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Special Issue: Fostering Diversity and Inclusion in Agribusiness and Agricultural Economics Classrooms and Departments - Part 4

(Special Guest Editors: Mariah Ehmke and Kenrett Jefferson-Moore)

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AAEA Agricultural & Applied Economics Association

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Applied Economics Teaching Resources

Applied Economics Teaching Resources (*AETR*) is an online, open access, and peer-reviewed professional publication series published by the Agricultural an Applied Economics Association (AAEA).

The aim is to provide an inclusive 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 to support and advance teaching and Extension education within the scholarly areas of agricultural and applied economics, and agribusiness economics and management. AETR seeks to publish articles that are diverse in both scope and authorship. It serves as a platform for addressing and contributing to our understanding of important societal issues, including inequality and discrimination, as well as how shifts in pedagogy (e.g., growing reliance on remote and hybrid learning modalities) may impact accessibility and inclusion.

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Teaching and Educational Commentary

Equity and Inclusion as Cornerstones for Building Academic Programs in Agricultural and Applied Economics

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Keywords: Academic programs, diversity, equity, inclusion

Abstract
In this essay, we discuss the importance of equity and inclusion as necessary conditions for increased diversity in agricultural and applied economics and agribusiness (AAEAB) programs. Intentional commitment of resources and integrated strategic execution at the local (university) levels are essential if diverse outcomes and attendant benefits are to materialize.

1 Introduction

As the United States has become more socially diverse, academic programming has adapted to improve academic engagement and the overall educational experience for students, as well as support more comprehensive professional development of faculty and staff. Diversity, equity, and inclusion (DEI) are vital components underpinning our academic curricula, recruitment and retention programming, and workforce development training. On our university campuses, the agricultural and applied economics and agribusiness (AAEAB) profession and for society[1] as a whole, increased diversity yields a myriad of benefits including enhanced critical thinking for a more educated citizenry, improved racial and cultural awareness, and increased long-term economic growth and competitiveness (Milem 2003; Gibbs 2014a; McCluskey 2016; Clayton 2021).

Recent enrollment trends in Food and Agricultural Education Information System (2022) data for 2016–2021[2] indicate an overall decline in undergraduate enrollment in AAEAB disciplines at 1862 and 1890 land-grant institutions (LGIs). This appears driven mainly by decreased enrollment by White non-Hispanic students that has tended to offset increases in minority enrollment (including Asian, Native Hawaiian or other Pacific Islander, Hispanic, and unspecified minorities), which has trended upward since 2016. At 1890 LGI AAEAB programs specifically, Black non-Hispanic enrollment has rebounded following a slight decrease due to the COVID-19 pandemic. Mixed enrollment trends aside, projected job growth due to growing demand for agriculturalists suggests that AAEAB disciplines may have a unique opportunity to build innovative pathways for diverse talent. The "2020–2025 Prospectus on Employment" from the U.S. Department of Agriculture and Purdue University (2020) show that management and business occupations make up 42 percent of the majority share of all jobs available in food, agriculture, renewable natural resources, and the environment sectors. In this article, we position equity and inclusion as central to DEI, and argue that they are essential for diverse outcomes. We are critical of approaches that merely focus on representation and that are rooted in deficit framing. The

[1] Research by Bayer and Rouse (2016), McCluskey (2016), and Yiridoe (2021) offer substantive reviews of the literature relevant to the economics and AAEAB professions.

[2] The Food and Agricultural Education Information System distributes an annual survey on programmatic trends to 1862, 1890, and 1994 LGIs. Not all institutions participate, and a few larger institutions did not respond to the survey throughout the period, 2016–2021. Also, there has been low participation among some 1890 and 1994 LGIs. However, the presented trends reveal compelling implications for the future of AAEAB among all LGI academic programs.

article contributes to existing literature by addressing these issues in the context of the AAEAB profession.

2 Centering Equity and Inclusion in DEI Initiatives

While *diversity* references social identity differences across dimensions[3] and their representation, *equity* focuses on ensuring fair treatment and access to opportunities for advancement while working to identify and eliminate barriers that limit full participation of underrepresented groups (Mercer 2021). One should not assume that homogeneous approaches would necessarily be equitable since individuals could require different resources and support for their advancement (Walters 2020). *Inclusion* seeks to create and sustain environments in which individuals of different identities are supported, and their perspectives and contributions are valued for full participation. The integration of these different elements encourages belonging and retention.

In our profession, DEI initiatives tend to focus mostly on increasing the proportion of individuals from historically marginalized or underrepresented groups. Often characterized as addressing a "pipeline" issue, this approach implies a linearity to achieving diversity by numbers where individuals appear to be included primarily for their differences to benefit the institutions. There is no substantial assessment of environments and systems to determine whether they are conducive to individuals' scholarly and professional development (Gibbs 2014b) in ways that benefit their belonging, productivity, and retention in institutions. Further, while student enrollment in AAEAB programs has diversified over time, AAEAB faculty has not (Hilsenroth et al. 2021). In general, as the student population diversifies, faculty diversity is critical for supporting long-term student success and for maintaining diverse and inclusive environments (Centeno 2021).

There is an urgent need for more effective strategies to bolster student and faculty/staff populations that go beyond merely increasing representation, which we view as a common programmatic shortcoming in DEI initiatives. Diversifying environments that are neither inclusive nor equitable is tantamount to experimentation. It is inefficient and does not facilitate retention of individuals from marginalized or underrepresented groups. Rather, it imposes high personal and professional costs on these individuals, impacting their mental health, career prospects, and lifetime earnings trajectories (Jefferson-Moore and Walters 2021). Higher education news organizations, including the *Chronicle of Higher Education* and *Inside Higher Ed,* have covered this phenomenon extensively in recent years. We agree with Mercer (2021) that equity and inclusion are processes which, when practiced with intention, lead to diverse outcomes. Intentional commitment of resources, robust multitiered systems of support, and coordinated execution are critical for the benefits of diversity to materialize.

Moreover, there is often an imprecision in language that distorts what diversity means and implies that it is antithetical to meritocratic principles (Gibbs 2014a). Initiatives that use deficit-based framing to emphasize challenges and remediation of individuals to fit within environments, tend to create and reinforce this perception. There needs to be a shift toward asset-based framing that recognizes the strengths and contributions of individuals before their challenges, and that also connects disparities to systemic factors that create inequity and exclusion within environments. DEI initiatives should therefore be aimed at cultivating a myriad of skills and talents, as well as promoting the full inclusion of excellence across the social spectrum with individuals from traditionally underrepresented and traditionally well-represented backgrounds (Gibbs 2014a).

[3] This includes gender, race, ethnicity, sexual identity, sexual orientation, disability, age, socioeconomic status, and national origin.

3 Local Level Engagement

We propose a broad framework highlighting commitment, structure, support, and success as four elements to assess in prioritizing equity and inclusion at the local (university) level. First, the commitment to DEI must be intentional with direction and support from administrators. There must be critical examination of department and college level policies and curricula, and of existing programs to identify equity gaps and make policy changes where necessary. Using evidence-based strategies, administrators should identify opportunities and set appropriate goals that are specific, measurable, attainable, relevant, and timebound (SMART) with accountability measures built in. Appropriate resources, including funding, should be assigned to initiatives that would facilitate and support equitable and inclusive environments. Each level of the academic ecosystem (administration, faculty, staff, and students) should be involved with and communicate initiatives, since the strategies would need to be executed across all levels of an institution (Martinez-Acosta and Favero 2018). An effective structure for programing will require organizational cultures that promote belonging and that focus on honing strengths as opposed to simply addressing deficits of individuals, particularly those from historically marginalized or underrepresented groups. Leaders and committees must be empowered and authorized to effect change systems within institutions and assess relevant DEI metrics across programs. Efforts must be collaborative, not duplicative, and the messaging must be coherent. Meaningful support would facilitate access to resources, and transparent and equitable treatment so that there are more opportunities for advancement, especially for those from historically marginalized groups. With elements working in tandem, success may be evident through such metrics as increased enrollment, retention rates, degrees awarded, and career placement (for students) and greater productivity, retention, and professional advancement (for faculty and staff).

4 Association Level Engagement via AAEA

As a leading national organization, the Agricultural and Applied Economics Association (AAEA) is committed to promoting a culture of engagement and supporting contributions from diverse perspectives to benefit and advance the profession. For the past forty years, the Committee on the Opportunities and Status of Blacks in Agricultural Economics (COSBAE) and the Committee on Women in Agricultural Economics (CWAE) have provided leadership on this front. Both sections have explicit missions to promote members' welfare and professional advancement, and advocate for greater inclusivity and equity within the AAEA. Recent programs include the COSBAE-CWAE Mentoring Initiative and the CWAE-COSBAE Building the Pipeline Initiative.[4] These aim for increased engagement by students and young professionals from underrepresented backgrounds, and provide framework for teaching, research, and outreach-oriented partnerships between the 1890 and 1862 LGIs. The sections also executed the CWAE-COSBAE Diversity and Culture Survey, which assessed progress on DEI metrics in the association and several agricultural economics departments at 1862 LGIs, primarily. Other notable efforts have included advocacy for and contributions to the AAEA Code of Conduct Policy and subsidized childcare at AAEA meetings.

