can fit into a broader extension program with supplemental resources.
5. It is important to note that when sharing these web applications, one must secure supporting educational material that explains concepts and use of web applications. We provided supplemental support in using the web application through different mediums, including embedded articles and popups, concept-based short videos, webinars, presentations, and workshops offering hands-on training. Providing various forms of support allows users to decide on the level of support that they need and which mechanisms best suit their needs.
6. As documentation of impacts has become more critical in both extension and research settings, web applications can help in reaching broader audiences who would not regularly attend an extension workshop or read an applied research article. Moreover, web applications allow multiple methods to track progress in learning and measure the adoption and use of information for decision making. These features become invaluable in documenting impact, and in improving future web applications. Specifically, R shiny applications allow the user to embed Google Analytics (https://shiny.rstudio.com/articles/google-analytics.html), as well as create custom programs to save and store user information.

4.1 Synergies Between University Teaching, Research, and Extension with Extension-Based Web Applications

Web applications can empower stakeholders to engage in data analytics while avoiding having to teach them coding or teach them how to build and test models. Further, web applications can be incorporated into classroom settings to allow students to learn methods to develop the analysis used or to improve the design of the web application for more exceptional user-friendliness. Students can provide a productive beta testing environment for newly developed web applications. Ultimately, we aim to teach students in the future how to build web applications on their own. We believe it would be beneficial to foster competition between student web applications similar to poster competitions that can provide a forum for developing web applications that best communicate results. Through the use of web applications, agribusiness extension audiences can be kept abreast of the latest data analytic methods and analysis that give them a competitive advantage.

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Case Study

A Fire Sale for an Incombustible Commodity: Entry and Exit in the Helium Market

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JEL Codes: A22, D21, Q31, W38
Keywords: Entry, exit, firm supply, government intervention, helium, perfect competition

Abstract
In this paper, we present a case study based on National Public Radio's Planet Money episode 933, titled "Find the Helium" to illustrate to microeconomics students a firm's cost structure in a competitive industry and unintended consequences of government intervention. Specifically, this case study examines the consequences of the Helium Privatization Act of 1996, which ordered the U.S. government to begin selling off its stocks of helium by 2005. As a result, the government flooded the market with cheap helium, disrupting the helium industry and causing private companies to exit the market. Throughout this case study, students are presented with details of these government acts, descriptions of how these acts and decisions impacted the helium market, as well as figures to display firm and industry effects. The last section contains questions that can be used during class discussions of this case study. Available upon request are detailed teaching notes (with student learning objectives) and a set of multiple-choice questions that can be used on exams, quizzes, and homework assignments, and answers and metadata for all case study questions.

1 Motivation and Scope of Case Study

One of the most powerful concepts that we learn through an introduction to microeconomics is that market forces are nearly always present. These forces, led by the self-interested decisions of economic agents, tend to push markets back to equilibrium. Government interventions into markets that are not mindful of such forces may generate unintended consequences.

One of the most important applications of this concept is the model of firm entry and exit into markets. Unfortunately, it can often be difficult to teach this concept in an engaging and interesting way. One of the coauthors of this case has noticed what can be best described as a sense of betrayal upon the faces of students, who had previously thought of economics as relevant and exciting, when introduced to the often-tedious exercise of drawing out cost curves.

Here, we present a case study, based on a Planet Money episode, which we hope will cover these important concepts in a technical but engaging way, with material that is both challenging and accessible.

Prior to this case study, you should have listened to episode 933 of National Public Radio's Planet Money, titled "Find the Helium" (Gonzalez 2019).

2 A Brief History of the U.S. Helium Market

The molecules of helium are small, stable, and light. Helium is the second smallest element in the periodic table, after hydrogen, but with two electrons, it is a noble gas that is chemically inert. This means that it is nonreactive under most circumstances and does not combine with other elements. It has high thermal conductivity and liquifies at an extremely low temperature of 4 ° Kelvin (about -452 ° Fahrenheit). These characteristics make it perfect for many practical applications, in keeping things cold, finding leaks, preventing fire, and, of course, being lighter than air. Helium from balloons also helps sound waves travel faster through your larynx, which can sound hilarious (although students should be cautioned that this can be fatal because it displaces oxygen in your lungs).

2.1 Producing Helium

Helium makes up a quarter of all matter in the universe, but it is very rare on earth because of its tendency to escape out to space. It was only identified as an element through solar observations in 1868, and in 1895 was found to be present in trace amounts in uranium minerals. It was finally discovered in useful amounts in 1903 when the mayor of Dexter, Kansas, found himself unable to light a fire with the town's new natural gas well (McCool; American Chemical Society 2000; Chaudhuri et al. 2010).

Virtually all helium on Earth comes as a by-product of the slow decay over eons of natural radioactive elements deep underground, and thus for practical purposes, it is a nonrenewable resource. Anderson (2018) reports that helium also exists in trace amounts in the atmosphere, but at current prices, its recovery is not economically viable. Helium accumulates in natural gas deposits. The vast majority of these deposits have 0.3 percent helium content or less, and the cost of extracting helium from these resources is higher than its economic value. As a result, the helium in these deposits is simply lost when the natural gas is produced.

Until relatively recently, most economically viable helium deposits have been found in the western United States, especially in a small region running from the Texas panhandle into western Kansas. Most of the helium actually extracted is a by-product of fuel production, as removing the helium makes the hydrocarbons (e.g., methane) burn better. When the helium content is even higher, typically between 3 percent and 10 percent of the natural gas, methane content tends to be low, and helium can become the primary product, not just a by-product. Until 2019, private producers had little incentive to access these high-quality resources on public lands, since retention of leases required the production of fuel.

In either case, upgrading is usually done through a cryogenic distillation process, as other gases liquefy first when the gas is cooled and can be drained off. The result is crude helium, which contains about 50 to 70 percent helium along with nitrogen and small amounts of hydrogen, neon, and non-liquified methane. Crude helium can then be purified through a multistage separation process using pressure, filtering, and temperature. Once its purity reaches 99.99 percent or higher, it is considered grade A (National Research Council 2010).

Grade A helium can be distributed in either gas or liquid form, and although the latter takes up less storage volume, it requires immensely cold temperatures. In 2019, the federal government's price per thousand cubic feet of crude helium ranged from $86 for government users to $119 for nongovernment users (U.S. Geological Survey), while the private sector's price for grade A helium was about $210 per thousand cubic feet in 2019. Retail market prices are negotiable for larger consumers, but small consumers may pay retail prices exceeding $1,000 per thousand cubic feet.

2.2 The History of Helium Production

Helium production in the United States can be divided into five separate stages, which we also represent graphically in Figure 1.

- The early consolidation period, running from the first world war through the second, in which helium production became a monopoly of the federal government.
- The early cold war period, in which the federal monopoly continued while the private sector began to find practical nonmilitary uses for helium.
- The conservation period, from 1960 through the 1980s, in which cold war concerns led to the private production of helium in order to create a large underground helium reserve.
- The privatization period, beginning in the 1990s, in which the federal government stopped producing helium and was required instead to sell off the helium reserve at cost.
- The stewardship period, starting only in the past decade, in which forced sales from the federal government's reserve were replaced by market-based auctions.

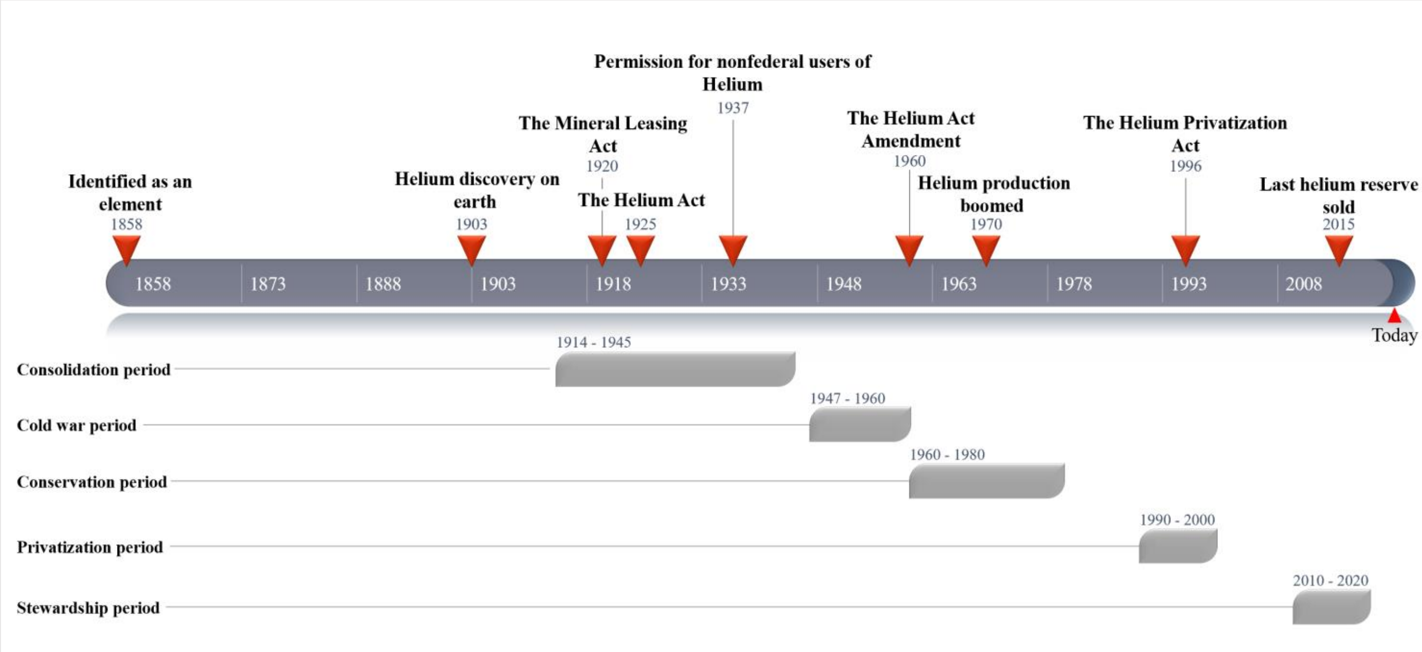


Figure 1: Timeline of Helium Market

Practical interest in helium began in 1917, when chemist Richard Bishop Moore suggested using helium in airships (Sears 2012). Helium is not flammable like hydrogen or the fuel used for hot air balloons. World War I ended before helium could be put to use, but the U.S. military remained very interested.

In 1918, Linde Air Products (now merged with Praxair) was awarded a military contract to build a plant near Fort Worth, Texas, to extract helium from natural gas pumped from the Petrolia oil field (Sears 2012). The Mineral Leasing Act of 1920 gave the federal government the right to extract helium from all U.S. natural gas fields (U.S. Department of the Interior, Bureau of Land Management 2007), but most natural gas fields contained too little helium to be considered economically viable. The Petrolia field was soon depleted, leading the government to search for more helium sources. The Helium Act of 1925 established the Federal Helium Reserve (FHR) at the new Cliffside field near Amarillo, Texas. The Helium Act designated the Bureau of Mines as the government's producer (U.S. Congress 1925) and empowered the bureau to acquire natural gas fields with the potential to produce helium. Exports were banned for national security purposes, effectively blocking Nazi Germany in its efforts to acquire access to a "uniquely indigenous" strategic natural resource (Levitt 2000). Instead, all production by the bureau was sold only to federal agencies at cost, and the bureau soon established a new production plant near Amarillo (Gomez and Huggard).

In the late 1920s, the Kentucky Oxygen-Hydrogen Company, soon known as the Helium Company and owned by the Girdler Corporation, was given a contract by the Navy to produce helium in Dexter, Kansas. In 1937, the year that broadcaster Herbert Morrison cried, "Oh, the humanity!" as he watched the Hindenburg, a German hydrogen zeppelin, burn, the bureau was finally given permission to lease helium to nonfederal users. Due to this, the Girdler Corporation—unable to compete with the federal government—requested that the bureau purchase its operations (Dick and Robinson 1985). As a result, the federal government had consolidated its control over all production and consumption of helium.

For the next quarter of a century, helium production remained a monopoly of the U.S. federal government, and the military was the primary customer through World War II (Price 1967). After the war and through the first half of the Cold War, new consumers began to enter the market as helium's primary appeal shifted from its lifting properties to its use in keeping rocket fuel very cold, in creating a safe atmosphere for arc welding, and in finding leaks in spacesuits, nuclear reactors, and other important containers. Private industry increasingly found these properties useful as well. The bureau also began to sell helium to over 50 commercial distributors of industrial gas. The largest distributors were Chemetron's National Cylinder Gas Co. (which merged in 1953 with the Girdler Corp.), Air Reduction Co., Union Carbide's Linde Co., and Air Products and Chemicals.

2.3 Conservation and Privatization

The conservation period began in 1960, with amendments to the Helium Act. Motivated by the Cold War and by the realization that private sector production of natural gas for its hydrocarbons was leading to the loss of most helium, Congress authorized the Bureau of Mines to accumulate a large national stockpile (U.S. Congress 1960). Since the most impermeable container for helium was in its original underground location, the new act charged the bureau with storing crude helium in the Bush Dome, a portion of the FHR in the now-depleted Cliffside field (Sears 2012; Jolley 2016).

In order to stock the FHR, the bureau contracted with private firms to build five extraction plants near helium-rich fields in Kansas, Texas, and Oklahoma, and was authorized to borrow from the U.S. Treasury to fund their purchases of helium. By 1970, production boomed to almost ten times the annual U.S. demand. This is shown in Figure 2 as the difference between the red solid line and blue dashed line, using data from the U.S. Geological Survey. The crude helium stock in the FHR was enough to supply the United States for the next 25 years.

The Helium Act Amendments of 1960 set the bureau's wholesale price at $35 per thousand cubic feet of crude helium (Sears 2012), or around $300 in 2020 dollars.[1] However, as companies became more efficient at producing helium, they were soon able to sell crude helium at a significantly lower price than the bureau. As a result, private industry became the primary provider to nongovernmental users (Sears 2012).