COSBAE also formed a strategic collaboration with Minorities in Agriculture, Natural Resources and Related Sciences (MANRRS)[5], which is a national association of minority agriculturalists at academic institutions, at governmental and non-governmental agencies, and in the industry. The organization has a primary focus on career development geared toward minorities in agriculture. MANRRS has collegiate chapters at 1890 and 1862 LGIs throughout the United States, Junior MANRRS chapters at high schools in several states, and an impressive roster of corporate partners. The goal of this partnership is to

[4] Efforts within the AAEA have since led to the establishment of a five-year diversity partnership between the AAEA and the U.S. Department of Agriculture, Economic Research Service (2023).

[5] MANRRS web page: https://www.manrrs.org/.

increase minority recruitment into the agricultural and applied economics profession, while fostering more inclusive pathways to support their professional development and career advancement.

5 Final Thoughts

Although comprehensive implementation may be challenging for some academic units, we have observed that DEI initiatives that are anchored by multicultural affairs units that prioritize equity and inclusion appear to have more successful outcomes for diversity. Though not an exhaustive list, intangible supports such as cultural events, advisement, mentoring, and personal/professional development, and tangible supports including scholarships, fellowships, and developmental funding appear to strongly influence belonging and retention of historically underrepresented students and faculty. Clearly, these initiatives require engagement and changes within institutional environments and across the broader academic ecosystem. Echoing Gibbs (2014a), we maintain that diversity is critical for excellence, and that changes in language and the approach of DEI initiatives are necessary if positive spillover benefits for society are to be realized.

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Research Article

Are We Similar? Differences in Grading Patterns among Departments in the Same College

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JEL Codes: I23
Keywords: Grade inflation, student characteristics, instructor characteristics, higher education

Abstract
Using a unique data set on institutional, instructor, and student characteristics, mixed effect models are estimated to identify factors correlated with class grade point averages (GPAs) over time among different departments in the College of Agriculture and Life Sciences (COALS) at Texas A&M University (TAMU). More departments show more potential grade inflation in the years 2004–2019 than during the years 1989–2003. After controlling for individual instructors, student characteristics appear to be more important than instructor and institutional characteristics, except for class size, in explaining GPAs. The number of students in a class is negatively correlated with grades for all departments and periods. If significant, increase in students' high school rank is positively correlated with university GPA. Graduate students, non-graduate instructors, visiting faculty, and lecturers tend to grade higher than professors. Out of the eight non-science, technology, engineering, and mathematics (STEM) departments, seven (87.5 percent) potentially encountered grade inflation. In contrast, out of the four STEM departments, only two (50 percent) experienced potential grade inflation.

1 Introduction

One cornerstone of academics is student grades. Given the importance of grades in academics, it is not surprising the number and range of studies concerned with examining different aspects of student grades. One aspect receiving attention since at least 1894 (Kohn 2002) is the empirical issue of grade inflation, an increase in student grades without an associated increase in knowledge and learning. Authors, however, disagree if grade improvement (increases in achievement or learning) and not inflation is giving rise to increasing grades (Kuh and Hu 1999; Boretz 2004; Mostrom and Blumberg 2012). A major concern with grade inflation is the existence of inflation may lead to a misallocation of resources since grades lose their ability to distinguish students' abilities. Grade inflation may also lead to other misallocations of resources.

Competition for students and increasing tuition and costs may lead universities to allow grade inflation in the hopes of increasing their reputation, increasing enrollment, and justifying tuition increases (Jewell, McPherson, and Tieslau 2013). Attracting additional students may also provide the university more funds through tuition and fees (Teixeira et al. 2014), but higher than deserved grades will eventually negatively affect the reputation of a university for failing to prepare professionals that meet industries' expectations (Chowdhury 2018). Using student success as a metric for measuring institution's performance may lead to higher grades. As noted by O'Neill (2015), if graduation rates are a criterion, universities may either improve teaching and student motivation or resort to the less expensive way of increasing graduation rates, such as lowering standards.

Concerns over graduation rates, such as those highlighted in recent proposed legislation, the College Completion Fund Act of 2021, may enable grade inflation. This legislation has the intent to ensure more students complete college and enjoy the benefits of a college degree (GovInfo 2022), and may result in lowering standards because it stresses completion rates in the bill. Denning et al. (2022)

provide reasons why one might expect decreasing graduation rates such as increasing tuition costs, increase in hours worked by students, and less time spent studying. They, however, note completion rates have been increasing rather than decreasing partially because of increasing grade point averages (GPAs). Although grade inflation may be addressing the social problem of low completion rates, it does so at the costs of potential declining college wage premium associated with decreased learning (Denning et al. 2022).

Besides distinguishing student abilities and funding, grades may lead to misallocation of students. Hermanowicz and Woodring (2019, p. 497) note, "Grades are a ubiquitous part of college," influencing a large part of undergraduate life from self-definition to graduation and job prospects (Rojstaczer and Healy 2012). With grades being such an important part of undergraduate life, it is no surprise studies such as Butcher, McEwan, and Weerapana (2014) and Opstad (2020) show grades may influence students' choice of majors. Further, different grading norms can be used to manage demand for majors (Diette and Raghav 2015; Hernández-Julián and Looney 2016). Several studies have shown grading norms may differ between universities, colleges, and even different departments within a college in a university (Hartnett and Centra 1977; Achen and Courant 2009; Herron and Markovich 2017; Bond and Mumford 2019). Although these studies suggest there are differences in grading patterns between departments of a college or university, they provide no clear evidence on factors causing these differences.

Using a unique data set, hierarchical mixed effect models are used to identify factors influencing grades in departments in College of Agriculture and Life Sciences (COALS) at Texas A&M University (TAMU). Interviews with different departments' personnel and comparative analysis of exogenous factors are implemented to better understand grades over time. The objectives are to:

1) Determine if potential grade inflation has been occurring by department and if it differs over time, and
2) Examine factors influencing mean class GPA among different departments in COALS to provide information on factors correlated with these differences and explore if the correlations have changed over time.

This study contributes to the existing literature in that it considers a wide array of factors affecting grades in different disciplines and draws parallels among departments. COALS includes a wide range of disciplines, which allows comparisons among the disciplines making the results more generalizable to other universities. Grades over time and differences in factors affecting grades may be used by the departments' administrations to understand whether the changes in grading patterns are the result of improved learning or are consequences of inflated grades.

2 Literature Review

In the past decades, there has been intense competition among universities for high school graduates (Smith, Pender, and Howell 2017). One reason for this competition is decreasing government spending on public education (Cattaneo et al. 2016), which forces universities to attract funding through additional sources, including student tuition and fees (Teixeira et al. 2014). Universities must either increase tuition and fees or enroll more students to address budget shortfalls. Both tasks are challenging. Justification for tuition and fees increases includes improved services and quality of education, which often leads to additional expenditures (Archibald and Feldman 2012). In addition, students' mobility and geographic integration of college markets (Hoxby 2000), as well as emergence of online education make attracting additional students harder. In this competitive environment, some universities try to increase their image and reputation while others, rather than engaging in expensive competition, simply accept weaker students (Jefferson, Gowar, and Naef 2019). Peace (2017) argues that even weaker students expect good grades in return for high tuition and fees. This notion of

"consumerism" creates pressure on institutions to grant higher than deserved grades. Instructors as well may be inclined to grade leniently to avoid time-consuming arguments with students, especially on assignments that may not have a right or wrong answer (Achen and Courant 2009). There is also a labor market justification for granting higher than deserved grades. Graduates from disciplines with higher paying jobs generally have lower grades compared to those graduating from lower pay job disciplines. This grade disparity may be used to attract students to the lower wage disciplines (Sabot and Wakeman-Linn 1991; Freeman 1999; Diette and Raghav 2016).

Evidence of grade inflation and factors affecting grades are the subject of numerous studies over the past decades (e.g., Birnbaum 1977; Kohn 2002; Schutz et al. 2015; Kostal, Kuncel, and Sackett 2016; Peace 2017). Kuh et al. (2006) and Rojstaczer and Healy (2012) find that even after accounting for student aptitude, grades still increased in recent decades. In addition to student characteristics, Yeritsyan, Mjelde, and Litzenberg (2022) also control for instructor-specific and institutional factors but still find grades have increased statistically significantly between 1985 and 2019. Denning et al. (2022) take a different approach and compare end of year test grades and students' GPAs. Over the span of twelve years, students earned better course grades in later years, although end of course exam scores stayed nearly the same (nine out of twelve exams were identical).

Grade inflation as a way of distinguishing student abilities is recognized to be one of the most important issues facing the academic world (Merrow 2004) for at least two reasons. First, inflated grades do not convey the proper message concerning students' abilities and knowledge to future employers. A student with a "B" from an institution where grade inflation is not occurring may be better prepared for the job market compared to a student with an "A" from an institution where grade inflation occurred. Employers without knowledge of grade inflation may be tempted to hire the graduate with higher grades. Second, because grades have a cap (usually 4.0), grade inflation places a good student close to an exceptional student, thus negating the ability of grades to differentiate between students even in the same institution (Kohn 2002).

Differences in grading standards are observed not only between different universities (Popov and Bernhardt 2013), but also between departments within the same university (Sabot and Wakeman-Linn 1991; Herron and Markovich 2017), and even between instructors in the same department (Jewell and McPherson 2012). Hartnett and Centra (1977) discuss departmental differences from the standpoint of students' aptitudes and preparedness. They find significant department-specific differences in student learning outcomes. Several other studies highlight grade differences between science, technology, engineering, and mathematics (STEM) majors and non-STEM majors within the same universities (Ost 2010; Witteveen and Attewell 2020). One common finding is STEM departments tend to grade tougher than departments granting non-STEM degrees. Tougher grading may result in a smaller number of students enrolling in STEM-related disciplines (Rask 2010). Bar, Kadiyali, and Zussman (2009) concur with this finding, adding publicly available grade distributions make it possible for students to self-select into leniently graded classes. Opstad (2020) suggests students may self-select career pathways based on grades; below average-performing students may select majors other low-performing students select. The reason given is it may be easier for a student to obtain a good grade when competing against peer students who are also low performing or less qualified. Studies such as Hartnett and Centra (1977), Achen and Courant (2009), and Herron and Markovich (2017) highlight differences in grading patterns between departments in a college or university. Specific reasons behind the differences, as well as any suggested course of action, are usually not discussed.

3 Data Description and Summary Statistics

Differences in grading patterns are examined for a period of 31 years (from Spring 1989 through Fall 2019), which provides longer coverage than most studies. Data observations are for individual classes (class level data) from Yeritsyan, Mjelde, and Litzenberg (2022). Twelve departments (some departments have had name changes over the period) within COALS at TAMU included in the study are as follows, along with the department's four letter designation and shortened name for brevity in the text.

- Department of Agricultural Economics (AGEC) – Ag. Economics
- Department of Agricultural Leadership Education and Communications (ALEC) – Ag. Leadership
- Department of Animal Science (ANSC) – Animal Science
- Department of Biochemistry and Biophysics (BICH) – Biochemistry
- Department of Biological and Agricultural Engineering (BAEN) – Ag. Engineering
- Department of Entomology (ENTO) – Entomology
- Department of Horticultural Sciences (HORT) – Horticulture
- Department of Plant Pathology and Microbiology (PLPA) – Plant Pathology
- Department of Poultry Science (POSC) – Poultry Science
- Recreation, Park, and Tourism Sciences (RPTS) – Recreation and Parks
- Department of Soil and Crop Sciences (SCSC) – Soil and Crops
- Wildlife and Fisheries Management (WFSC) – Wildlife Management

Data were compiled using information from TAMU, departmental websites, and undergraduate catalogs. Missing data were collected through open access web sources, emails to instructors, and conversations with staff and faculty in different departments (Yeritsyan, Mjelde, and Litzenberg 2022). Classes of less than five students, individual problems, summer semesters, and study abroad are not included in the data.

Because what happened in the distant past may not be as relevant as the present, the data is divided into two periods, 1989–2003 and 2004–2019, which divides the data in approximately two equal periods. Unfortunately, no one event or policy change exists that suggests a date for dividing the data; however, the date roughly corresponds to changes in generations attending college and several policy implications. Around this date, Baby Boomers II (Also known as Generation Jones - born 155-68) were finishing college and Millennials (born 1981-1996) were starting college. Generation X (born 1965-1996) attended college in both periods. . Second, starting in the mid-1980s to mid-2000s, the university implemented policy changes affecting the number of credits necessary to graduate and tuition. These changes are discussed in the student characteristics section.

While differences between periods help in long-term trends, the recent period may be more relevant for addressing policy changes. Thus, the comparative analysis is implemented among departments and within each department between the two periods. GPAs are analyzed as a function of institutional (class time and duration, number of credits, upper or lower division courses, and number of total students in the class) instructor-related (instructor gender, position, and graduating from a university accredited by Association of American Universities (AAU)), and student-related (class averages of student gender, high school percentile or rank, SAT score, class load, and no grade) characteristics (Table 1). Summary statistics, along with tests of differences in the mean values of the variables by period, are in Table 2. Finally, because the data are for class and not department, any class may include students from multiple departments.

Table 1: Description of the Variables Used in the GPA Models

Variable Name	Description
GPA	Class mean GPA
Ln trend	Natural logarithm of trend as given by semester
Morning	Equals 1 if class starts before 12:01, 0 otherwise
Afternoon	Equals 1 if class starts between 12:01 to 15:59, 0 otherwise (dropped to avoid perfect collinearity)
Meet 1	Equals 1 if the class meets once per week—usually class duration is 2.5 hours for a three-credit class, 0 otherwise (dropped to avoid perfect collinearity)
Meet 2	Equals 1 if the class meets twice per week—usually class duration is 75 minutes for a three-credit class, 0 otherwise
Meet 3	Equals 1 if the class meets three times per week—usually class duration is 50 minutes for a three-credit class, 0 otherwise
Lower division	Equals 1 if the class is listed as a 100 or 200 level class, 0 otherwise (dropped to avoid perfect collinearity)
Upper division	Equals 1 if the class is listed as a 300 or 400 level class, 0 otherwise
Total students	Number of students receiving a grade A–F and no grades (see share below) in the class
Low credit	Equals 1 if the class is 1 or 2 credit hours, 0 otherwise—very few classes are 2 credits (dropped to avoid perfect collinearity)
High credit	Equals 1 if the class is 3 credit hours or more, 0 otherwise—very few classes have more than 3 credits
Instructor	Instructor name used as a level, 1,377 instructors
Instructor gender	Gender of the instructor, male = 1 and female = 0
Professor	Equals 1 if the position at the time of instruction was professor, 0 otherwise (dropped to avoid perfect collinearity)
Associate prof	Equals 1 if the position at the time of instruction was associate professor, 0 otherwise
Assistant prof	Equals 1 if the position at the time of instruction was assistant professor, 0 otherwise
Lecturer graduate	Equals 1 if the position at the time of instruction was graduate student, 0 otherwise
Other lecture	Equals 1 if the position at the time of instruction was other lecturer, 0 otherwise (includes visiting faculty, lecturers, non-graduate instructors)
AAU	Equals 1 if the university was AAU member at the time of the instructor's graduation (includes Canadian universities), 0 otherwise

Table 1 continued.

Variable Name	Description
Student gender	Percentage of male students in the class
SAT	Class average of students' combined SAT math scores
Student load	Average number of credits students in the class are enrolled
HS percentile	The average high school rank of students in the class, calculated as the percentile of students in the school that rank below the given student
Share no grade	Share of students who enrolled in the class but did not receive an A–F grade for the class. Includes students who dropped beyond the initial drop date, received an incomplete grade, took the class pass/fail, or was dropped from the class by the dean's office divided by total students

3.1 Departmental GPAs

Department mean GPAs show variability by department, years, and between the two periods (Figure 1). For presentation purposes, the departments are grouped into four subgroups. This grouping consists of Social Sciences, Animal Oriented, Plant Oriented, and Other. All departments' (except Horticulture, Soil and Crop Sciences, and Poultry Science) mean differences between the two period's GPAs are statistically significant (hence the word "significant" is used for ease of reading) at p values of 0.05 or less (Table 2). Three departments, Ag. Leadership, Ag. Engineering, and Wildlife Management, had significant decreases in mean GPAs in the second period relative to the first period. The remaining six departments had positive significant increases. Mean departmental GPAs range from 2.91 (Recreation and Parks) to 3.61 (Ag. Leadership) in the first period, and 3.00 (Wildlife Management) to 3.48 (Animal Science) in the second period. Even within the same grouping, departments have different grading patterns. Within the Social Sciences grouping (Ag. Economics, Recreation and Parks, and Ag. Leadership), Recreation and Parks GPAs, for example, are relatively flat in the first period but show a steady increase in the second period, while Ag. Economics GPAs show a slight increasing trend through most of the first period, then a flat or decreasing trend for the first part of the second period, and an increasing trend after that until the end.

3.2 Institutional Characteristics

Most classes meet in the morning. Only Plant Pathology has less than 50 percent of their classes in the morning. The percentage of classes in the morning range from nearly 82 percent for Animal Science and Entomology in the first period to 38 percent in Plant Pathology in the second period. Except for Plant Pathology and Poultry Science, all departments showed a significant decrease in morning classes with the corresponding increase in afternoon classes between the two periods. There appears to be no common tendency for the number of times courses meet. Most classes in COALS are upper division (junior and senior) classes with all departments having 53 percent or more of their classes being upper division. In the first period, Horticulture and Entomology are the only departments that had nearly equal split between lower division (freshmen and sophomore) and upper division classes. However, in the second period, they increase the share of upper division classes.