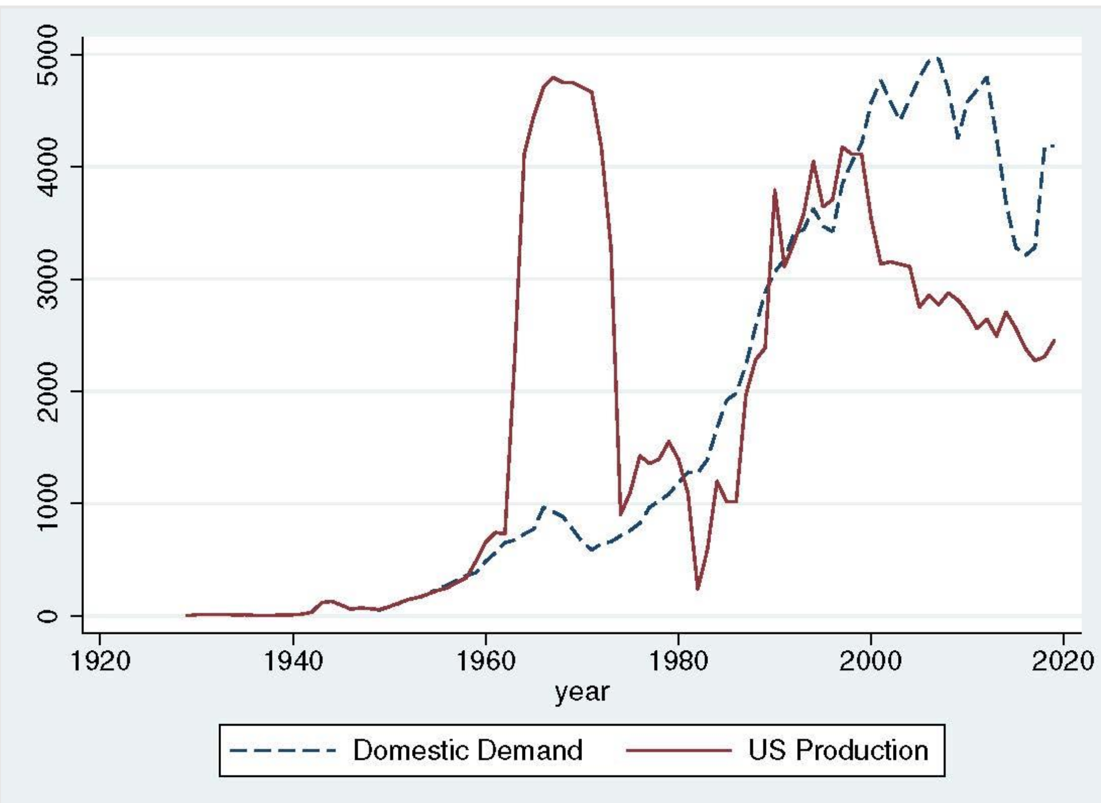


Figure 2: Production and Use of Crude Helium (Millions of Standard Cubic Feet)

[1] https://data.bls.gov/cgi-bin/cpicalc.pl

Still, most U.S. production of crude helium during this period went into the FHR, and exports remained relatively low, inducing a few other countries with economically viable natural gas deposits who began their own production. In the 1960s, the United States accounted for 99 percent of the world's reported helium production and 95 percent of apparent world consumption. By the 1970s, the U.S. share fell to 93 percent of world production and 64 percent of consumption. In the 1980s, these shares continued falling to 72 percent and 56 percent, respectively. Foreign production of helium was first centered in Russia and Poland, but gradually shifted to Canada, Algeria, and Qatar.

The Bureau of Mines stopped adding to the FHR by 1980. Production slowed back down to only 50 percent more than U.S. demand, especially after the bureau's Keyes plant in Oklahoma was shut down in 1982 (Weaver), with the excess production exported to the rest of the world. Liu (1983) forecast a looming shortage of helium by the late 1980s that would require using the FHR stockpile, though Uri (1987) argued that the forecast was incorrect. By 1994, the U.S. helium industry was dominated by 14 private companies running 18 different extraction plants, and U.S. exports made up more than two thirds of all helium purchased around the rest of the world (U.S. Geological Survey). The Bureau of Mines still ran the Exell plant near Amarillo, but its production was a small share of overall output.

The privatization period began in the mid-1990s, as Congress concluded that helium conservation was no longer necessary due to private production. The Bureau of Mines was closed in 1995, and its helium operations were transferred to the Bureau of Land Management. Congress then decided that the federal government should get out of the business of producing and selling helium. The Helium Privatization Act of 1996 required that the federal government stop producing helium within two years. The Exell plant was soon closed. The act then required the Bureau of Land Management to sell off its reserve helium, starting by 2005 at the latest and ending by 2015 (U.S. Congress 1996).

Congress set the price of crude helium without regard to its market value. Congress priced helium at the average cost needed for retiring $1.4 billion in federal debt used to fund the FHR (National Research Council 2010). By 2006, the privatization period resulted in government prices that were below private (market) prices (J.R. Campbell & Associates, Inc. 2013). This would have major unintended implications upon private firms in the market, which we will explore in the next section. These implications would ultimately lead Congress to reconsider their actions. In 2013, the Helium Stewardship Act was passed. The chief purpose of this act was to convert federal sales mandated at a fixed low price into market-based auctions, which was expected to improve production incentives.

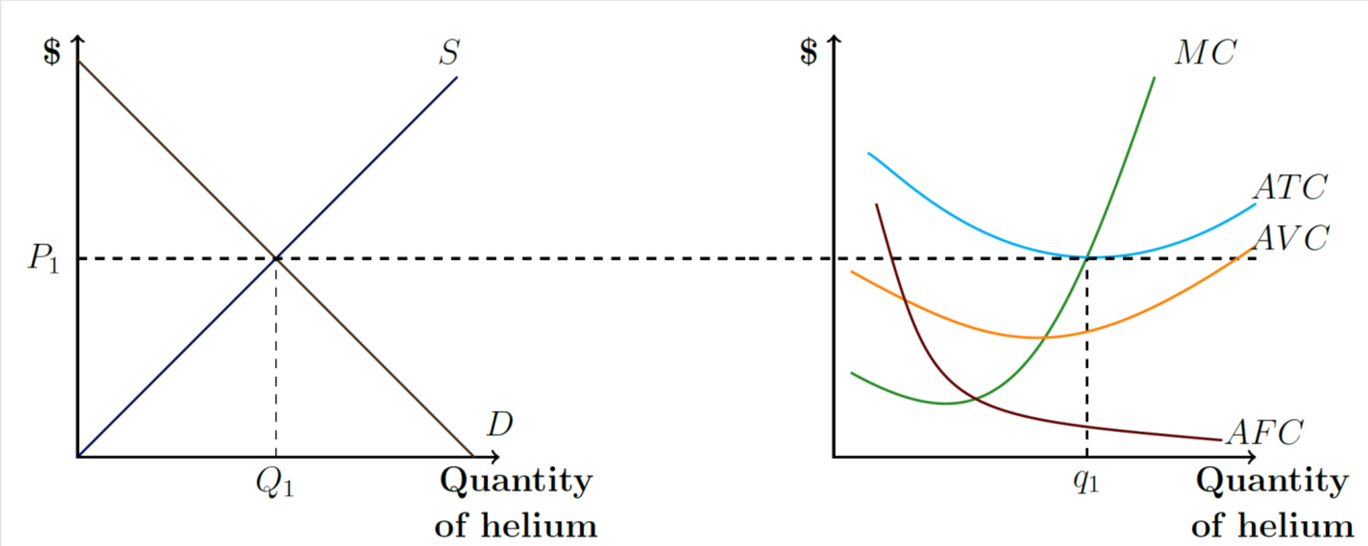
In 2017, however, a trade embargo of Qatar by its Arab neighbors led to a dramatic decline in the world supply of helium, reminding observers that sales from the FHR are not the only disruptive force in the helium market (Anderson 2018). The Helium Extraction Act was subsequently introduced in 2017 to improve incentives for private helium exploration on U.S. federal lands. This act was finally passed and signed in 2019, as a part of the Natural Resource Management Act (S.47 2019). Meanwhile, production continues in Qatar and Algeria, and new plants are coming online in Tanzania, Russia, and Canada (DeCarlo and Uy 2017).

3 Economic Analysis of the Helium Privatization Act

In this section, we will walk you through the economic analysis of the Helium Privatization Act.

3.1 Initial Equilibrium

In the decade before the Helium Privatization Act of 1996, the government held a large stock of helium, but otherwise remained on the sidelines of the market. We model the initial equilibrium in the market in Figure 3. This figure makes two important assumptions. First, we assume that this market can be modeled using the framework of perfect competition. In other words, while we will show that there is clearly a finite number of firms participating on the supply side of this market, we choose to assume that there is sufficient competition for the firms to act as price takers. In the appendix, we present an advanced question that relaxes this assumption. Second, we assume that all firms had the same



(a) Industry (b) Firm

Figure 3: The Competitive Helium Market

hypothetical cost curves. Because of these assumptions, we will specify the helium market as perfectly competitive. See Karlan and Morduch (2014) and Acemoglu, Laibson, and List (2018) for a textbook presentation of such a model.

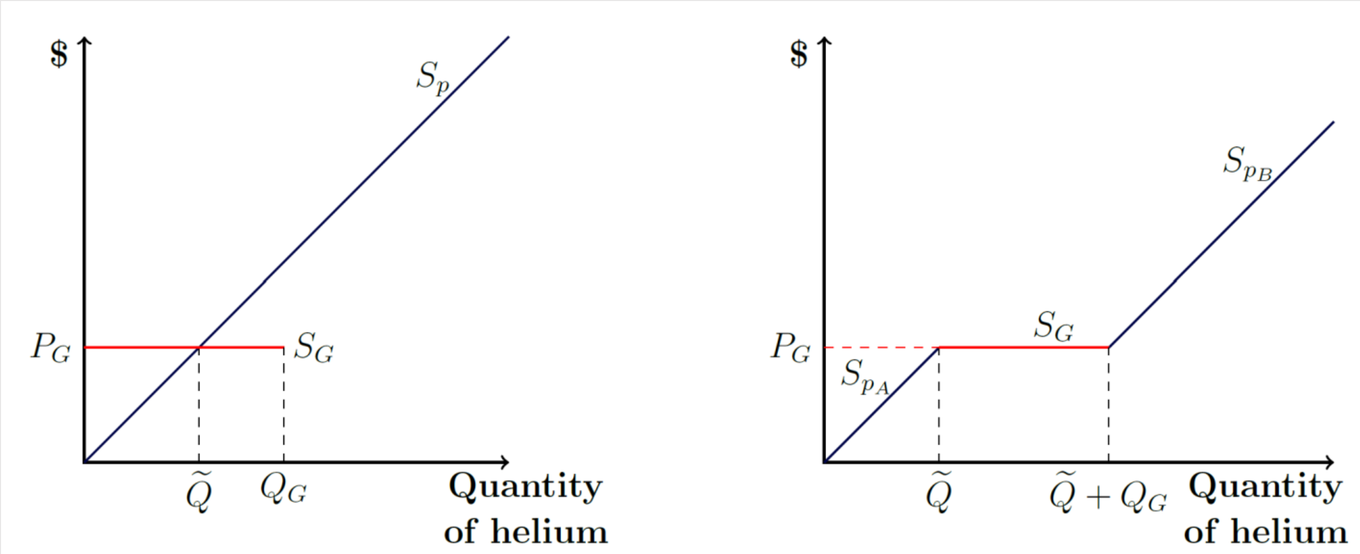
The industry price (P_1), with all firms acting as price takers, is determined where demand (D) equals supply (S) in Figure 3a. Assuming all firms face the same hypothetical cost curves, they produce q_1 cubic feet of helium. This quantity for the firms is determined where price (P_1), which is also marginal revenue (MR) under perfect competition, is equal to marginal cost (MC), in Figure 3b. This is also where price equals average total cost (ATC). Since profit can be calculated as $\pi = (P_1 - ATC) * q_1$, the economic profit for each firm is equal to zero, which must occur when an industry is in long-run competitive equilibrium. Recall that economic profits include opportunity cost, so stating that economic profits are equal to zero is essentially saying that firms cannot make any more money in competitive industry X than they could in competitive industry Y. If there were a difference in profits between two competitive industries, resources would flow out of one industry (raising the level of profit) and into another industry (decreasing the level of profit). This process would continue until the level of economic profits returned to zero in each industry.

3.2 Consequences of the Helium Privatization Act

At the time of passage of the Helium Privatization Act of 1996, there were 11 plants producing Grade A helium in the United States. For several years during the next decade, purchases from the FHR accounted for more than half of total U.S. sales. By 2011, U.S. production had declined by almost 20 percent even though exports had more than doubled and only 6 plants remained in operation (U.S. Geological Survey).[2] In this section, we examine how our model of firms within a perfectly competitive industry may help to explain these changes in the market.

First, we will model the impact of the government sell off of helium that took place on account of the Helium Privatization Act of 1996. Before examining the impact upon individual firms, it is worthwhile to carefully consider the exact impact that the government intervention had on the supply curve in the market. In order to do this, the left panel of Figure 4 displays, separately, the private and government supplies of helium to the market, while the right panel combines them.

[2] We display details on the number of operating plants in Figure 8.



(a) Private and Government Supply (b) Combined Industry Supply

Figure 4: Helium Market Supply after Privatization

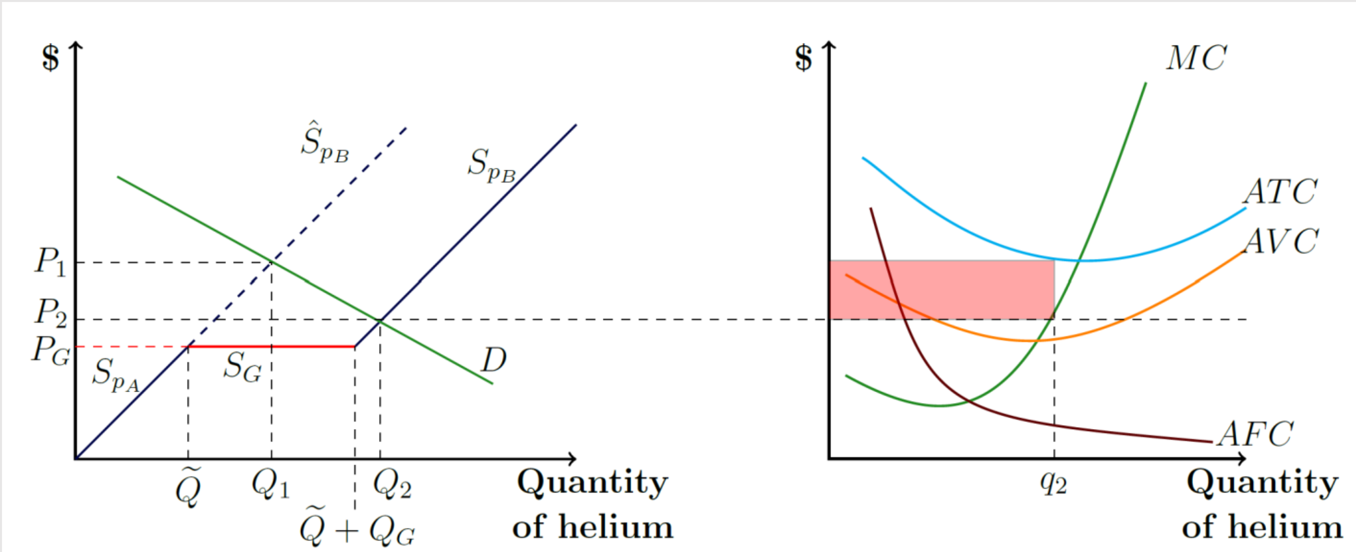
In Figure 4a, we see a standard upward sloping supply curve, labeled S_p. Let's think of this as the market supply curve for private firms. Recall that the Helium Privatization Act of 1996 initially tasked the administrators of the government's helium stock with selling it to private buyers as quickly as possible at a *set price*. Regardless of how much helium the government was selling, the price remained at the predetermined price. Because the government was selling the helium at a fixed price, we represent the government supply, S_G, as being perfectly elastic at a fixed price of P_G. The government had a large, but not infinite, supply of helium to sell. We assume that the government had Q_G to sell at this fixed price. Notice that the private supply curve passes through the government supply curve; we label this intersection point as $\tilde{Q}$.