Table 2: Variable Mean Values in Periods 1 and 2 and t-tests for Differences in Mean Values

		Social Sciences			Plant Oriented			Animal Oriented			Other		
Variable	**Period**	**AGEC**	**ALEC**	**RPTS**	**HORT**	**PLPA**	**SCSC**	**ANSC**	**POSC**	**BAEN**	**BICH**	**ENTO**	**WFSC**
GPA	1	2.987	3.609	2.911	3.414	3.009	3.043	3.307	3.213	3.262	3.015	3.150	3.095
	2	3.098	3.474	3.073	3.435	3.250	3.100	3.482	3.280	3.179	3.085	3.261	2.998
	Diff.	0.111*	-0.135*	0.162*	0.021	0.241*	0.057	0.175*	0.067	-0.083*	0.070*	0.111*	-0.097*
Institutional Variables													
Morning	1	0.657	0.726	0.691	0.747	0.480	0.702	0.815	0.621	0.805	0.622	0.819	0.685
	2	0.556	0.548	0.518	0.564	0.384	0.602	0.714	0.647	0.668	0.560	0.517	0.591
	Diff.	-0.101*	-0.178*	-0.173*	-0.183*	-0.096	-0.100*	-0.101*	0.026	-0.137*	-0.062*	-0.302*	-0.094*
After-noon	1	0.343	0.272	0.309	0.253	0.520	0.298	0.185	0.379	0.195	0.378	0.181	0.315
	2	0.444	0.452	0.482	0.436	0.616	0.398	0.286	0.353	0.332	0.440	0.483	0.409
	Diff.	0.101*	0.178*	0.173*	0.183*	0.096	0.100*	0.101*	-0.026	0.137*	0.062*	0.302*	0.094*
Meet 1	1	0.000	0.444	0.170	0.386	0.440	0.284	0.448	0.316	0.276	0.195	0.046	0.172
	2	0.068	0.349	0.063	0.472	0.530	0.232	0.502	0.226	0.103	0.229	0.295	0.287
	Diff.	0.068*	-0.095*	-0.107*	0.086*	0.090	-0.052	0.054*	-0.090*	-0.173*	0.034	0.249*	0.115*
Meet 2	1	0.579	0.534	0.439	0.593	0.353	0.369	0.362	0.353	0.514	0.419	0.858	0.737
	2	0.634	0.530	0.581	0.511	0.315	0.437	0.300	0.380	0.620	0.460	0.513	0.665
	Diff.	0.055*	-0.004	0.142*	-0.082*	-0.038	0.068*	-0.062*	0.027	0.106*	0.041	-0.345*	-0.072*
Meet 3	1	0.421	0.022	0.390	0.021	0.207	0.348	0.190	0.331	0.210	0.386	0.096	0.090
	2	0.298	0.122	0.355	0.017	0.156	0.331	0.198	0.395	0.277	0.311	0.192	0.048
	Diff.	-0.123*	0.100*	-0.035	-0.004	-0.051	-0.017	0.008	0.064	0.067*	-0.075*	0.096*	-0.042*
Lower division	1	0.109	0.142	0.244	0.472	0.107	0.13	0.34	0.401	0.293	0.037	0.448	0.144
	2	0.134	0.124	0.153	0.347	0.123	0.158	0.338	0.214	0.12	0.042	0.315	0.078
	Diff.	0.025	-0.018	-0.091*	-0.125*	0.016	0.028	-0.002	-0.187*	-0.173*	0.005	-0.133*	-0.066*
Upper division	1	0.891	0.858	0.756	0.528	0.893	0.870	0.660	0.599	0.707	0.963	0.552	0.856
	2	0.866	0.876	0.847	0.653	0.877	0.842	0.662	0.786	0.880	0.958	0.685	0.922
	Diff.	-0.025	0.018	0.091*	0.125*	-0.016	-0.028	0.002	0.187*	0.173*	-0.005	0.133*	0.066*
Total students	1	62.195	55.688	43.32	45.514	36.507	45.576	63.775	39.342	31.185	62.711	41.915	41.846
	2	69.773	40.612	46.967	48.201	41.414	47.063	62.718	40.282	35.971	48.602	53.942	34.300
	Diff.	7.578*	-15.080*	3.647*	2.687	4.907	1.488	-1.057	0.940	4.786*	-14.110*	12.027*	-7.546*

Table 2 continued.

		Social Sciences			Plant Oriented			Animal Oriented		Other			
Variable	**Period**	**AGEC**	**ALEC**	**RPTS**	**HORT**	**PLPA**	**SCSC**	**ANSC**	**POSC**	**BAEN**	**BICH**	**ENTO**	**WFSC**
Low credit	1	0	0.51	0.129	0.378	0.327	0.2857	0.481	0.305	0.274	0.266	0.043	0.164
	2	0.017	0.192	0.043	0.35	0.474	0.199	0.498	0.276	0.098	0.28	0.235	0.147
	Diff.	0.017*	-0.318*	-0.086*	-0.028	0.147*	-0.087*	0.017	-0.029	-0.176*	0.014	0.192*	-0.017
High credit	1	1.000	0.490	0.871	0.622	0.673	0.7143	0.519	0.695	0.726	0.734	0.957	0.836
	2	0.983	0.808	0.957	0.650	0.526	0.801	0.502	0.724	0.902	0.720	0.765	0.853
	Diff.	-0.017*	0.318*	0.086*	0.028	-0.147*	0.087*	-0.017	0.029	0.176*	-0.014	-0.192*	0.017
Instructor Variables													
Instruct. gender	1	0.951	0.611	0.782	0.764	0.627	0.967	0.859	0.960	0.890	0.779	0.993	0.912
	2	0.914	0.461	0.694	0.846	0.798	0.887	0.786	0.905	0.800	0.695	0.798	0.860
	Diff.	-0.037*	-0.150*	-0.088*	0.082*	0.171*	-0.080*	-0.073*	-0.055*	-0.090*	-0.083*	-0.195*	-0.052*
Professor	1	0.546	0.195	0.294	0.376	0.340	0.484	0.446	0.386	0.499	0.478	0.918	0.539
	2	0.654	0.148	0.214	0.506	0.629	0.489	0.437	0.309	0.478	0.378	0.495	0.585
	Diff.	0.108*	-0.047*	-0.079*	0.131*	0.289*	0.004	-0.009	-0.077*	-0.020	-0.100*	-0.423*	0.046
Assistant prof	1	0.138	0.230	0.235	0.093	0.093	0.029	0.129	0.081	0.123	0.104	0.050	0.132
	2	0.109	0.294	0.130	0.034	0.126	0.130	0.112	0.315	0.122	0.116	0.165	0.090
	Diff.	-0.029	0.064*	-0.105	-0.058*	0.032	0.101*	-0.016	0.234*	-0.001	0.012	0.115*	-0.042*
Assoc. prof	1	0.194	0.227	0.205	0.117	0.240	0.327	0.167	0.346	0.257	0.197	0.028	0.178
	2	0.091	0.249	0.243	0.105	0.215	0.294	0.260	0.252	0.241	0.166	0.194	0.224
	Diff.	-0.102*	0.021	0.038	-0.012	-0.025	-0.033	0.093*	-0.093*	-0.016	-0.031	0.166*	0.046
Lecturer graduate	1	0.068	0.285	0.138	0.184	0.313	0.077	0.185	0.074	0.019	0.040	0.004	0.072
	2	0.054	0.165	0.206	0.057	0.000	0.003	0.140	0.077	0.019	0.021	0.049	0.057
	Diff.	-0.014	-0.119*	0.068*	-0.126*	-0.313*	-0.074*	-0.044*	0.004	0.000	-0.019*	0.045*	-0.016
Other lecturer	1	0.055	0.063	0.129	0.231	0.012	0.083	0.074	0.114	0.102	0.181	0.000	0.078
	2	0.091	0.144	0.208	0.297	0.030	0.084	0.051	0.047	0.139	0.319	0.097	0.044
	Diff.	0.037*	0.081*	0.079*	0.066*	0.028	0.001	-0.023*	-0.066*	0.038	0.138*	0.097*	-0.034*
Non-AAU	1	0.595	0.526	0.566	0.512	0.827	0.542	0.753	0.691	0.843	0.513	0.566	0.816
	2	0.385	0.561	0.586	0.554	0.659	0.574	0.549	0.472	0.711	0.476	0.348	0.711
	Diff.	-0.210*	0.035	0.020	0.042	-0.168*	0.032	-0.204*	-0.219*	-0.132*	-0.037	-0.218*	-0.105*

Table 2 continued.

		Social Sciences			Plant Oriented			Animal Oriented		Other			
Variable	**Period**	**AGEC**	**ALEC**	**RPTS**	**HORT**	**PLPA**	**SCSC**	**ANSC**	**POSC**	**BAEN**	**BICH**	**ENTO**	**WFSC**
Student Variables													
Student gender	1	0.650	0.516	0.502	0.398	0.555	0.739	0.493	0.656	0.802	0.445	0.591	0.561
	2	0.648	0.424	0.418	0.358	0.461	0.706	0.320	0.557	0.781	0.400	0.411	0.508
	Diff.	-0.003	-0.092*	-0.084*	-0.040*	-0.093*	-0.033*	-0.173*	-0.099*	-0.022*	-0.045*	-0.180*	-0.054*
SAT	1	536.455	528.940	528.022	541.225	549.957	547.436	546.728	525.742	563.844	603.335	551.364	554.240
	2	550.955	527.968	543.309	558.052	569.051	549.944	560.975	532.083	592.254	623.538	576.754	568.296
	Diff.	14.500*	-0.973	15.287*	16.827*	19.094*	2.508	14.247*	6.341*	28.410*	20.204*	25.391*	14.056*
Student load	1	14.147	14.223	13.762	13.974	13.918	14.016	14.063	14.323	14.227	14.127	13.974	13.934
	2	13.678	14.114	14.129	14.019	13.955	13.924	13.854	14.286	14.031	13.853	14.019	14.084
	Diff.	-0.468*	-0.109*	0.367*	0.045*	0.038	-0.092*	-0.209*	-0.037	-0.196*	-0.274*	0.045	0.150*
HS percent.	1	76.302	76.146	73.970	78.296	79.295	78.355	81.741	73.857	81.949	88.209	80.167	79.897
	2	73.042	73.031	73.324	78.867	80.296	74.064	83.701	74.391	81.056	87.655	83.949	80.583
	Diff.	-3.260*	-3.115*	-0.646	0.571	1.001	-4.291*	1.960*	0.534	-0.893	-0.554*	3.782*	0.686
Share no grade	1	0.039	0.019	0.043	0.032	0.040	0.041	0.026	0.027	0.021	0.063	0.030	0.042
	2	0.026	0.019	0.042	0.027	0.019	0.031	0.022	0.027	0.017	0.051	0.028	0.037
	Diff.	-0.014*	0.000	-0.001	-0.005*	-0.021	-0.010*	-0.004*	0.000	-0.004*	-0.012	-0.003	-0.005

Note: * denotes statistical significance at 0.05 or lower (p value < 0.05). See text for definitions of department acronyms.

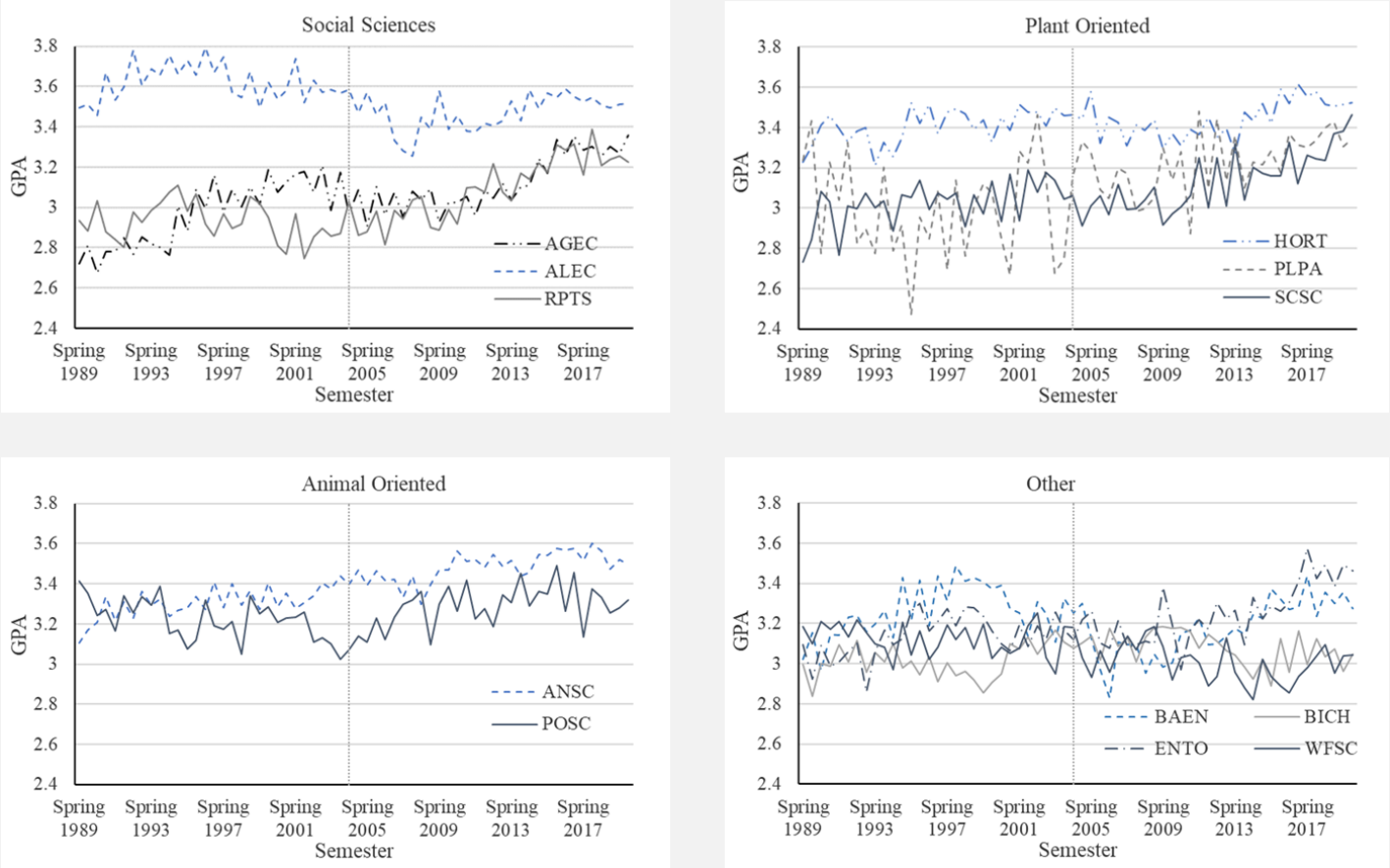

Figure 1: College of Agriculture and Life Sciences Departments' Average GPAs by Semester from 1989 to 2019

Ag. Leadership, Biochemistry, and Wildlife Management show significant decreases in average student enrollment in classes, whereas Horticulture, Plant Pathology, Soil and Crops, Animal Science, and Poultry Science had no changes in average student enrollment per class between the two periods. Ag. Economics, Recreation and Parks, Ag. Engineering, and Entomology had significant increases in average enrollment per class. Average class size is the largest in Ag. Economics (over 69 students in period two) and is the smallest in Ag. Engineering (31 students in the first period). By far, most classes in COALS are three or more credits. Ag. Economics, Plant Pathology, and Entomology have seen decreases in the percentage of three or more credit classes. In Ag. Leadership, Recreation and Parks, Soil and Crops, and Ag. Engineering, percentages of classes with three or more credits increased between the two periods.

There are large variations in class sizes among the departments, and there is variability within a class by semester. Animal Science and Wildlife Management have a fairly stable number of students in classes, while others, such as Soil and Crops had increases in class size until the mid-2000s, but then show a decrease in numbers.

3.3 Instructor Characteristics

All departments have significant decreases in the percentage of male instructors in period two over period one, except Horticulture and Plant Pathology, which have significant increases. Ag. Leadership is the only department that had predominantly female instructors, but only in the second period (54 percent female instructors, note: the value reported in the table is percent male instructors). The percentage of male instructors is as large as 99 percent (in Entomology). Rank of instructors also varies

among the different departments and periods, with no easily discernable pattern. In the first period, for example, almost 92 percent of all instructors in Entomology were professors, while in the same period in Ag. Leadership, only 19 percent of all instructors were professors. If significant, the percentage of instructors that graduated from non-AAU schools decreased between the two periods. The percentage of instructors graduating from a non-AAU school ranged from 51 percent (Horticulture and Biochemistry) to 84 percent (Ag. Engineering) in the first period, and from 35 percent (Entomology) to 71 percent (Wildlife Management) in the second period.

3.4 Student Characteristics

Compared to the previous two groups of characteristics, student characteristics have more similarities in direction and magnitudes among the departments. All departments had decreases in the percent of male students between the first and second period except Ag. Economics, which had no significant change. The percentages of male students, however, still show a wide range, from 40 percent in Horticulture to 80 percent in Ag. Engineering for the first period, and 32 percent in Animal Science to 78 percent in Ag. Engineering in the second period. Average SAT scores are significantly higher in all departments in the second period, except Ag. Leadership and Soil and Crops. SAT scores visibly drop in the last two semesters in almost all departments (Figure 2). The lower end of the range on average SAT scores changed little between the two periods, 526 (Poultry Science) and 528 (Ag. Leadership), whereas the upper end has increased from 603 to 624 (both in Biochemistry).