In Figure 4b, we aggregate the two supply curves shown in Figure 5a. Remember that when we add up parts of supply or demand into market supply or market demand, we add things *horizontally*. The first units that will be supplied to the market are given by the units that the private firms could produce at a price below P_G. In the left panel, we saw that the private market was able to produce Q of these units. We refer to this portion of the supply curve as S_{p_A}. The next cheapest units to produce were the Q_G units of helium supplied by the government at a price of P_G. Combined, the market could supply a total of $\tilde{Q} + Q_G$ at P_G. As the price rose above P_G, the private firms would begin to supply the units beyond $\tilde{Q}$. This last portion of the market supply curve is referred to as S_{p_B}.

We now examine the consequences of the government's helium supply impact on the production decisions of individual helium plants. First, we will analyze the new short-run equilibrium followed by the new potential long-run equilibrium. Finally, we conclude by discussing how and why government policy changed in this market.

3.2.1 New Short-Run Equilibrium

Above, we stated that for some years sales from the FHR were the majority, but not all, of sales in the United States. We therefore assume that Q_G was less than the previous quantity exchanged in the private market, Q_1. In Figure 5a, the new equilibrium occurs where the unchanged demand curve intersects with the new supply curve. For reference, we represent with a dashed line the previous position of the units supplied by the private market beyond $\tilde{Q}$ as $\hat{S}_{p_B}$. The actual supply, once accounting for the government intervention into this market, is represented by S_{p_B}.



(a) Industry (b) Firm

Figure 5: The Helium Market after the Helium Privatization Act

We observe the new market short-run equilibrium price in the left panel of Figure 5. Here, we see that the demand curve now intersects with supply at a price of P_2. This intersection occurs along S_{p_B}. This means that firms will supply all helium to the market that they would be able to produce at a price lower than the price at which the government was selling helium. In other words, the entire amount of helium represented by S_{p_A}, which we call $\tilde{Q}$, is sold. Additionally, in this example all helium made available by the government, Q_G is sold, such that $Q_2 > \tilde{Q} + Q_G$.

The consequence of the fact that the demand curve intersects the supply curve along the S_{p_B} segment is that P_2 ends up being greater than P_G; the government is not supplying so much helium to the market that it is selling to the highest value helium consumers in the market. Thus, in a sense the private market still sets the price for helium, but the price is much lower than it was without the presence of Q_G in the market.

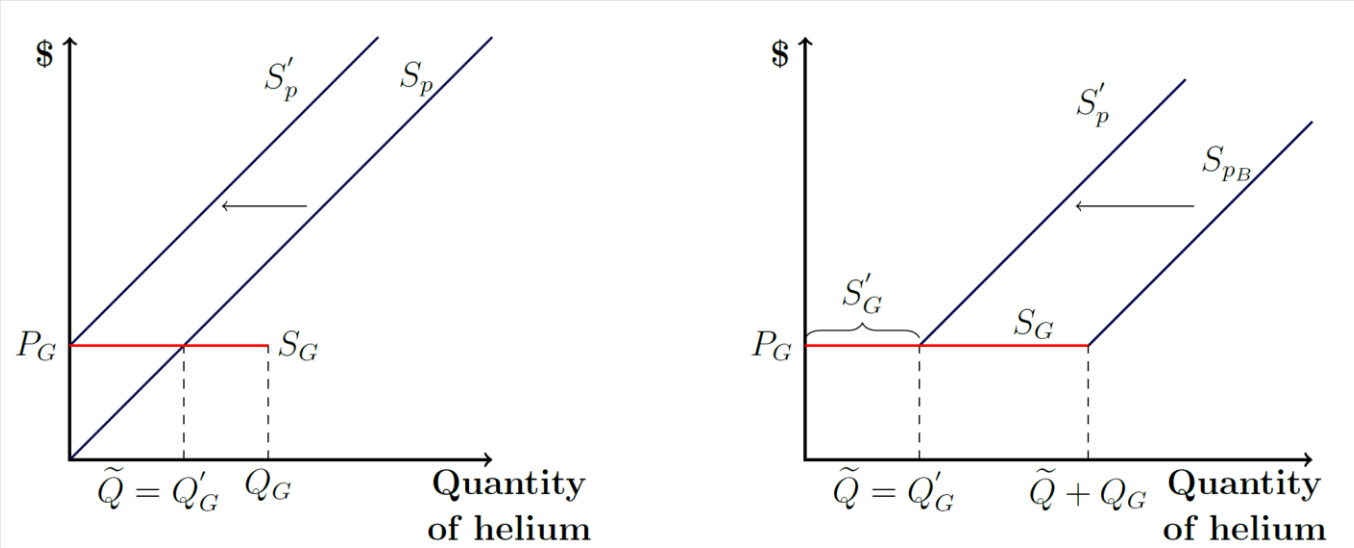
In summary, the key impact of this intervention was to lower the market price. Recall that all firms in a competitive market are price takers, so they must now sell their helium at P_2. As firms were earning no economic profits in the previous equilibrium, we would expect economic losses to now occur. We examine this in Figure 5b.

Figure 5b reveals the short-run equilibrium for a firm in this market, as given by the market price set in Figure 5a, just like Figure 3a did for the initial equilibrium. Here, it becomes clear that the lower price faced by firms will indeed lead to negative profits. As can be seen in the figure, the intersection of price (P_2) and marginal cost (MC) is at q_2. Therefore, the firm's profit maximizing quantity is q_2. At this quantity, the price is below the average total cost and the firms are earning negative profits (losses), as profit is given by $(P - ATC) * q$. This negative profit is represented by the red shaded box.

3.2.2. New Long-Run Equilibrium

Generally, if firms are earning negative profit, there will be exit from the industry until the market reaches a new long-run equilibrium, and the number of firms is one of the determinants of supply. As firms exit a competitive market, market supply will shift to the left. This will increase the market price until remaining firms no longer lose money.

We take one more look at our model of this market structure in Figure 6. The process of firm exit may seem complicated in this context, but it is relatively straightforward if we go back to the graph that separated private supply from government supply. Because only private firms' supply decisions are



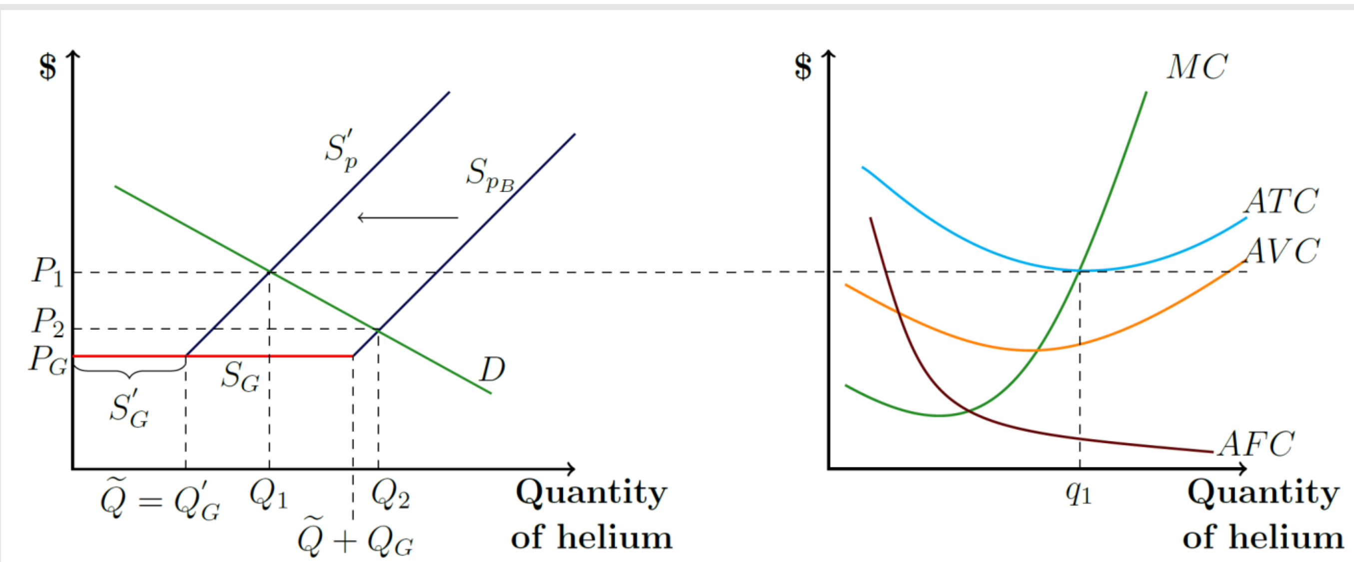
(a) Private and Government Supply

(b) Combined Industry Supply

Figure 6: The Helium Market Supply after Exit

affected by the losses caused by the decrease in price, we simply need to shift S_p to the left, resulting in S'_p. We assume that this shift is sufficient to eliminate all of the private supply curve below P_G. In addition, in this market, the prior equilibrium can only be achieved if there is some change to government policy. Specifically, the government would either need to raise the price at which it is selling helium or decrease the quantity that it was selling. In fact, the government did move in this direction with auctions, as we will later discuss. We choose to represent this with a new smaller quantity being sold: S'_G. Combining these two curves now, we see the new market supply curve in Figure 6b.

We now turn our attention to Figure 7a, which shows the new market supply curve, along with demand. Here, we see that when we account for both the new government supply, along with the decrease in private supply that results from economic losses in the market, the price may recover to P_1.



(a) Industry

(b) Firm

Figure 7: The Helium Market after Exit

When we turn our attention to Figure 7b, we can see that when the price returns to P_1, firms are back to earning zero economic profits in this industry. In other words, the market has returned to long-run equilibrium.

This, however, does not mean that there are no consequences to the government intervention in this market. Many firms were driven out of business and had to leave the market.
This can be understood by the fact that while the total quantity exchanged in the market has returned to Q_1, only $Q_1 - Q_G'$ of this supply is provided by private firms. In other words, while Figure 7b looks exactly the same as Figure 3b, with firms each producing q_1 units, there are less firms in the market who are producing. Previously, there were $\frac{Q_1}{q_1}$ firms, but now there are only $\frac{Q_1 - Q_G'}{q_1}$ firms.

4 Conclusion

Above we have seen the effects in the helium market of the government selling off a fixed amount of helium at a nonmarket driven price. In our modeling of this event, the primary effect of this action was to initially lower price. This then disrupted the private market from a long-run equilibrium, driving a representative firm's economic profits from zero into negative territory. As a result of negative profits, firms began to exit the industry. This exit from the market drove prices back up. In our modeling of this intervention, price was ultimately able to return to its original level, if the government reduced its own supply to the market. The number of private firms operating in the industry, however, is reduced. This outcome is largely consistent with the data that we have presented in Figure 2.

Ultimately, as we have alluded to earlier, the U.S. government shifted its policy away from selling off the helium stock at this fixed price. In an effort to stabilize the market and encourage private production, the Helium Stewardship Act of 2013 gradually phased in auctions of the helium reserve at market-based prices above the minimum necessary to retire the related debt (U.S. Congress 2013). As we see in Figure 8, this policy change was apparently significant enough not only to prevent further private exit from the industry, but also to encourage entry in the long run, as the number of helium plants began to recover as a result.

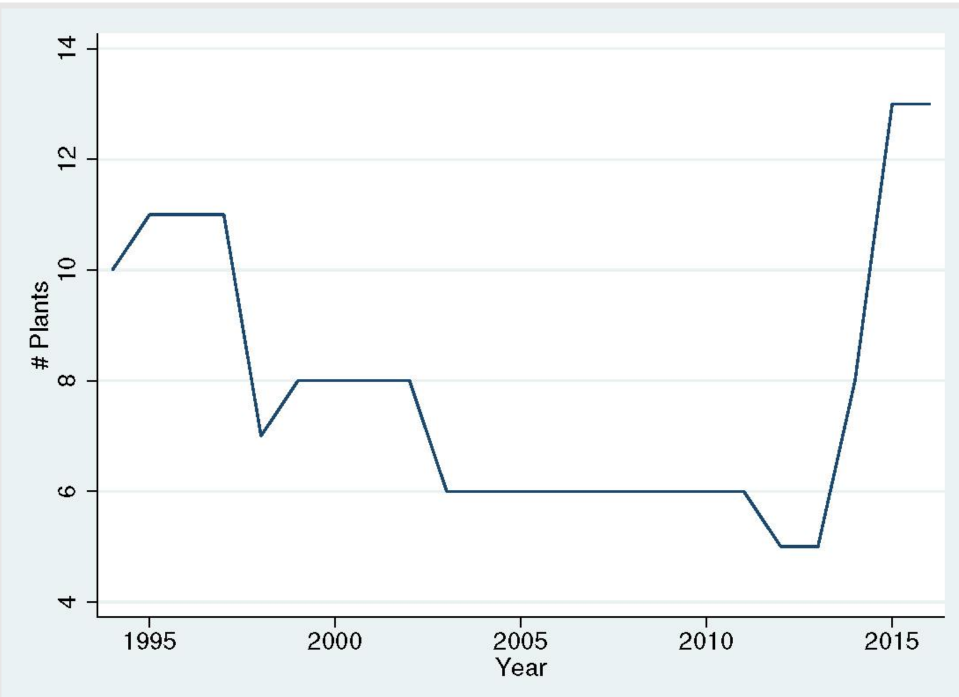


Figure 8: Plants Producing Grade A Helium

This case study provides a useful stylized example of a market adjustment, helping students to better understand the concepts of cost curves, the competitive market, and exit from an industry. The companion Planet Money episode covering this case should help ground the students in the material covered here, and we recommend that students be assigned to listen to it before class. Much as the case with Lacy, Sørensen, and Gibbons (2020), we believe that this material provides the students with an application of government intervention that illuminates specific standard economic principles in an entertaining example. In addition, it helps to make a good general point for students in these classes: policies often have unintended consequences, and those policies which can recognize how the goals of policy makers may be carried out in a way that is mindful of market forces may ultimately more effectively accomplish their goals.

5 Discussion Questions

1. Review the economic model that we presented in the case study.
    (a) Draw side-by-side industry and firm/plant graphs to display the long-run equilibrium in the helium market assuming it is perfectly competitive.
    (b) On the same graph, draw the effect on the industry and firms/plants from the government selling off its helium stock, as we have modeled it in the case study.
    (c) Finally, show how exit of firms/plants and reduced government supply returned the market back to competitive equilibrium.
2. Extending our analysis: let's now assume that the government made available twice as much helium as drawn in the graphs above. Answer the following questions:
    (a) Using this new information, draw the effect on the industry and firms from the government selling off its helium stock.
    (b) Can private exit bring the market back to equilibrium? Why or why not?
3. Anticipation Effects: As shown in Figures 2, some reduction in output occurred before the government began selling off helium at a lower price in 2003. Because future policy was clearly spelled out in the Helium Privatization Act of 1996, firms could see that the market was going to change and had some sense of what these changes were going to look like. Using your knowledge of economic analysis, explain why firms would react before the government began to sell off their helium.
4. Up until now, we have assumed that different helium plants all faced the same cost curves. We will now relax this assumption and assume that different plants may have had different cost curves. Below is some specific information about different plants that you will refer to when answering the questions below.