In six departments (Ag. Economics, Ag. Leadership, Ag. Engineering, Animal Science, Biochemistry, and Soil and Crops), average student load significantly decreased, and in three departments (Horticulture, Recreation and Parks, and Wildlife Management), load increased. Several conflicting policy changes may impact student load. The university gradually decreased the number of credits necessary to graduate from 140 to 120 between the mid-1980s and early 2000s. Currently, TAMU generally requires 120 credits to graduate. Any student taking more than 150 credits is required to pay out-of-state tuition. The number of credits a student can take before having to pay out-of-state tuition decreased between 1999 and 2006. Students graduating with 123 or less credits may be eligible for a small tuition rebate. In Fall 2005, TAMU changed tuition from per credit to a set rate for students taking twelve plus credits. TAMU introduced flat versus variable rate tuition in 2014 where students entering the university can select a tuition plan for the next four years.

Average high school rank is 73 percentile or higher in all departments, meaning that in high school 73 percent or more of all students ranked below those students accepted to COALS. Four departments (Ag. Economics, Ag. Leadership, Biochemistry, and Soil and Crops) had significant decreases in high school rank, whereas two departments (Animal Science and Entomology) show increases between the two periods. Other departments' groupings, which includes three STEM majors (Entomology, Ag. Engineering, and Biochemistry), showed students' high school rank increased in both time periods until the last couple of years. The share of no grade has either significantly decreased or has not changed between the two periods for all departments. Biochemistry (with more than 5 percent of students receiving no grades) had the largest percentage of no grades in both periods.

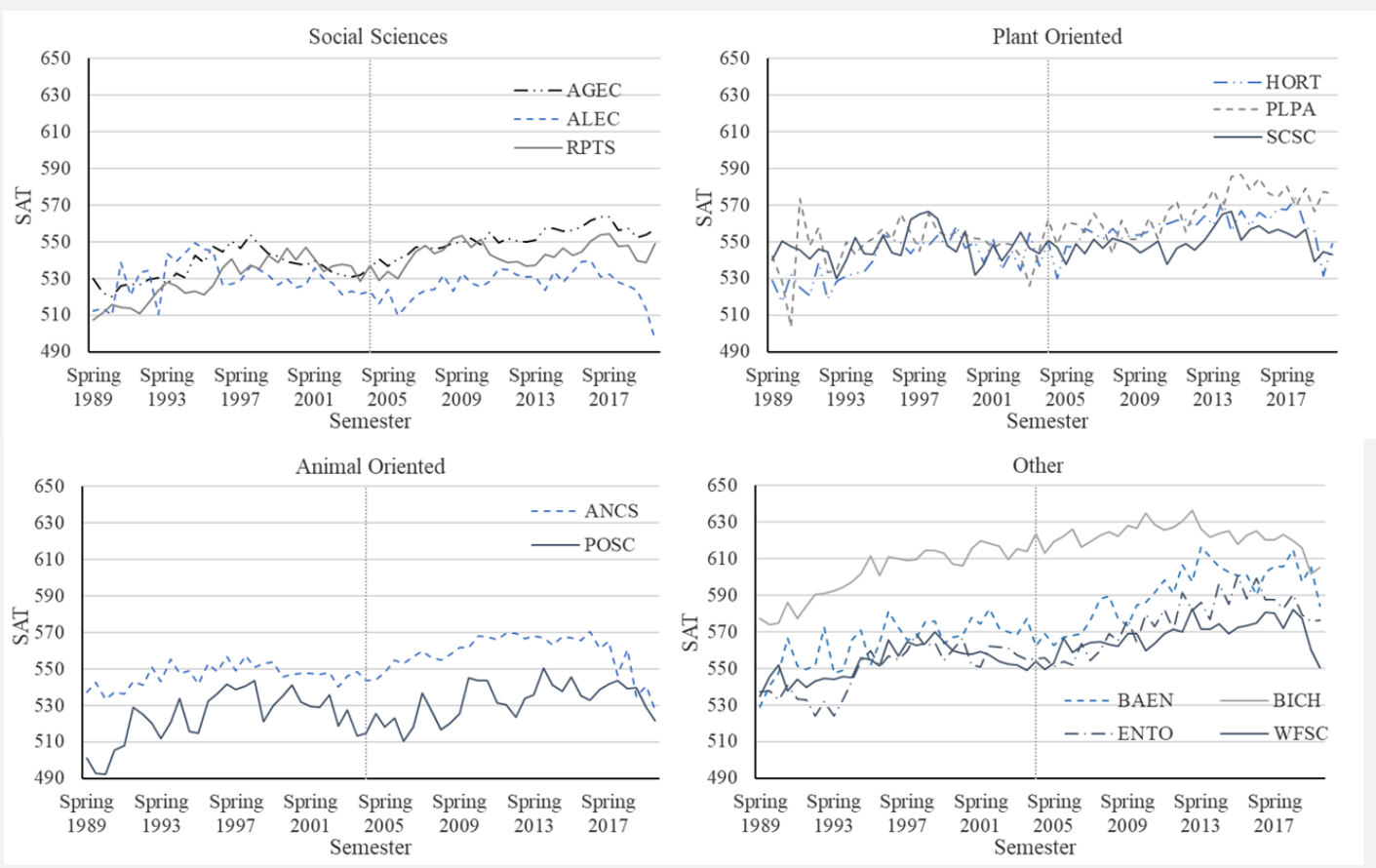

Figure 2: College of Agriculture and Life Sciences Departments' Average SAT Scores by Semester from 1989 to 2019

4 Model

Descriptive statistics show there are differences among departments within COALS. Furthermore, different instructors have different teaching styles and may grade differently, which may make the assumption of independence of observations invalid. To account for these differences, mixed effect models (Goldstein and Hoboken 2011) are estimated individually for each department. Previous studies have also used mixed effect models in examining grading patterns (Kokkelenberg, Dillon, and Christy 2008; Beenstock and Feldman 2016; Hernández-Julián and Looney 2016).

The mixed effect model estimated contains both fixed and random components along with two levels. The first level measures the fixed effect or within-individual variation and includes intercept and explanatory variables (institutional, instructor, and student-specific characteristics). The second level measures the random effect or the between individual variations for instructors, thus incorporating instructor-specific variability in estimation of the average grade in each class.

The Level 1 equation is:

$$y_{ij} = \beta_{0j} + \beta_1 x_{ij} + \varepsilon_{ij} \quad (1)$$

where y_{ij} is the GPA for the i^{th} class taught by the j^{th} instructor, x_{ij} is the vector of the i^{th} class characteristic (institutional, instructor, and student-specific characteristics) for j^{th} instructor, β_{0j} represents fixed effects, or mean GPA for the j^{th} instructor, β_1 is the vector of coefficients for class characteristics, and ε_{ij} represents residuals for the i^{th} class taught by the j^{th} instructor. The Level 2 equation is:

$$\beta_{0j} = \gamma_{00} + u_{0j} \quad (2)$$

Where β_{0j} is the fixed effect or mean GPA for the j^{th} instructor, γ_{00} is the fixed intercept across all groups, and u_{0j} is the deviation of the j^{th} instructor from the fixed intercept. The error terms are assumed to be distributed with mean zero and constant variance within a level, but the variance can differ between the levels.

5 Results

Given the number of models and variables, limited discussion is provided on inferences on the coefficients by department and period (Tables 3 and 4). As shown in the two tables, there are period and departmental differences in significances, signs, and magnitudes of some of the coefficients, but also many similarities.

5.1 Potential Grade Inflation

In the first period, one department (Poultry Science) has a significant and negative coefficient associated with trend, whereas four departments (Ag. Economics, Ag. Engineering, Animal Science, and Soil and Crops) have positive and significant coefficients associated with trend after controlling for the other characteristics. In the second period, the negative significant trend coefficient is observed in Biochemistry, while the number of departments with positive significant trend coefficients doubles (Ag. Economics, Ag. Leadership, Ag. Engineering, Horticulture, Plant Pathology, Poultry Science, Recreation and Parks, and Soil and Crops). It appears the increase in COALS grades reported by Yeritsyan, Mjelde, and Litzenberg (2022) for COALS as a whole is caused by most of the departments experiencing increasing trend in grades, especially in the second period, but not all departments.