    In 1996, there were 10 plants owned by seven private firms that were producing exclusively Grade A helium. A decade later, this number had dropped by nearly half. Nitrotec closed both of its Colorado plants, the Burlington plant in 1998 and the Cheyenne Wells plant in 2002. Unocal sold its plant in Moab, Utah, to new owners, and Keyes Helium Company sold its Oklahoma plant. Meanwhile, Newpoint Gas opened up a new Grade A helium plant in Shiprock, New Mexico, in 2002, but this was soon sold to Shiprock Helium, which then sold the plant to Nacogdoches Oil. Throughout this time, only five plants operating in 1996 continued to produce Grade A helium: the Air Products Helium, Inc. plants in Liberal, Kansas, and Hansford County, Texas, the Praxair plants in Ulysees and Bushton, Kansas, and the BOC Gases plant in Otis, Kansas.

    (a) Draw the costs curves in one graph for Praxair's Ulysses plant. In a separate graph (you may want to draw these side by side) draw the cost curves for Nitrotec's Cheyenne Wells plant. Assume that both firms faced the same decrease in price (from P_1 to P_2). Using the graph, show why one plant shut down and why the other did not.

(b) Using the result from above, refute the following statement: "the decrease in helium production can be explained by plants that left the industry, but not by the firms that remained."

(c) Consider Nitrotec's short-run decision to close its Burlington plant after the passage of the Helium Privatization Act of 1996, even before sales from the FHR began. Then consider its long-run decision to close the Cheyenne Wells plant, after sales began. Draw one graph for each plant, explaining why one plant shut down in the short run, while another plant exited in the long run.

(d) Even while other plants were exiting the market, a new plant owned by Newpont Gas entered in Shiprock, New Mexico. Explain why this may have happened.

(e) As mentioned above, firms could produce both Grade A helium as well as crude helium. Assume that Grade A helium is more expensive to produce. Also, assume that Grade A helium sells at a higher price than crude helium.

   i. Using two side-by-side graphs, draw graphs depicting a firm that will earn positive profits for each of these two products.
   ii. Now suppose that there is downward pressure on the price of helium. Decrease the prices in these markets (keeping the price for Grade A higher than the price for crude helium) and show that the firm may now find it optimal to produce only crude helium, but not grade A.

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Case Study

Capital Budgeting Analysis of a Vertically Integrated Egg Firm: Conventional and Cage-Free Egg Production

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JEL Codes: G30, G31, M21
Keywords: Agribusiness finance, cage-free eggs, capital budgeting, corporate finance, strategic management

Abstract
This case features a financial analyst building a capital budgeting model of a stylized vertically integrated egg firm. The case describes the egg industry and the role played by large firms, and highlights the potential for continuing fast growth of cage-free eggs in the near future. Cage-free eggs may grow rapidly at the expense of conventional eggs because of (1) recent regulation requiring producers to switch from conventional to cage-free production, and (2) pledges by large egg buyers such as McDonalds, Starbucks, Walmart, and more than 200 restaurants and supermarkets, to buy cage-free only products by 2025. The case discusses how investment, production, and financial statement parameters are collected and assembled by the analyst to prepare a capital budgeting model, which might be used to evaluate the financial performance of an egg firm managing a portfolio of conventional and cage-free eggs. The reader is challenged to analyze how investment, leverage, and profitability may change under two hypothetical investment policies. A quick-investment policy would capture a scenario on which the cage-free market grows quickly in the following years and therefore the egg firm would invest aggressively in cage-free facilities, in sync with the market. A second investment policy captures a slower cage-free growth scenario.

1 Introduction

In the spring of 2020, Stephanie Adler, a financial analyst working for a bank serving the agribusiness sector was analyzing the U.S. egg industry. The bank anticipated increasing loan requests from this industry because recent changes in regulation might accelerate investment in egg production facilities. Stephanie had recently examined the financials of an egg producer—at the farm level—and realized that additional analysis was needed from the perspective of a vertically integrated egg firm. A vertically integrated firm owned flocks of laying hens; raised replacement hens; collected, packaged, and marketed shell eggs and egg products; and finally sold the hens that were no longer efficient layers. First, she needed to take a closer look at the shell egg industry, perhaps looking at a Porter's Five Forces analysis of the characteristics of this industry. She also had two quantitative tasks: (1) to analyze a capital budgeting model (spreadsheet) she had already prepared, and (2) to evaluate whether the vertically integrated egg firm should change its portfolio of products (e.g., the mix of conventional and cage-free volume), and if so, how quickly investments should be made. Such an analysis was needed given that the U.S. egg industry was likely to transition from conventional to cage-free production because of both consumer demand and recent changes in regulation. In November 2018, the Prevention of Cruelty to Farm Animals Act was approved, requiring all eggs sold in California to come from cage-free production by 2022. Other states had also passed cage-free laws.

To accomplish her goal, the financial analyst needed to look closely at the assumptions of her capital budgeting model. She knew that the model was built with assumptions that might not be realistic.

She wanted to identify and critique those assumptions in an articulated manner so that she would be well prepared to explain the model to potential users. She also needed to explain to her boss how two cage-free investment policies would impact both firm profitability and leverage.[1]

2 Background

2.1 Production and Consumption Statistics on Egg Production

In 2019, 9.438 billion dozen eggs were produced in the United States, compared with 9.173 billion in 2018 and 8.887 billion in 2017 (U.S. Department of Agriculture, National Agricultural Statistics Service 2020).[2] Almost all eggs produced were consumed domestically, with only 3 percent being exported in 2019 (American Egg Board 2020). Americans consumed annually, on average, 292.9 eggs per capita in 2019, with consumption recently growing between 1 and 2 percent. As of 2019, consumption was projected to reach 294.7 eggs in 2020 and 297.4 in 2021 (U.S. Department of Agriculture, Agricultural Marketing Service Farm Service Agency 2020).

Seven large companies including Cal-Maine Foods Inc., Rose Acre Farms Inc., Rembrandt Enterprises, Michael Foods Inc., Hillandale Farms Inc., Sparboe Companies, and Opal Foods LLC captured roughly one third of the chicken table egg industry in terms of total production volume and revenues in 2019 (Table 1). It was estimated that 63 firms with at least 1 million hens each produced 86 percent of total eggs in the United States (Wong 2017). Most large egg firms were highly mechanized, vertically integrated, and highly cost effective. To illustrate how cost effective the overall egg industry was, one dozen eggs equivalent was sold slightly above $1.00 to retail stores, “egg breakers,” and food service companies in 2019.[3] While small farmers have historically made up the egg industry, integration of large companies has increased concentration over the last 5 years, leaving small producers as contract growers for large companies (IBISWorld 2019). As of 2019, Cal-Maine Foods Inc. was the only publicly traded firm in the United States focused exclusively on eggs production and commercialization.

Table 1. Large Egg Producers in the United States as of 2019

Firm	Hens (Million)	Share (%)	Revenues ($ Million)	Market Share (%)
Cal-Maine Foods Inc.	42.5	12.5%	1,460.0	15.5%
Rose Acre Farms Inc.	24.8	7.3%	578.8	6.1%
Rembrandt Enterprises	14.5	4.3%	338.4	3.6%
Michael Foods Inc.	11.3	3.3%	264.4	2.8%
Hillandale Farms Inc.	9.0	2.6%	210.0	2.2%
Sparboe Companies	7.2	2.1%	209.6	2.2%
Opal Foods LLC	5.4	1.6%	126.0	1.3%
Others	225.3	66.3%	6,241.3	66.2%
Total	340.0	100.0%	9,428.5	100.0%

Sources: Assembled by authors with information in IBISWorld (2019). Total hens population is from United Egg Producers (2020).

[1] After completing this case, students should be able to: (1) analyze the egg industry, using a systematic analysis framework, (2) critique the assumptions of a stylized capital budgeting model of a vertically integrated egg firm, (3) discuss alternative financial metrics to evaluate capital budgeting decisions and recommend the technique(s) that are most appropriate for this case, and (4) evaluate the impact of two cage-free investment policies on firm profitability and leverage.

[2] The egg industry could be divided in two categories: shell or table eggs (with 87.5 percent share in terms of revenues in 2019) and hatching eggs (12.5 percent), the latter typically used by egg producers to replace and grow the egg-laying flock. This case study focuses on shell eggs.

[3] In 2019, it was estimated that 60 percent of total shell egg production was sold through retail stores, 30 percent was sold to egg breakers who further processed eggs for manufacturers, 7 percent went to the food service or institutional industry, and 3 percent was exported (American Egg Board 2020).

2.2 Egg Production Systems

There are three main production systems: conventional or cage production, cage-free, and free-range. In conventional production, chickens are confined to a small space within cages (e.g., 80 square inches of floor space per hen), and egg collection and feeding are largely automated. Eggs produced under cage production are commercialized as conventional or nonspecialty eggs. In a cage-free production system, chickens are housed indoors in large aviaries rather than in cages. Each chicken is provided more space than in cages (144 square inches), and cage-free facilities allow hens to perform natural behaviors such as perching, scratching, dust bathing, and nesting.[4] In a free-range system, chickens are cage-free, have access to the outdoors, and are produced typically following organic production practices (i.e., certified organic eggs). Eggs produced under cage-free and free-range systems are referred to as specialty eggs. (Eggs with additional nutritional attributes were also part of the specialty eggs category). In 2019, conventional production was the prevalent production system, with a 76.4 percent share. Cage-free and free-range or organic had a combined 23.6 percent share, as shown in Figure 1.

2.3 Cage-Free Eggs: A Growing Segment

While cage-free production is not a new production method, it has grown rapidly during the previous 5 years. From 2008 to 2014, cage-free production represented only between 5 and 6 percent of the U.S. egg market (Toffel and Van Sice 2013; Kesmodel 2015; Egg Industry Center 2019). The rapid growth in cage-free production is because of (1) recent regulation requiring producers to switch from conventional to cage-free production, and (2) pledges by large egg buyers such as McDonalds, Starbucks, Walmart, and more than 200 restaurants and supermarkets, to buy cage-free only products by 2025 (Markets Insider 2017).

The industry has become increasingly regulated to protect hens caged in very small spaces. A *New York Times* article noted that 80 square inches of floor space per hen was “not much higher than a shoe box” (Gelles 2016). Animal welfare groups considered caged laying hens to be one of the most abused

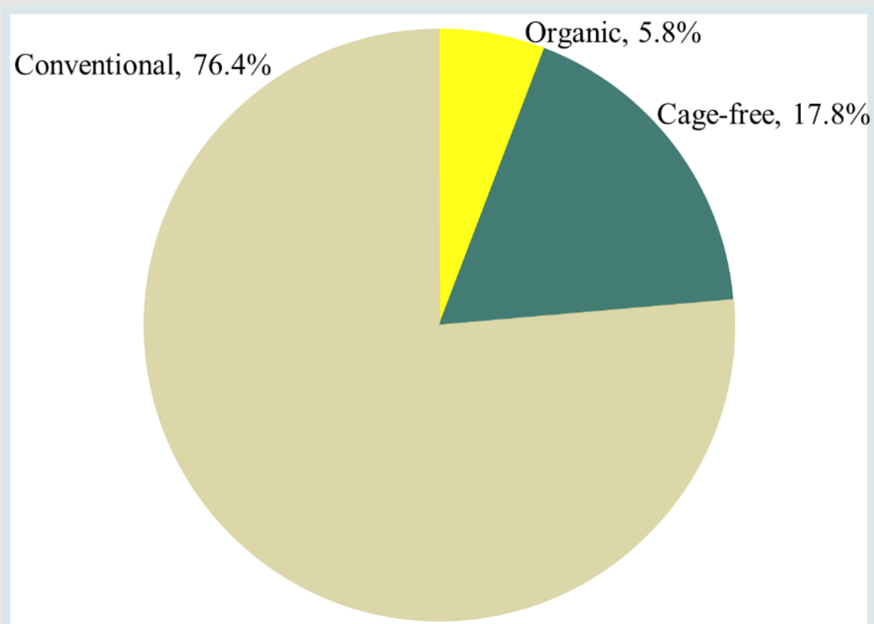

Figure 1. Laying Hens by Production System in the United States in 2019

Source: STATISTA (2020)
Note: All organic producing hens in this figure are produced following free-range practices.

[4] For more technicalities on production systems, refer to United Egg Producers (2017) and Coalition for Sustainable Eggs Supply (2015).

animals, because they were confined in such very small cages (Kesmodel 2015). From this perspective, low egg production costs and low consumer prices were possible at the expense of abused animals. After many years of gradual regulations aimed to protect laying hens (and other animals), on November 6, 2018, California voters approved the Prevention of Cruelty to Farm Animals Act, which required all eggs sold in California to come from cage-free production by 2022. Michigan, Washington, Ohio, Massachusetts, and Oregon have also passed laws regulating laying hen environments.

The big question in the industry was whether egg producers would be able to adjust their laying hen housing systems to comply with expected cage-free demand. All producers listed in Table 1 produced cage-free eggs in 2019, but at relatively low proportions, which illustrated the relatively low market penetration of cage-free eggs. Several forces were impacting the change from conventional toward cage-free production. First, it was costlier, by 41 percent, to produce cage-free eggs, and the price premium paid by consumers over the price of conventional eggs sometimes did not cover the extra costs (Trejo-Pech and Thompson 2020). Second, while large buyers were pledging more cage-free eggs, it was not clear they would be willing to sacrifice profits for the extra cost of producing those eggs. As an example, in 2019 Cal-Maine Foods Inc. noted that the changes it made to its procedures and infrastructure to comply with cage-free regulations resulted in additional production costs that the company was unable to directly pass onto consumers (IBISWorld 2019). Another unknown was whether cage-free rules would continue to gain traction in other states in the future. The preconception that cage-free chickens were treated more humanely was relatively clear to American consumers, as Figure 2 shows. Consumers

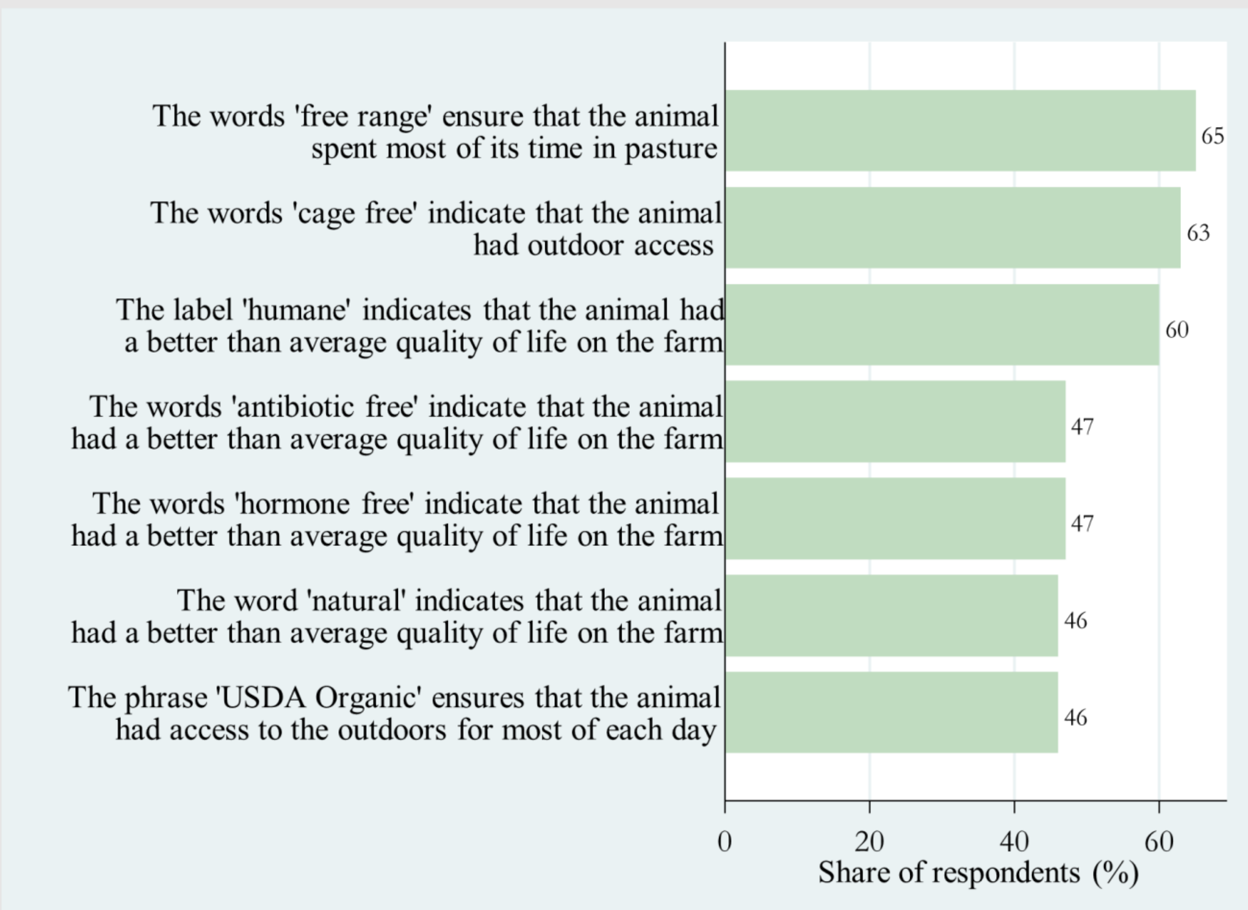

Figure 2. Consumer Perceptions Regarding Animal Welfare Phrases of the Food Products in the United States

Source: STATISTA (2016). Survey conducted by Lake Research Partners (Lake Research Partners 2016).

appeared to be willing to pay more for eggs produced under cruelty-free conditions, but it was not clear how much they were willing to pay. A recent research study surveying consumers had reported that egg consumers were willing to pay for cage-free eggs, on average, $1.16 per dozen above the regular price paid for conventional eggs (i.e., cage-free price premium). However, half of the consumers surveyed said they were willing to pay no more than $0.30 per dozen cage-free price premium, suggesting that a small fraction of consumers were willing to pay sizable amounts for cage-free eggs (Lusk 2019).

Overall, by early 2020 it was unclear whether cage-free production was a better production system for the well-being of animals and workers and for low-income households who were more sensitive to potential egg price increases as cage-free eggs displaced conventional production.

3 A Capital Budgeting Model for a Vertically Integrated Firm

Vertically integrated egg firms engage in all aspects of this business, including the production of pullets or young hens, and the production, grading, packaging, marketing, and distribution of shell eggs. Typically, these firms also prepare hen feed rations and sell egg products such as liquid, frozen, and dried eggs.[5] All firms listed in Table 1 engaged in all or most of these activities and operated two business segments, mainly: (a) conventional and (b) cage-free and other specialty eggs (IBISWorld 2019).

The bank's financial analyst, Stephanie, needed a spreadsheet capturing the business model of a vertically integrated firm, which at the same time needed to be simple and easily adaptable to different potential firms and clients of the bank. The bank was anticipating unusual investment amounts—and financing needs—by egg firms as they transition to produce more cage-free eggs. The model would be useful for financial evaluation and loan adjudication decisions.

Stephanie conceptualized a capital budgeting model in which a firm invested in a given number of conventional and cage-free facilities and produced and processed eggs during the useful life of the facilities, expecting that projected cash flows discounted at a risk-adjusted cost of capital would at least equal to the value of investment. The model would accommodate future investment in cage-free facilities and evaluate its impact on profitability and leverage.

3.1 Price and Cost Parameters

Finding reliable production, cost, investment, and price parameters for the capital budgeting model was a challenge itself since all egg firms, with the exception of Cal-Maine Foods Inc., were privately held firms, which meant they did not disclose their complete financial statements to the public. Even annual financial statements released by Cal-Maine to the public did not provide the level of detail needed to build a model. Stephanie needed to read and analyze historical 10-Q and 10-K reports issued by Cal-Maine Foods Inc. to the Securities Exchange Commission to obtain certain parameters (by business segment), which she required for the modeling effort.[6] Stephanie compiled and processed data reported by Cal-Maine from 2017 to 2019. To standardize the financial information, Stephanie had converted some dollar values into dollars per dozens of eggs, which was the metric commonly used in the egg industry. Other values were expressed as a percentage of revenues. Table 2 provides the parameters Stephanie decided to use as representative for a stylized income statement of a "typical" vertically integrated egg firm.[7]

Stephanie knew that price and cost parameters would vary between firms and thought that the descriptive statistics presented in Table 2 could serve as a basis for a sensitivity or scenario analysis. Regarding the firm size for the typical egg firm modeled, Stephanie was aware that prospective large egg firms for this bank would not be as large as Cal-Maine Foods, which was the largest firm in the country

[5] By-products could include hard cooked eggs, hatching eggs, hens, and manure.

[6] Annual financial statements typically do not breakdown financial data by business segments. Business segments data is usually discussed in the quarterly or annual reports (10-Q and 10-K, respectively) firms file with the Securities Exchange Commission. In this case, the relevant business segments are specialty and nonspecialty eggs.

[7] The term stylized is used to denote the fact that the modeling is kept as simple as possible. Stylized facts are discussed below and indicated in Table 4.

Table 2. Income Statement Parameters

Item	Average	Min	Max	Std. Dev.
Prices:				
Conventional shell eggs ($ per dozen)	0.991	0.705	1.226	0.216
Specialty shell eggs ($ per dozen)[a]	1.928	1.916	1.939	0.009
Egg products and other (% of revenue)[c]	3.4%	3.3%	3.5%	0.1%
Farm production cost:				
Total farm production cost ($ per dozen)	0.701	0.688	0.725	0.017
Conventional shell eggs ($ per dozen)[b]	0.637	NA	NA	NA
Specialty shell eggs ($ per dozen)[a, b]	0.898	NA	NA	NA
Egg products and other (% of total costs)[c]	2.6%	2.0%	3.2%	0.5%
Processing and packaging ($ per dozen)	0.206	0.196	0.214	0.007
Selling, General, and Administrative (SG&A) expenses (% of revenue):				
Marketing of specialty eggs[a,d]	11.0%	10.6%	11.5%	0.4%
Other nonspecific SG&A	9.4%	8.3%	10.9%	1.1%

Sources: Several 10-Q and 10-K Cal-Maine Foods Inc. reports from 2017 to 2019. Accessed in June 2020, available at https://www.sec.gov/edgar/search-and-access.
Note: Cost and expenses include depreciation.
[a] We assume that specialty eggs are cage-free eggs only. However, specialty eggs sold by Cal-Maine may include cage-free and other specialty eggs such as organic. Organic eggs, however, have a small market share (Figure 1).
[b] Farm production costs are estimated by dividing total farm production cost by the number of dozen eggs produced. Farm production cost of conventional and cage-free eggs are estimated by authors considering that Cal-Maine Foods produced, on average, 75 percent conventional and 25 percent specialty eggs during the 3-year period, and assuming that it costs 41 percent more to produce specialty eggs according to Trejo-Pech and Thompson (2020).
[c] Egg products included liquid, frozen, and dried eggs; "others" included hard-cooked eggs, hatching eggs, hens, and manure.
[d] Marketing of specialty eggs are expressed in relation to specialty revenue only, and other nonspecific SG&A are in relation to total revenue.

(Table 1). The Risk Management Association defined egg firms with more than $50 million annual revenue as large companies (IBISWorld 2019). Based on this definition, Stephanie built her baseline model assuming that the firm would have ten conventional and ten cage-free housing facilities.[8]

3.2 Investment and Production Parameters

Stephanie further considered that firm size would affect the cost structure. Relatively small firms might have higher fixed costs. However, given that the bank's goal was to have a benchmark model for large egg firms, she considered that a scale effect factor was not necessary for her initial projections. The characteristics of the 20 housing facilities by production type are given in Table 3.

Data in Table 3 are from a study by the Coalition for Sustainable Egg Supply comparing conventional and cage-free production at the farm level. The Coalition for Sustainable Egg Supply is an entity composed of leading animal welfare scientists, egg farmers, food service firms, and food retailers. Table 3 provides average values of two production flocks in 2010 and 2011. Stephanie adjusted values from the Coalition for Sustainable Egg Supply study into end of 2019 dollar values by using the U.S. Producer Price Index (U.S. Department of Labor, Bureau of Labor Statistics 2020).

Stephanie's assumption to model a firm having the same number (i.e., 10) of conventional and cage-free housing facilities had an added advantage. Such a firm could be seen as managing a portfolio of

[8] Expected revenues of a firm with ten conventional and ten cage-free facilities were estimated to be $89.2 million (Table 4).

Table 3. Investment and Production Data for Conventional and Cage-Free Production Types

Item	Conventional	Cage-Free	Total
Investment ($/facility)			
Land	22,774	11,387	34,161
House plus equipment	3,359,182	2,220,476	5,579,658
Number of housing facilities assumed	10	10	20
Production data			
Total hens purchased (units/flock/housing facility)	196,128	49,760	245,888
Eggs produced per flock (dozens/flock/housing facility)	5,928,337	1,423,795	7,352,132
Dozen eggs produced per hen/flock/housing facility	30.2	28.6	29.9
Shares in terms of number of eggs	81%	19%	100%
Shares in terms of number of hens	80%	20%	100%
Shares in terms of investment value	60%	40%	100%

Source: Coalition for Sustainable Eggs Supply (2015). Dollar values were adjusted into end of 2019 dollar values by using the U.S. Producer Price Index (U.S. Department of Labor, Bureau of Labor Statistics 2020).

two products, with approximately 80 percent and 20 percent conventional and cage-free shares in terms of volumes, respectively, which resembled the composition of the U.S. market in 2020 (Figure 1).

Budgeting investment and operating profits for a representative vertically integrated egg firm was very challenging since values would vary depending on farm location, firm size, hen strain, location of buyers, among other factors. Thus, Stephanie was aware that her model was a “stylized” model at best, but should be useful to estimate financial benchmarks, and most importantly, to evaluate the effect of potential investing and financing decisions as firms started to displace conventional with cage-free eggs.

3.3 Baseline Output

Stephanie had prepared the baseline capital budgeting model (Table 4) using data in Tables 2 and 3 and other assumptions specified in Table 4 footnotes. For this baseline model, free cash flows were projected in real terms (i.e., with no inflation projected), and assuming that prices, costs, and egg production quantities would be constant during eight flock production cycles, equivalent to 10 years (i.e., each flock cycle is assumed to last 15 months). Stephanie thought stylizing a model made it efficient but at the same time made it look unrealistic.[9]

There are alternative financial metrics to evaluate an investment, and Stephanie preferred to use rates of return rather than absolute values such as the net present value. She estimated the internal rate of return for this baseline model obtaining 16.7 percent per 15-month flock.[10] Compared with a 10 percent discount rate used in a previous analysis in this industry (Bir et al. 2018), it seemed that the project was financially sound. She has recently learned that the discount rate could be used to calculate the modified internal rate of return (MIRR).[11] Using the 10 percent discount rate, MIRR was equal to 13.2 percent per flock.[12] Stephanie wondered what rate of return provided a more accurate assessment of a project’s internal profitability and why.

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[9] A discussion on relaxing some assumptions is provided in the teaching notes that accompanies this paper.

[10] This is approximately equivalent to 13.4 percent annually (e.g., 16.7 percent * (12/15)).

[11] Modified internal rate of return (MIRR) provides a measure of internal profitability, based on the timing and magnitude of a project’s cash flows, just as internal rate of return does. MIRR, however, assumes that intermediate cash flows are reinvested at the firm’s cost of capital, while IRR assumes reinvestment at the IRR rate.

[12] Discounting projected real cash flows (without projected inflation rates) with a nominal opportunity cost of capital provides a conservative valuation. This is discussed in the teaching notes that accompany this paper.

4 The Financial Analysis Task

By 2020, it was unclear whether the cage-free egg supply would grow fast enough to honor the pledges made by large egg buyers to buy cage-free eggs only in the mid-term future. Analysts estimated that fully honoring those pledges would imply that the market share of cage-free would need to roughly jump to 70 percent by 2026 (Markets Insider 2017). Nobody knew how quickly the market would displace conventional eggs, however, because of the high cost of new cage-free housing investments,[13] higher cage-free operating costs, higher mortality rates in cage-free production (i.e., lower eggs per hen, as Table 3 shows), and unknown limits of consumers' willingness to pay higher prices for eggs. What was more certain, however, was that egg firms would make additional investments to change the conventional/cage-free mix in their portfolio of products to remain competitive, in sync with changes in the overall egg market mix.

Firms' future cage-free investments might have several effects. First, cage-free eggs would likely cannibalize conventional eggs since they were substitutes and egg consumption was projected to grow at low rates in the mid term.[14] The implication of this is that investing in cage-free facilities might require disinvestment in conventional production facilities to avoid overproducing, with the added complication that one conventional facility produced approximately four times the number of eggs produced by a cage-free facility, as shown in Table 3. Second, cage-free investment and conventional disinvestment could occur at such speed that cash flows might drastically change and increase firm leverage, which would in turn make a firm riskier from the perspective of the bank. Third, the baseline model assumed that cage-free egg prices would remain high (relative to conventional eggs) through the complete eight flock cycles (Table 4). It is likely, however, that cage-free prices would decrease as cage-free market share grew because of the combination of mandated regulation and large buyers' demand, but not necessarily from demand created by the final consumer. It might be the case that up to a certain level of cage-free market share, additional buyers were not able to pay a high premium for cruelty free eggs. Stephanie was wondering how to incorporate this potential decrease in cage-free price as firms invested in additional cage-free production.