5.2 Institutional Characteristics

Institutional characteristics appear to show few patterns concerning significance, signs, and magnitudes of the coefficients. Eleven of the 24 coefficients associated with morning classes are significant, and all but two are negative. Only in Plant Pathology (not significant), Soil and Crops, and Poultry Science are the sign and significance of this coefficient consistent between the two periods. Classes taught during morning hours (if significant) are correlated with lower GPAs than afternoon classes with the one exception, Biochemistry in the second period. This is in line with Marbouti et al.'s (2018) finding that early morning and late Friday afternoon classes attendance and grades are lower than other meeting times. Classes meeting only once a week generally are correlated with higher grades. In period one, 10 coefficients are significant and negative for meeting two or more times a week. Only one department, Ag. Economics, had a significant and positive coefficient for meeting two or more times a week. Differences between time periods are present. In period two, five coefficients are negative and significant when meeting more than once a week, and five coefficients are significant and positive when meeting more than once a week. For both periods, only Entomology and Recreation and Parks had no significant coefficients associated with the number of classes per week.

The number of students in the class is negatively correlated with grades for all departments and periods except for Recreation and Parks in period two where the coefficient is insignificant. This finding is in line with many studies who find students perform better in smaller class sizes (Nye, Hedges, and Konstantopoulos 2001; Kokkelenberg, Dillon, and Christy 2008; Diette and Raghav 2015). If significant,

Table 3: Class GPAs Parameter Estimates using a Mixed Effect Model for Period 1 (Years 1989–2003)

	Social Sciences			Plant Oriented			Animal Oriented		Other			
Variable	**AGEC**	**ALEC**	**RPTS**	**HORT**	**PLPA**	**SCSC**	**ANSC**	**POSC**	**BAEN**	**BICH**	**ENTO**	**WFSC**
Ln trend	0.006*	-0.004	-0.002	0.002	-0.0003	0.005*	0.005*	-0.012*	0.008*	0.001	-0.001	-0.002
	(0.001)	(0.002)	(0.003)	(0.002)	(0.006)	(0.002)	(0.001)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Institutional Variables												
Morning	-0.060*	-0.001	-0.097*	0.073*	-0.030	-0.100*	-0.074*	-0.208*	-0.037	0.013	-0.191*	-0.081
	(0.020)	(0.030)	(0.037)	(0.031)	(0.110)	(0.050)	(0.025)	(0.057)	(0.038)	(0.022)	(0.063)	(0.045)
Meet 2	0.051*	-0.142*	-0.111	-0.177	-0.061	-0.471	-0.277*	-0.405*	-0.158*	-0.187*	-0.347	0.018
	(0.024)	(0.034)	(0.084)	(0.140)	(0.118)	(0.286)	(0.033)	(0.199)	(0.048)	(0.058)	(0.251)	(0.154)
Meet 3	n/a	-0.391*	-0.087	-0.119	-0.627*	-0.789*	-0.254*	-0.205	-0.056	-0.206*	-0.146	0.101
		(0.086)	(0.088)	(0.163)	(0.150)	(0.292)	(0.042)	(0.201)	(0.062)	(0.064)	(0.263)	(0.163)
Upper division	-0.005	-0.017	0.111	0.018	-0.205	-0.223*	0.146*	-0.102	0.134*	0.108	-0.131	-0.054
	(0.058)	(0.043)	(0.047)	(0.035)	(0.206)	(0.093)	(0.035)	(0.058)	(0.047)	(0.062)	(0.090)	(0.061)
Total students	-0.001*	-0.002*	-0.004*	-0.002*	-0.008*	-0.002*	-0.002*	-0.001*	-0.003*	-0.003*	-0.003*	-0.002*
	(0.0003)	(0.0003)	(0.001)	(0.0003)	(0.002)	(0.001)	(0.0002)	(0.001)	(0.001)	(0.0003)	(0.001)	(0.001)
High credit	n/a	-0.152*	-0.069	-0.165	-0.139	0.171	-0.033	-0.018	-0.231*	-0.493*	-0.098	-0.700*
		(0.035)	(0.094)	(0.142)	(0.128)	(0.293)	(0.033)	(0.203)	(0.052)	(0.056)	(0.297)	(0.156)
Instructor Variables												
Instructor gender	-0.0002	-0.014	-0.022	-0.050	-0.101	-0.004	-0.036	-0.147	0.166	0.074	xxx	-0.042
	(0.134)	(0.055)	(0.092)	(0.066)	(0.090)	(0.163)	(0.067)	(0.140)	(0.157)	(0.072)		(0.116)
Assistant prof	0.050	0.060	0.081	0.006	0.036	-0.263*	0.069	-0.099	0.001	-0.008	-0.287*	-0.046
	(0.050)	(0.063)	(0.091)	(0.068)	(0.141)	(0.107)	(0.047)	(0.100)	(0.097)	(0.056)	(0.133)	(0.081)
Associate prof	0.050	-0.051	0.064	-0.036	0.026	0.078	0.058	0.056	-0.157	-0.005	-0.086	0.042
	(0.037)	(0.049)	(0.078)	(0.050)	(0.115)	(0.059)	(0.033)	(0.074)	(0.086)	(0.039)	(0.102)	(0.056)
Lecturer graduate	-0.103	0.141*	0.201	0.070	-0.124	-0.004	0.091	0.188	-0.071	-0.139	xxx	0.006
	(0.778)	(0.068)	(0.114)	(0.076)	(0.146)	(0.150)	(0.059)	(0.117)	(0.192)	(0.097)		(0.096)

Table 4 continued.

	Social Sciences			Plant Oriented			Animal Oriented			Other		
Variable	**AGEC**	**ALEC**	**RPTS**	**HORT**	**PLPA**	**SCSC**	**ANSC**	**POSC**	**BAEN**	**BICH**	**ENTO**	**WFSC**
Other lecturer	-0.065	-0.006	0.204	0.180	xxx	0.492*	0.153	0.310	-0.140	-0.049	n/a	0.224
	(0.136)	(0.090)	(0.130)	(0.114)		(0.193)	(0.083)	(0.171)	(0.162)	(0.100)		(0.149)
Non-AAU	0.129*	-0.123*	0.024	0.013	0.078	-0.073	-0.089	0.013	0.098	-0.049	-0.017	-0.044
	(0.064)	(0.054)	(0.098)	(0.058)	(0.135)	(0.121)	(0.064)	(0.094)	(0.112)	(0.062)	(0.105)	(0.088)
Student Variables												
Student gender	-0.575*	-0.299*	-0.130	-0.341*	-0.014	0.069	-0.136*	0.335*	-0.421*	-0.132	-0.110	-0.236*
	(0.100)	(0.112)	(0.147)	(0.087)	(0.236)	(0.114)	(0.067)	(0.172)	(0.112)	(0.080)	(0.114)	(0.107)
SAT	0.003*	0.003*	-0.0003	0.002*	0.0005	0.001	0.002*	0.001	0.001	0.005*	0.003*	-0.0001
	(0.001)	(0.001)	(0.001)	(0.0004)	(0.001)	(0.001)	(0.0004)	(0.001)	(0.001)	(0.0004)	(0.001)	(0.001)
Student load	0.037*	0.009	-0.022	0.001	-0.090	0.040	0.035*	-0.062*	0.007	0.039*	0.039*	0.026
	(0.018)	(0.016)	(0.019)	(0.013)	(0.050)	(0.024)	(0.112)	(0.020)	(0.018)	(0.017)	(0.016)	(0.024)
HS percentile	0.005*	0.003	-0.001	0.002	0.008*	0.001	0.008*	0.007*	0.006*	0.006*	0.006*	0.003
	(0.001)	(0.002)	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Share no grade	-1.317*	-1.314*	-2.526*	-0.558*	-0.411	-1.031*	-0.808*	-1.963*	-1.602*	-0.695*	-0.104	-0.884*
	(0.212)	(0.354)	(0.358)	(0.261)	(0.613)	(0.270)	(0.239)	(0.546)	(0.383)	(0.174)	(0.405)	(0.296)
Random-Effect Parameters												
Instructor	0.569*	0.016*	0.073*	0.029*	0.041*	0.089*	0.045*	0.020*	0.066*	0.071*	0.050*	0.049*
Residual	0.048*	0.043*	0.107*	0.056*	0.075*	0.076*	0.055*	0.082*	0.072*	0.053*	0.054*	0.076*

Note:* denotes statistical significance at 0.05 or lower (p value < 0.05). Standard errors in parentheses below the estimated coefficients. When the number of observations is fewer than five observations (marked as xxx), the variable is removed for confidentiality reasons and because conclusions drawn would be suspect. See text for definitions of department acronyms.