Stephanie needed to prepare an investment schedule capturing the implications just discussed. The investment schedule would in turn feed into the baseline model (Table 4) to evaluate the financial effects of new cage-free investments. She recognized that there were many possible combinations of growing cage-free in the portfolio mix. To make her analysis as simple as possible, she defined two investment policies. A quick-investment policy would capture a scenario on which the cage-free market grows quickly in the following years and therefore the egg firm would invest aggressively in cage-free facilities, in sync with the market. A second investment policy captures a slower cage-free growth scenario. Table 5 captures the two hypothetical investment policies. By investing quickly, the egg firm would achieve a 71 percent cage-free and 29 percent conventional mix by the end of the fourth flock cycle. In contrast, under a slow investment policy, the firm would achieve 55 percent cage-free and 45 percent conventional by the end of the sixth flock cycle.

Stephanie was about to start her analyses with some questions in mind. Were those investment policies financially feasible at all given financing constraints? A typical egg firm operating with this bank (her employer) had about 30 percent leverage ratio, defined as total debt divided by total assets, and paid about 20 percent of dividends as a percentage of net income. The bank typically charged a 6 percent interest rate and considered firms with leverage above 50 percent to be highly risky. Stephanie also wondered which of the two investment policies in Table 5 was more profitable. Profitability was important to her employer. When a bank loaned money, its main consideration would be whether the client would be able to pay back the loan. The more "cushion" in profitability the better; in other words, finance a project so that there is income to spare, and it is easier for the client to pay back the borrowed

[13] Converting conventional hen houses and equipment facilities were too costly to a point that it was probably more efficient for firms to demolish conventional facilities rather than remodel them and build cage-free facilities from scratch.
[14] By 2019, the volume of egg substitute products in the United States was negligible (STATISTA 2020).

funds. The bank's concern about leverage entered into her considerations as well. How much more would taking on either project impact the client's existing capital structure? Would one investment policy be better than the other in terms of leverage and risk? While Stephanie was excited about promoting more cage-free investment, from her new banking perspective, she didn't want to encourage ventures that might end in disaster for the bank. In addition, from a client's perspective, what were advantages and disadvantages of following a quick investment policy instead of slower investment?

Stephanie's preliminary results showed that both investment policies yielded a higher MIRR compared with the baseline scenario, with the quick investment policy being slightly better than the slow investment policy. This was consistent with the fact that quantity produced would slightly grow under both investment policies by about 1 percent annually, on average. Under the quick-investment policy, firm' leverage would grow from 30 percent in the baseline to around 50 percent, and the company would need to cut dividends since it would experience economic losses in some years. In contrast, under the low-investment policy, leverage would be low, around current levels of 30 percent, because the firm would be able to generate cash for projected investments.

Stephanie was ready to complete her analysis. She needed to show her boss and colleagues in the bank that she was knowledgeable on the shell egg industry. She also wanted to be able to explain them the capital budgeting model, the assumptions behind it, and how both cage-free investment policies might impact both firm profitability and leverage. To guide her analysis, she prepared a list of questions she thought may help her.

Table 5 shows additional housing facilities planned for the following flock cycles. Positive numbers imply investment and negative numbers imply disinvestment (e.g., demolishing a conventional housing facility). Investments and disinvestments are assumed to occur one flock prior to producing. For instance, the demolition of two conventional facilities and the construction of ten cage-free facilities by the end of flock one affects quantities produced in flock two. In practice, it may take between 1 to 2 years to build a cage-free house (Ibarburu 2019).

5 Discussion Questions

1. Perform an industry analysis of the egg production business using Porter's Five Forces.
2. Discuss the assumptions of the baseline capital budgeting model. What assumptions would you relax to make the model more realistic? Explain.
3. Given the differences between the calculated internal rate of return and the modified internal rate of return for the baseline model, what rate of return do you think more accurately represents the project's internal profitability and why?
4. Identify and discuss what inputs you would need to update/change in the baseline capital budgeting (spreadsheet) model to re-estimate profitability (i.e., IRR and MIRR) and estimate leverage under the two investment policies described in Table 5. Be specific as possible. For example, when considering investments in additional facilities, discuss how depreciation schedules would change.
5. From the perspective of the egg firm, what are advantages and disadvantages of following a quick-investment policy instead of slower investment?

Table 4. Baseline Capital Budgeting Model for a Stylized Vertically Integrated Egg Firm in the United States Assuming Ten Conventional and Ten Cage-Free Housing Facilities

Flock cycle	0	1	2	=>	8
CAPEX ($ thousand)	66,372.1	0.0	0.0	...	0.0
Conventional ($ thousand)	33,819.6	0.0	0.0	...	0.0
Cage-free ($ thousand)	22,318.6	0.0	0.0	...	0.0
Other facilities ($ thousand)	10,233.9	0.0	0.0		0.0
Revenues ($ thousand)		89,235.9	89,235.9	...	89,235.9
Conventional ($ thousand)		58,743.4	58,743.4	...	58,743.4
Cage-free ($ thousand)		27,454.8	27,454.8	...	27,454.8
Egg products and others ($ thousand)		3,037.6	3,037.6	...	3,037.6
Price conventional ($ per dozen)		0.99	0.99	...	0.99
Price cage-free ($ per dozen)		1.93	1.93	...	1.93
Total eggs (thousand dozens)		73,521.3	73,521.3	...	73,521.3
Conventional (thousand dozens)		59,283.4	59,283.4	...	59,283.4
Cage-free (thousand dozens)		14,238.0	14,238.0	...	14,238.0
Farm prod cost ($ thousand)		50,528.0	50,528.0	...	50,528.0
Conventional ($ thousand)		37,745.8	37,745.8	...	37,745.8
Cage-free ($ thousand)		12,782.1	12,782.1	...	12,782.1
Conventional ($ per dozen)		0.637	0.637	...	0.637
Cage-free ($ per dozen)		0.898	0.898	...	0.898
Egg products and other ($ thousand)		2,074.8	2,074.8		2,074.8
Processing and packaging ($ thousand)		15,117.0	15,117.0	...	15,117.0
Processing and packaging ($ per dozen)		0.206	0.206	...	0.206
SG&A ($ thousand)		11,410.2	11,410.2	...	11,410.2
Mkt cage-free eggs ($ thousand)		3,028.6	3,028.6	...	3,028.6
Mkt cage-free eggs (% of c.f. egg rev.)		11.0%	11.0%	...	11.0%
Other nonspecific SG&A ($ thousand)		8,381.6	8,381.6	...	8,381.6
Other nonspecific SG&A (% of revenue)		9.4%	9.4%	...	9.4%
Total costs and expenses ($ thousand)		79,130.0	79,130.0	...	79,130.0
Operating income ($ thousand)		10,105.9	10,105.9	...	10,105.9
Operating margin (%)		11.3%	11.3%	...	11.3%
NOPAT ($ thousand)		7,377.3	7,377.3	...	7,377.3
NOPAT margin (%)		8.3%	8.3%	...	8.3%
Depreciation ($ thousand)		8,253.8	8,253.8	...	8,253.8
Conventional ($ thousand)		4,199.0	4,199.0	...	4,199.0
Cage-free ($ thousand)		2,775.6	2,775.6	...	2,775.6
Other facilities ($ thousand)		1,279.2	1,279.2		1,279.2
Free cash flow ($ thousand)	(66,372.1)	15,631.1	15,631.1	...	15,631.1

Notes: CAPEX stands for capital expenditures; SG&A stands for selling, general, administrative expenses; and NOPAT is net operating profits after taxes. Assumptions for this *baseline* model: 1. No inflation rate forecasted; quantities are the same from flock two to flock eight, 2. Prices and variable cost change with units produced/sold, 3. No investment in working capital, 4. No residual value at the end of the eight flock cycle. In other words, initial investments are fully depreciated, and zero residual market value is assumed, 5. Income tax rate is 27 percent (KPMG 2018).

Table 5. Two Possible Investment Policies for a Prospective Firm Growing Cage-Free Production

Investment policies per flock cycle	1	2	3	4	5	6
Quick investment policy:						
Additional conventional egg facilities	-2	-2	-2	0	0	0
Additional cage-free egg facilities	10	10	10	0	0	0
Share of conventional eggs (%)	81%	62%	45%	29%	29%	29%
Share of cage-free eggs (%)	19%	38%	55%	71%	71%	71%
Slow investment policy:						
Additional conventional egg facilities	0	-1	-1	-1	-1	0
Additional cage-free egg facilities	0	5	5	5	5	0
Share of conventional eggs (%)	81%	81%	71%	62%	54%	45%
Share of cage-free eggs (%)	19%	19%	29%	38%	46%	55%

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Teaching and Educational Commentary

Curating Campus Support Resources to Provide Easy Access for All Students

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Abstract
Anxiety and stress levels experienced by students on college campuses have increased over the last decade. The current COVID-19 pandemic and increased racial tensions have likely exacerbated these feelings further. In an effort to improve student well-being and learning outcomes across a large and diverse student body, we created a repository of information on support services offered to students at the University of California, Davis. Starting with a list of questions we encountered in faculty and staff interactions with students in the Managerial Economics major, we developed a frequently asked questions (FAQ) page that provides brief answers and links to important resources. This resource page can be integrated into online course sites or linked in syllabi; serves as a reference for instructors; and gives all students access to crucial information when navigating life on campus. We describe the initial design, discuss the feedback received after piloting it with students, and explain resulting revisions. The presented usage data indicate that students, faculty, and staff are actively engaging with this resource. Our shared experiences offer important insights for faculty and staff at other universities committed to addressing the achievement gap in economics and higher education in general.

1 Introduction

A college degree is associated with financial stability, career satisfaction, and even success outside of the workplace. It usually coincides with students transitioning into adulthood, and can aid the development of independence, self-sufficiency, and confidence. While enrollment in higher education has increased across all populations, young adults have also become more distressed, more likely to suffer from major depression, and more prone to suicide than in previous generations (Twenge et al. 2019). College students in particular have reported increased levels of anxiety and stress (Cooper, Downing, and Brownell 2018), and tragic outcomes continue to receive national media attention (Scelfo 2015; Brody 2018; Bahrampour 2019). To better serve the needs of a growing and changing student body at UC Davis, the College of Agricultural and Environmental Studies (CA&ES) and the Managerial Economics major, in particular, we created a student resource page that consolidated information and links to support services offered on campus into a single directory. Our primary objectives were to:

(1) Provide easy access to important information for students with a particular emphasis on assisting students during times of high stress, and

(2) Support instructors that often serve as a first point of contact for struggling students.

Choosing a FAQ format, this page provides answers ranging from how to find tutoring support and receive special exam accommodations; locate campus health and counseling services; navigate legal assistance for international and undocumented students; prepare for professional careers; and improve overall wellbeing and engage with the larger campus community. Ensuring that information about support services and resources is easily available to all students is just a first but very important step to addressing disparities in academic performance between groups of students in higher education. Documenting and sharing our experiences in this paper aims at reducing the costs for faculty and staff at other institutions and expediting the design and implementation of similar repositories. A review of resources and services necessary to create these repositories and built-in student and faculty feedback can further expose student needs not sufficiently addressed by support services already in place.

More than 9,000 freshmen and transfer students join UC Davis each year, many of them coming from historically underrepresented racial and ethnic backgrounds (Easley 2018). Ranked number 1 and 2 for agricultural science nationally and worldwide, CA&ES is also the second largest college on campus with more than 7,000 undergraduate students taking classes across its 29 undergraduate majors.[1] A diverse student body is one of the assets of UC Davis and efforts like becoming a Hispanic Serving Institution “shows we’re closing the gap on access to higher education” (Chancellor Gary S. May cited in Kitaura 2019). Yet, the ability to succeed on college campuses continues to vary significantly across students. The economics profession in particular includes disproportionately few underrepresented minorities (Bayer and Rouse 2016; Akke 2020).

While all students are adjusting to being away from home for the first time, first generation college students that are predominantly nonwhite and from low-income backgrounds face unique challenges when transitioning to life on campus (Postsecondary National Policy Institute 2018). International students have to overcome additional language barriers and need to adjust to new cultural norms and customs. Managerial Economics is the largest major in CA&ES and the fourth largest major on campus overall. It has seen significant increases in enrollment with disproportionate increases in students from underrepresented minorities as well as international students. It has also experienced significant increases in transfer students and nonresident students as summarized in Table 1. Finally, more than half of the students majoring in Managerial Economics were originally admitted into other majors at UC Davis and have likely experienced stresses and challenges in their academic careers prior to switching into this major.[2]

As instructors, we are often the first point of contact for struggling students, yet we lack the resources to offer additional support that allows all students to successfully navigate campus life and improve their learning outcomes when teaching undergraduate classes of more than a 100 students. Furthermore, missed classes, unsubmitted assignments, and failed exams, often symptoms of student distress, can go undetected longer in large classes. While new and targeted services are continuously added, these resources are dispersed among many centers and can often only be accessed by consulting

Table 1. Changes in the Student Population of the Managerial Economics Major

	Fall 2014	Fall 2019
Number of students in major (late in the Quarter)	1,240	1,632
Transfer students	360	487
Non-California students (USA)	24	62
International students	169	459
Underrepresented Minority (URM) students	165	272

Note: These statistics were compiled using the most recent Student Information System data made available by the Office of University Registrar. Transfer students are those students arriving in our major during their junior year from other institutions and community colleges. They do not include those that arrive in other majors and change majors at a later point in time. The Managerial Economics major is administered by the Department of Agricultural and Resource Economics at UC Davis. Students must choose at least one of four emphases (Agribusiness Economics, Business Economics, Environmental and Resource Economics, and International Business Economics) to select restricted elective requirements that focus on a specific area of study within this major.

[1] See https://caes.ucdavis.edu/about/overview/facts-distinctions for additional facts and distinction for CA&ES and https://aggiedata.ucdavis.edu/ for the top ten majors.
[2] Although not reported here, Food Sciences observes similar trends.

knowledgeable individuals in charge of particular programs. Many of the academic support services might not reach some of our students most in need of these programs. Our own experiences teaching a variety of large undergraduate classes in two majors within our college—Managerial Economics and Food Sciences—highlighted the need to better support students during times of high stress to ensure that they will not fall behind academically. Simultaneously, we wanted to design a teaching support tool that allows deans, advisors, and staff to share resources with faculty and students more effectively across campus.

Starting with a list of questions we encountered when teaching and soliciting further feedback from faculty and staff about their experiences, we collaborated closely with Academic Technology Services (ATS) staff to design an interactive FAQs page students could access through their Canvas course sites.[3] Piloting and revising our design after receiving additional feedback from students allowed us to continue to make this tool more user-friendly. In particular, we modified our approach to easily disseminate updates and ensure that information posted on individual course sites remains current. It further supported our outreach efforts, allows staff and students to access and share our compiled resources independently of instructor adoption, and allowed us to monitor page use.

The remainder of this paper is structured as follows: we first describe the initial design of the page and subsequent revisions based on the feedback we received in detail. We then present data on page usage and suggestive evidence on improvements in learning outcomes. We conclude with future directions for exploration.

2 FAQ Page Design

Our focus when designing this resource was that all students are able to easily access information when they most needed it, and in a place they already know how to navigate. We decided early on that we wanted to integrate information on available support services with the general course information as much as possible. Students are used to engaging with course content via Canvas course sites. Challenges and distress might arise or be top of mind while trying to complete assignments on this site. A benefit of using these sites is that students would not have to navigate away and actively seek out additional resources when engaging in their own general searches on other websites. Instructors could further reinforce the availability and usage of our resource page by promoting it in their lectures and refer back to it as needed when issues arise with individual students.

We created our resource within the Canvas environment, injecting custom HTML code into the rich content editor such that we could share the resulting page via the content sharing features built into Canvas. Instructors could also just copy and paste the code and customize it before creating a page within their course sites. In the pilot phase of our rollout, we asked select faculty to join us in testing the Canvas page during the Fall quarter in 2017, reaching around 750 students. By arranging student inquiries in a familiar FAQ format, sorting questions by themes, and in the order of urgency within each theme, we wanted to connect students to answers quickly. To not overwhelm students with too much information all at once and make our site visually appealing to students, we created drop-down menus and used simple images, followed by a brief description of relevant services, as well as links to additional resource sites with more detailed information.

The survey data and constructive feedback collected exposed several weaknesses of our original approach and allowed us to review and edit the provided information. Most importantly, once our original code was embedded by instructors and shared, only they had editing privileges, and ATS staff was not able to update, add, or correct information provided on the individual course pages. The burden to keep the material current and address any emerging issues fell on each instructor under our chosen approach.

We decided to adapt the content to a different platform. Our FAQ page is now housed on WordPress.com, and we are able to review and revise the FAQ page as needed and can centrally update

[3]Canvas is the learning management system adopted at UC Davis.

the page before the beginning of each quarter.[4] We continue to encourage instructors to integrate our page within their Canvas course sites by embedding the page using iFrame elements, but they now can also simply link to our WordPress.com site on their syllabi or other materials provided to students.

Our new approach also gave us broader design options. In the original design of the FAQ page, some of the icons were not visible for some students, and some simply did not work well when trying to guide students quickly to what they were looking for. Some of these difficulties were a result of design limitations within the Canvas environment and permissions to view embedded images. We critically evaluated our original visual icons representing the various categories, added additional pictures, and improved the overall organization of the page. As a result, our page design is more in line with traditional website appearances.

Our revisions further incorporated additional student feedback received with regards to the information provided. Students suggested that in some instances, it was difficult to navigate from our page to the desired and more specific resources. We reviewed our links provided and were able to identify more direct links that made specific information more readily accessible in some cases. We also learned that overall wellness and community engagement were even more important to students than we had originally assumed. While we offered much needed information for students in distress, students felt we did not include enough of these resources in our FAQ page. Food security has become an important general concern among our student population, and students specifically mentioned the challenge of accessing affordable and nutritious foods in their comments. We added a link to the food pantry on campus and now provide other resources that will connect students to various resources in the Davis community as well. We also added information on healthy eating, exercise, and work-life balance. Finally, students asked to include volunteering opportunities, information about social clubs, and other community activities on our page. Although UC Davis students are encouraged to take part in various campus activities and to get involved in the Davis community to develop life skills and play an active role in transforming their community, these opportunities were not easily accessible to all students. We added additional campus and community resources to our FAQ page.

We did not incorporate all recommendations received, however, and acknowledge trade-offs when trying to support all students and instructors in our college and across campus. Students suggested that more specific information on academic advising in their respective majors might be helpful. We are including links to dean's office advising by college, but providing information specific to each major was not the focus of our efforts and was not feasible in this format. We did add language to indicate that advising services are available within each major and encourage students to seek out appointments with academic advisors or reach out to their instructors. This is one area where instructors can offer individual support and already work closely with advising staff in most cases.

Overall, revising our original design was not without challenges. We had to rebuild the page's formatting from scratch, as well as migrate text, links, and images by hand from our original page built within Canvas. In retrospect, we strongly recommend building such resources independent of course managing sites to avoid additional formatting and maintenance costs. Furthermore, during the pilot phase, student access was dependent on the integration of this resource page by each instructor, making it contingent upon their interest in adaptation and familiarity with Canvas tools, as well as overall organization of materials provided to students via Canvas. Instructors can now also include a link to our FAQ page on their syllabi, and students can find and share this resource even when professors are not promoting it. Similarly, advising staff can utilize the resource and promote it with students in individual appointments, via email lists and on social media accounts.

One additional benefit of our redesign and use of a WordPress.com site is that it enables us to directly track page usage. We are presenting usage data collected via surveys during the pilot phase,

[4] Please visit https://ebeler.faculty.ucdavis.edu/resources/ to view the FAQ page as well as instructions provided to instructors.

newly available page analytics, and briefly discuss suggestive evidence on the effect on learning outcomes in the remainder of the paper.

3 FAQ Page Adoption by Students and Faculty

We began our assessment of student use of our developed FAQ page by distributing a survey during the pilot phase. Table A1 in the Appendix documents the five questions included in our brief survey in two of our own classes taught during the 2017 fall quarter. We received 166 completed survey responses. Eighty-two percent of students felt that the resource was easy or somewhat easy to navigate, and 73 percent said they were likely to use the page again. Furthermore, 69 percent of respondents said they would recommend the resource to other students, an aspect made easier after our revision. The following three comments further illustrate the overwhelmingly positive reaction even prior to our revisions and highlight that students felt our resource is particularly beneficial to new and incoming students:

> *"It was really easy to find information because it was all categorized based on the questions we had . . . I found everything I needed, and I am sure other students will be able to have an easy time as well. I really appreciate that we have these resources available to us because it makes life so much easier. Thank you."*

> *"I would definitely recommend this to freshmen and other students that are wanting to learn more about resources and information offered by the colleges."*

> *"I thought all the information was very useful. I would definitely recommend using this to a first year student."*

These positive responses as well as the constructive feedback offered were already an indication that students actively used this resource. Once we migrated our revised FAQ page to WordPress.com, we were able to access usage data more directly.

We started promoting this new approach prior to the 2019 Spring quarter and observed a more than 500 percent increase in usage at the beginning of the Fall quarter. We continue to observe significant spikes at the beginning of each quarter as shown in Figure 1. These are likely a combination of our targeted outreach efforts and heightened attention of students during that time. Prior to the beginning of each quarter and with the support of the CA&ES's Dean of Undergraduate Studies, we email all faculty about our resource, include selective feedback to motivate its use, and include instructions for a Canvas page integration or inclusion of the link in their syllabi. We also recommend that instructors introduce this resource to their students during the first week of classes. The dean's office support staff commented that the FAQ page "is an excellent resource for all of our students" and has started to actively encourage all faculty to integrate our FAQ page into their course materials through other channels. They for instance introduce new faculty to this resource during faculty orientation events. Furthermore, we continue to promote our resource directly among instructors within our departments, especially those newly hired. Overall, these efforts resulted in 91,516 total and 70,242 unique page views to date.

For the large number of new faculty that recently joined our campus community, many of which are asked to teach large undergraduate classes, this resource can be particularly useful. It can improve their teaching effectiveness and engagement with students, and in turn minimize their anxiety and experienced stresses. To receive direct feedback on the usefulness of our tool to instructors, the dean's office reached out to new faculty in particular with a follow-up email. The following comments received indicate that our tool indeed supports their teaching efforts:

> *"This is excellent and will be perfect for my class. Most of the students this quarter are new transfer students. Thanks!"*

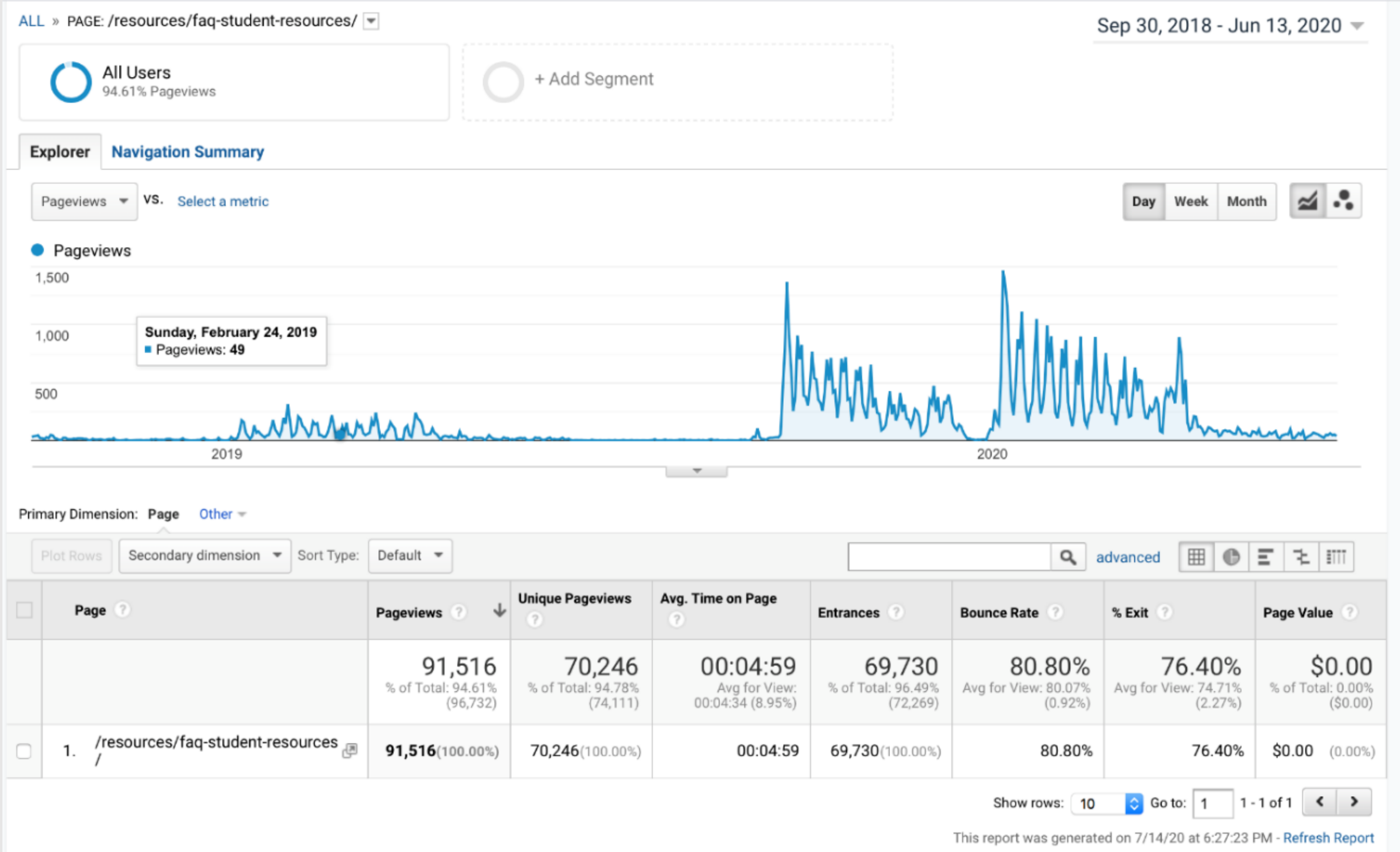

Figure 1. FAQ Page User Statistics

Note: This graph depicts user statistics over the time period of our WordPress implementation. We began promoting this resource with faculty prior to the spring quarter of 2019 and continue to observe significant spikes at the beginning of each term when we intensify our outreach efforts. While we saw an increased use at the beginning of the 2020 spring quarter with 892 page views on the first day of the quarter, students significantly reduced their continuous interactions for the remainder of this remote teaching quarter.

> *"This is a great resource for students. I've included it on the Canvas site for a course I'm teaching this fall and forwarded the info to share with department faculty."*

> *"As a professor who teaches a very large enrollment undergraduate class (570 students), I find that some students may need tutoring or writing support. Having this tool enabled me to direct my students to the right campus resource for help."*

Finally, while we are not able to directly measure the impact on learning outcomes, we have noticed that more students have taken advantage of special accommodations like increased exam time and help with note taking, as well at tutoring and writing services in the large classes we teach. The quality of writing for submitted final projects has also improved, especially among international students. A look at time to graduation further revealed a slight increase in the rates of students graduating on time in our major. Among freshmen who arrived from 2012 to 2015 at UC Davis, those in Managerial Economics graduated on time at a rate of 70.5 percent compared with the campus and CA&ES averages of 61.87 and 66.06 percent.[5] For transfer students arriving in our major between 2014 and 2017, the on-time

[5] The on-time graduation rate in Food Sciences increased to 77.80 percent and is almost on par with the 2030 campus-wide goal of 78 percent.

graduation rate of 64.10 percent is significantly higher than the campus and CA&ES averages of 48.20 and 39.71 percent. It approaches the 2030 campus goal of 66 percent.[6]

4 Conclusions and Future Directions

Increased levels of anxiety and stress continue to impact students overall well-being for a large share of the over 30,000 undergraduate students currently enrolled at UC Davis. Although student diversity is one of the assets of large public institutions like UC Davis, the ability to succeed on college campuses varies significantly across students. As instructors, we are often the first point of contact for struggling students. However, we often lack the resources to support students in unique situations and from diverse backgrounds in achieving course-specific learning outcomes or overall academic success, and students in distress can go unnoticed in large classes. We wanted to explore ways to make the already existing support services offered on campus accessible to as many students as possible while at the same time minimizing the additional burden put on instructors teaching large undergraduate classes.

Our own experiences and additional feedback from faculty and staff led us to design a repository of information on support services in a FAQ layout. We placed a particular emphasis on assisting students during times of high stress, making the resource easy to use, and keeping the information provided general enough such that it can be used across campus effectively. Several revisions have made it easier for faculty to integrate our page into their course materials on Canvas or share a link in other course material provided. Staff and students can now also share the resource independently. Finally, our revised approach allowed us to better track usage, and we continue to observe upward trends in both page views and unique visitors.

Our data analysis, though limited, strongly indicates that we have created a valuable student resource page that supports teaching and learning in our majors, and we continue to expand our outreach and promotion to allow more faculty and students to benefit from this comprehensive resource guide. Prior to the start of the 2020 spring quarter, we have incorporated information about COVID-19 and included links to updates for the campus community as well as resources created specifically to support students during these extraordinary times. Transitioning to remote instruction has made it even more critical to ensure that all students have easy access to information about support services in one place. What is striking is that while we see the same spike in usage at the beginning of the 2020 Spring quarter, Figure 1 also shows a significant decline in usage for the remainder of the remote teaching quarter. Many of the services we compiled limited their operations, and their websites referred students back to the same COVID-19 student resource link we had added at the beginning of our page. Students might have directly referred to this centralized page throughout the remainder of the quarter in an attempt to address urgent issues rather than repeatedly consulting our more comprehensive resource guide.

Of course, making information easier accessible to all students will not be enough to reduce the hardship and distress disproportionally experienced by some of our students. Our analysis of 2019 graduation data revealed that while slightly increasing as well, students from underrepresented minorities and international students continued to have lower on-time graduation rates in our majors and across campus. Being able to address diverse outcomes across specific groups of students will require a more thorough evaluation of why we continue to see an achievement gap in higher education, including potentially different levels of preparedness prior to arriving on campus and additional support needed once here. The transition to remote teaching and learning likely increased existing disparities and added new challenges—some students thrived at home while others were unable to fully participate or concentrate on learning. Some but not all of them reached out asking for help or special accommodations because of their unique situations directly. We are actively involved in a systematic review of institutional biases that hinder and new approaches that support learning outcomes for students from underrepresented minorities, and continue to explore ways to support every student's well-being and

[6] In Food Science 52.90 percent of transfer students in graduate on time.

success. Ensuring that information about support services and resources is easily available to all students is just the first but very important step in these efforts.

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2(4) doi: 10.22004/ag.econ.307149

Appendix:

Table A1. Student Feedback Survey During Pilot Phase of Implementation

Survey Question	Response Options
Question 1. ELECTRONIC CONSENT: Please select your choice below. Clicking on the "agree" button below indicates that: ● you have read the information on the first page of this quiz informing you about the context of this survey ● you voluntarily agree to participate ● you are at least 18 years of age If you do not wish to participate, please decline participation by clicking on the "disagree" button.	Agree Disagree
Questions 2. How easy was the site to navigate?	Very easy Somewhat easy Neutral Somewhat difficult Very difficult
Question 3. How likely are you to use this site in the future?	Very likely Occasionally Rarely Not very likely
Question 4. How likely would you be to recommend this site to another student?	Very likely Might recommend Neutral Not very likely
Question 5. Was there anything or any information that you were looking for and could not locate?	Yes. If yes, please briefly describe. No

Note: This survey was distributed to two large undergraduate classes taught by one of the coauthors each during the 2017 fall quarter. We received 166 completed responses.

Teaching and Education Commentary

A Commentary on Extension Education Programming: An Overview of the CattleTrace Extension Program and Graduate Extension Education

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JEL Codes: Q000
Keywords: Beef cattle, extension, program evaluation, traceability

Abstract
This commentary reviews the development of an extension education program within the context of the Agricultural and Applied Economics Association's Extension Competition. The competition gives graduate students the opportunity to develop extension education skills through the development of an extension education program that focuses on CattleTrace, one of the largest beef-cattle disease tracing programs in the United States. The extension program's main objective is to identify industry participants and provide them with economic analysis and potential policy impacts relating to CattleTrace. The main outputs of the program include in-person workshops and conferences, informational factsheets, and economic decision tools.

1 Introduction

Extension services and programming have a track record of adapting not only to new developments in knowledge, technologies, and policies, but also to changes in consumer demand, producer demographics, and other factors to provide critical, researched-based information to producers and consumers. Training the next generation of extension economists is therefore of the utmost importance. But that task has become ever-more challenging. Given reduced funding, declining rural populations, increasing competition from private outlets, and demand for information on a wider and wider variety of topics, Taylor and Zhang (2019) suggest the development of skills-building workshops and seminars that will allow undergraduate and graduate students to prepare to pursue extension services careers.

One training opportunity is provided by the Agricultural and Applied Economics Association's (AAEA) Extension Competition, which helps graduate students develop extension education skills. This commentary highlights the need for similar training opportunities, provides an overview of the analysis on which an extension program is built, and illustrates the comprehensive nature of extension service delivery for a multi-stakeholder program using a case study: establishment of an extension program for CattleTrace, a disease traceability program designed to (1) educate beef stakeholders in Kansas about the expected impact of the program, (2) provide information and resources to help producers make informed decisions in relation to the program, and (3) provide an industry-wide analysis of the program's expected economic impact. This commentary conveys and reflects on highlights of a presentation on the CattleTrace Extension Program—a presentation that received first place in the 2019 AAEA Extension Graduate Student Competition.

Design and delivery of extension education programs are often overlooked in the academic training of extension students. In the United States, North Carolina State University is the only bachelor's program specifically focused on extension education, and few agricultural economists' course requirements include extension education training. As more students look to enter industry or extension, rather than academia, improved training related to extension programming in graduate programs is needed.

Cole (1981) referenced the use of "tried-and-true" methods of extension teaching and divided them into three main categories: individual contact, group contact, and mass media. Office visits, farm visits, or phone calls fall under individual contact. Workshops, illustrated lectures, and symposiums are considered group contact. Mass media includes news stories, radio, and publications. A report compiled by the Federal Extension Service in 1954 outlined the same broad categories and their relative effectiveness at the time. These historical reports suggest that utilizing methods from all three broad teaching method categories is important to information dissemination.

Researchers with the University of Tennessee Extension Service examined preferred methods of information delivery in the digital age. Their study found that traditional methods, face-to-face delivery and factsheet publication, were still the most effective tools. Relatively young study participants, mostly consisting of producers, did not necessarily have a preference for technology-based delivery (Sneed and Franck 2019). A commentary provided by Rader (2011) suggested that to be successful, online extension programs should structure their websites to meet stakeholder needs, allow collaboration among stakeholders, and present material that is specifically designed for web-based delivery. Each of these observations were taken into consideration in developing the CattleTrace Extension Program.

2. Cattle Traceability

Traceability has increasingly become a focus for beef industry stakeholders, including the United States Department of Agriculture (USDA), the National Cattlemen's Beef Association (NCBA), and high-volume beef-exporting states (NCBA 2017). The focus on traceability within the United States began after several international animal disease outbreaks. Additionally, increased globalization and imports and exports of both live animals and meat, has made disease monitoring increasingly important. In April 2019, the USDA announced that by January 1, 2023, all beef and dairy animals moving interstate will be required to have radio frequency identification. A lack of confidence about the viability of industry-wide implementation of such a regulation resulted in the regulation's redaction (USDA APHIS 2019). The uncertainty and concern surrounding traceability policy emphasizes the timeliness of an extension program.

Market segmentation, production variability, geographical disbursement of production, and strong global demand makes traceability difficult to implement. Despite the lack of a national traceability program, U.S. beef has remained internationally competitive. The positive international perception of domestic beef, along with a fear of increased cost and other long-term implications, has led some industry stakeholders to oppose a potential government-mandated traceability program (Golan et al. 2004).

Several studies, including Coffey et al. (2005), support the positive impact that a traceability program could have on the U.S. beef industry by avoiding loses from reduced exports and inventory in the event of a disease outbreak. However, all current studies suggest a significant economic impact to the industry due to implementation—so much so, that the NCBA included traceability in its 2016–2020 Long-Range Plan (NCBA 2017). Determining the costs and economic impacts of a traceability program within the United States is difficult due to the nature of the supply chain, but it is crucial to allow the potentially affected industry segments to mitigate any potential adverse impacts.

Extension programs are often provided in an effort to disseminate information or to aid producers in understanding the impact of production decisions. The proposed CattleTrace Extension Program is preemptive, allowing cattle producers and industry stakeholders to directly shape the development and implementation of a national disease traceability program by disseminating traceability research and pilot program information directly to producers and other industry stakeholders.

3. CattleTrace Extension Program Overview

In 2018, a pilot program called CattleTrace (uscattletrace.org) was launched in Kansas with the support of industry stakeholders to begin directing the beef industry toward a cohesive, birth-to-slaughter disease traceability program. In January 2020, a new initiative, U.S. CattleTrace, combined the efforts of

CattleTrace with pilot projects underway in Florida and Texas. The CattleTrace program includes participants from all segments of beef cattle production.

The extension program described in this commentary is based on an economic analysis of the cost of implementing the pilot CattleTrace program in Kansas. The analysis included estimated cost budgets for each industry segment and scaled economic analyses based on head of cattle and capacity, allowing for economies-of-scale considerations.[1] The analysis showed that cow-calf producers would bear more than 80 percent of the total economic cost for the industry.[2] Each industry segment received a factsheet describing the expected impacts for that segment as well as expected benefits to the industry as a whole (Figure 1).

The target audience for the CattleTrace Extension Program is Kansas beef-industry stakeholders. Because the beef industry is highly segmented, the extension program prepares segment-specific presentations and workshops. These events include an overview of the CattleTrace Pilot Program, its segment-specific impact, and its budget as well as first-hand accounts of program implementation on the operations of CattleTrace participants. Additionally, these events include time for questions and roundtable discussions to garner reactions and address producers' concerns. By providing economic analysis and estimating budgets for each segment, the extension program aids producers in making decisions and managing costs when implementing the traceability program.

3.1. Extension Program Delivery and Communication Methods

To maximize information dissemination and retention, the CattleTrace Extension Program makes use of existing events for Kansas beef producers, including Kansas State University's (KSU) Cattlemen's Day,

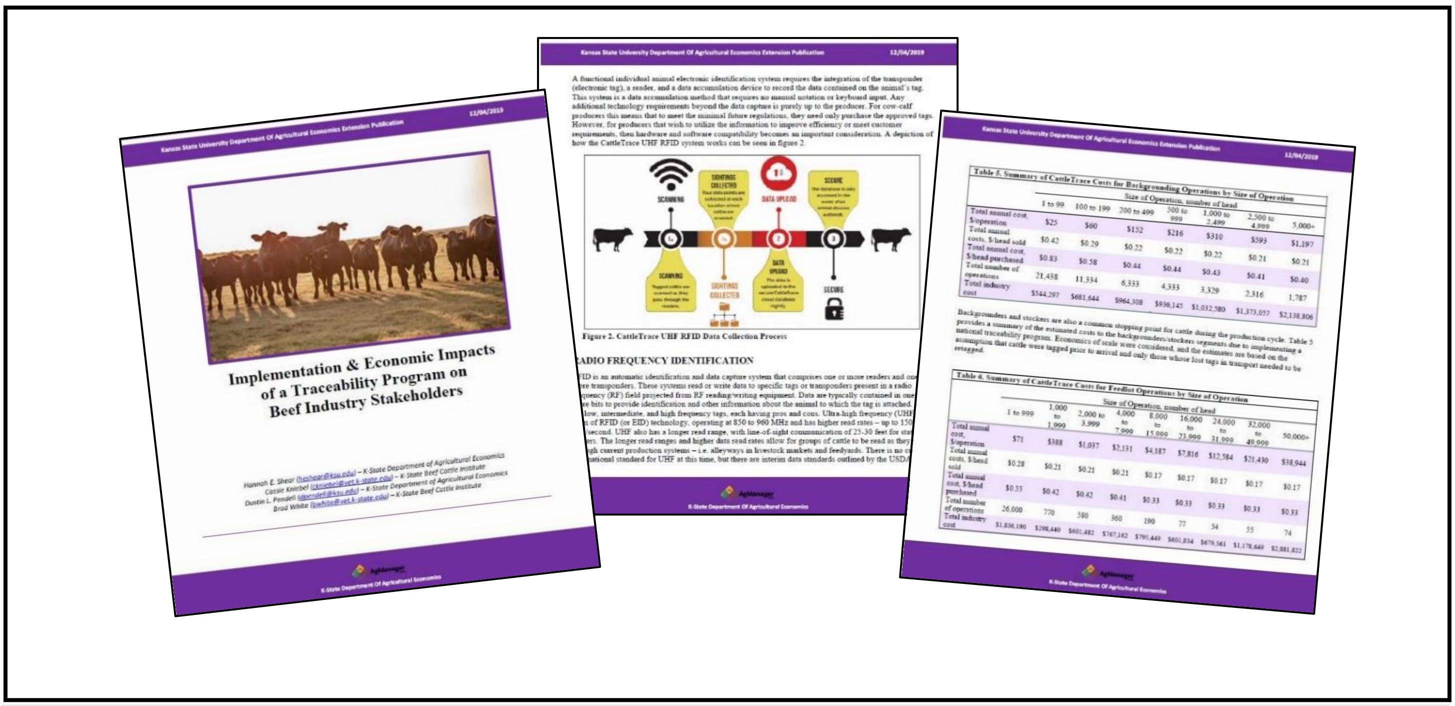

Figure 1. CattleTrace Extension Program factsheet (Available in print and online on Agmanager.info).

[1] See http://www.agmanager.info/livestock-meat/cross-subject-areas/implementation-and-economic-impacts-traceability-program-beef. The beef industry is segmented into cow-calf producers who sell calves for their main source of income, backgrounders and stockers who feed calves to a particular weight before selling, sale barns that assist in the selling of livestock, feedlots where cattle are fed for a short period of time on grain, and packers.

[2] See http://www.agmanager.info/making-%C2%A2ents-cattletrace-costs-and-economic-impacts.

Figure 2. CattleTrace Extension Program Summary Diagram (Including program outputs, resources, and events)

Kansas State Stocker Field Days, and the Ranching Summit.[1,3]

The program provides several types of print and online publications. It issues press releases to announce workshops, point users to program resources, and provide contact information.[4] One release summarized the impact of the traceability system on the beef industry in Kansas. Several established newsletters serve as outlets for program advertisement, providing links to program resources such as factsheets. CattleTrace's active social media pages, including Twitter and Facebook, are used to post event information and provide links to program resources. All extension program materials, including segment-specific factsheets, are made available through the CattleTrace and AgManager.info websites.

The primary extension program leaders make appearances to communicate program information. They participate in radio interviews with Agricultural Today, Kansas State University's Radio Network.[5] On the Beef Cattle Institute's Cattle Chat podcast, they advertise workshops and discuss the economic impact of the traceability program in Kansas.[6]

3.2. Programmatic Impact Assessment

The 1954 federal report on extension teaching found that program enrollment, participation, and publications measure program reach but not necessarily program outcomes such as behavior change (Wilson and Gallup 1954). A report by Smith and Straugh (1983) identified the main challenges facing extension program evaluation as difficulty in identifying both program goals and qualitative ways of measuring impacts.

To address these challenges, the CattleTrace Extension Program at the outset identified explicit objectives and quantifiable measures of program reach and effectiveness. The measures are pre- and

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[3] See https://www.asi.k-state.edu/events/cattlemens-day/, https://www.asi.k-state.edu/news/News_stockerfieldday.html, and https://www.asi.k-state.edu/events/ranchingsummit/index.html.
[4] See https://www.uscattletrace.org/blog.
[5] See https://www.ksre.k-state.edu/news/radio-network/ag-today.html.
[6] See https://ksubci.org/2019/12/06/cattletrace-industry-impacts-cattle-cycle-cow-depreciation-top-3-tips-for-managing-cow-depreciation-dollar-cost-averaging-approach/.

post-workshop surveys, which elicit the information gained from program participation as well as feedback on information delivery. Most critical are questions on the post-workshop survey, administered about six months after the event, about how likely participants are to participate in the CattleTrace program or to implement their own traceability program. These questions help workshop organizers determine whether the workshop will directly lead to any changes by beef producers. These organizers also track downloads of workshop materials, such as budgets and factsheets, and unique visits to program information sites.

4. Conclusion

Providing timely information and decision tools to producers is a key mission of extension and of the extension program for the pilot CattleTrace program in Kansas. By providing segment-specific economic analyses of, and information about, the expected impact of the pilot traceability program on AgManger.info and through workshops, this extension program offers Kansas beef producers the opportunity not only to make optimal decisions but also to help shape the policy and design of a national disease traceability program.

Extension program development, assessment, and delivery are not typically included in graduate extension education. Notably, the extension program for the pilot CattleTrace program in Kansas was developed by a KSU graduate student under the guidance of extension professionals. The presentation on the program received first place in an AAEA Extension Graduate Student Competition, which allows graduate students to deliver an outline of their program to extension specialists for feedback and suggestions for improvement. This competition helps prepare students for a successful career in extension and outreach.

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