Table 4: Class GPAs Parameter Estimates using a Mixed Effect Model for Period 2 (Years 2004–2019)

	Social Sciences			Plant Oriented			Animal Oriented			Other		
Variable	**AGEC**	**ALEC**	**RPTS**	**HORT**	**PLPA**	**SCSC**	**ANSC**	**POSC**	**BAEN**	**BICH**	**ENTO**	**WFSC**
Ln trend	0.006*	0.005*	0.004*	0.006*	0.008*	0.006*	0.001	0.008*	0.005*	-0.004*	0.005	-0.001
	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.001)	(0.003)	(0.002)	(0.001)	(0.003)	(0.002)
					InstitutionalVariables							
Morning	-0.010	-0.054*	-0.034	-0.001	-0.025	-0.167*	-0.011	-0.200*	0.024	0.065*	-0.002	0.032
	(0.020)	(0.019)	(0.026)	(0.026)	(0.055)	(0.046)	(0.020)	(0.041)	(0.037)	(0.024)	(0.037)	(0.038)
Meet 2	0.113*	0.073*	-0.051	0.152*	-0.142	0.215*	0.016	-0.369*	-0.103	-0.273*	0.027	-0.142*
	(0.058)	(0.024)	(0.072)	(0.047)	(0.091)	(0.073)	(0.026)	(0.069)	(0.059)	(0.033)	(0.071)	(0.055)
Meet 3	0.109	0.075*	-0.031	0.154	-0.077	0.132	-0.029	-0.202*	-0.114	-0.295*	0.103	0.045
	(0.060)	(0.031)	(0.075)	(0.088)	(0.122)	(0.077)	(0.033)	(0.082)	(0.067)	(0.042)	(0.081)	(0.094)
Upper division	0.076	0.044	-0.030	-0.019	-0.123	-0.172*	0.175*	-0.068	0.005	-0.091	0.187*	-0.264*
	(0.044)	(0.033)	(0.041)	(0.040)	(0.076)	(0.071)	(0.027)	(0.058)	(0.055)	(0.057)	(0.054)	(0.071)
Total students	-0.001*	-0.002*	-0.001	-0.002*	-0.003*	-0.001*	-0.001*	-0.002*	-0.006*	-0.001*	-0.001*	-0.004*
	(0.0002)	(0.0004)	(0.001)	(0.0002)	(0.001)	(0.0005)	(0.0001)	(0.001)	(0.001)	(0.0003)	(0.0004)	(0.001)
High credit	-0.478*	-0.251*	-0.187*	-0.382*	-0.399*	-0.352*	-0.228*	0.003	-0.406*	-0.286*	-0.219*	-0.352*
	(0.084)	(0.025)	(0.088)	(0.051)	(0.080)	(0.071)	(0.025)	(0.071)	(0.062)	(0.036)	(0.076)	(0.062)
					Instructor Variables							
Instructor gender	-0.096	0.126*	-0.190*	0.009	-0.079	0.187	-0.094	-0.096	-0.061	-0.081	-0.083	-0.171
	(0.096)	(0.058)	(0.076)	(0.112)	(0.079)	(0.144)	(0.060)	(0.165)	(0.095)	(0.082)	(0.150)	(0.133)
Assistant prof	0.106	0.071	0.034	-0.017	0.247*	0.166	-0.021	0.063	0.037	-0.089	-0.122	-0.068
	(0.064)	(0.059)	(0.073)	(0.095)	(0.085)	(0.096)	(0.049)	(0.078)	(0.083)	(0.056)	(0.086)	(0.085)
Associate prof	0.041	0.006	-0.035	-0.001	0.063	0.142	0.002	-0.042	0.024	-0.043	-0.167*	-0.106
	(0.047)	(0.052)	(0.055)	(0.060)	(0.066)	(0.091)	(0.033)	(0.064)	(0.066)	(0.048)	(0.071)	(0.068)
Lecturer graduate	0.065	0.120	0.073	0.223	n/a	xxx	0.137*	- 0.063	-0.198	-0.150	-0.036	0.050
	(0.074)	(0.073)	(0.088)	(0.139)			(0.065)	(0.099)	(0.153)	(0.126)	(0.185)	(0.128)
Other lecturer	0.107	0.121	0.247*	0.080	0.132	0.481*	0.167	0.132	-0.123	0.005	0.098	-0.165
	(0.072)	(0.080)	(0.102)	(0.129)	(0.220)	(0.213)	(0.091)	(0.222)	(0.116)	(0.108)	(0.176)	(0.157)

Table 4 continued.

	Social Sciences			Plant Oriented			Animal Oriented		Other			
Variable	**AGEC**	**ALEC**	**RPTS**	**HORT**	**PLPA**	**SCSC**	**ANSC**	**POSC**	**BAEN**	**BICH**	**ENTO**	**WFSC**
Non-AAU	-0.023	-0.058	0.057	0.139	-0.033	-0.136	-0.069	-0.085	0.087	-0.037	0.078	-0.122
	(0.047)	(0.037)	(0.064)	(0.091)	(0.094)	(0.087)	(0.042)	(0.111)	(0.069)	(0.046)	(0.113)	(0.082)
Student Variables												
Student gender	-0.296*	-0.434	-0.265*	-0.053	-0.364*	-0.438*	-0.245*	0.050	-0.329*	-0.148*	-0.043	-0.493*
	(0.095)	(0.070)	(0.095)	(0.092)	(0.154)	(0.116)	(0.067)	(0.128)	(0.109)	(0.072)	(0.132)	(0.101)
SAT	0.003*	0.001*	-0.0005	0.001*	0.001	0.001	0.002*	-0.0003	0.001*	0.004*	0.004*	-0.0004
	(0.001)	(0.0004)	(0.001)	(0.001)	(0.001)	(0.001)	(0.0003)	(0.001)	(0.001)	(0.0004)	(0.001)	(0.001)
Student load	-0.018	0.023	0.028	0.004	-0.043	0.015	0.005	0.010	-0.090*	-0.015	0.051*	0.005
	(0.016)	(0.013)	(0.017)	(0.017)	(0.027)	(0.020)	(0.012)	(0.026)	(0.020)	(0.013)	(0.022)	(0.018)
HS percentile	0.005*	0.005*	0.001	0.008*	0.008*	0.001	0.007*	0.007*	0.009*	0.015*	0.007*	0.004
	(0.002)	(0.001)	(0.017)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.018)
Share no grade	-1.986*	-2.081*	-0.054	-0.677*	-1.825*	-0.317	-1.106*	-0.279*	-1.110*	-0.842*	-0.977*	-0.891*
	(0.271)	(0.248)	(0.108)	(0.192)	(0.564)	(0.299)	(0.192)	(0.331)	(0.389)	(0.148)	(0.359)	(0.291)
Random-Effect Parameters												
Instructor	0.060*	0.058*	0.095*	0.068*	0.032*	0.125*	0.041*	0.087*	0.085*	0.085*	0.086*	0.097*
Residual	0.049*	0.067*	0.061*	0.064*	0.068*	0.071*	0.064*	0.058*	0.087*	0.069*	0.093*	0.072*

Note:* denotes statistical significance at 0.05 or lower (p value < 0.05). Standard errors in parentheses below the estimated coefficients. When the number of observations is fewer than five observations (marked as xxx), the variable is removed for confidentiality reasons and because conclusions drawn would be suspect. See text for definitions of department acronyms.

courses with three or more credits are correlated with lower grades relative to courses with one or two credits.

5.3 Instructors' Characteristics

Of the 138 coefficients (six are not considered because they are drawn on a small number of observations) associated with instructor characteristics, only thirteen are significant (six in the first and seven in the second period). In an ideal world, none of the variables in this group would correlate with grades. Only in Soil and Crop Sciences is the coefficient associated with other instructors significant in both periods. In the second period, instructors' gender is significantly correlated with grades in Recreation and Parks (males grading lower than females) and in Ag. Leadership (females grading lower than males). Assistant professors are significantly correlated with lower grades than professors in Soil and Crops and Entomology in the first period. In Plant Pathology for the second period, assistant professors are significantly correlated with higher grades than professors. Associate professors are significantly correlated with lower grades than professors only in Entomology in the second period. Graduating from an AAU or non-AAU school appears to have little to no correlations with grades, especially in the second period. If significant, graduate students and other lecturers' coefficients are positive, indicating higher grades than professors, but this occurs in only a few cases (period one Ag. Leadership and Soil and Crops; period two Recreation and Parks, Soil and Crops, and Animal Science). Research suggests that one of the reasons for higher grades granted by visiting and adjunct faculty could be the expectation of higher student evaluations (Sonner 2000; Kezim, Pariseau, and Quinn 2005). These instructors are often hired on the term-by-term basis, and higher student evaluations are more likely to result in their contract being extended. But this does not seem to be the general case in COALS.

5.4 Students' Characteristics

Students' characteristics have more significant coefficients compared to instructors' characteristics. If significant, students' characteristics generally have similar inferences in all departments: a decrease in the percentage of male students, as well as increases in SAT score and high school rank, have positive correlations with GPA, while an increase in the share of students with no grades has a negative correlation with GPA. Studies such as Voyer and Voyer (2014) and O'Dea et al. (2018) also find females tend to receive higher grades. In two of the four departments where student gender is insignificant in the second period, the percentage of female students is larger than males (Ag. Leadership and Horticulture).

In five departments (Recreation and Parks, Plant Pathology, Poultry Science, Soil and Crops, and Wildlife Management) for both periods, increasing SAT scores are not significantly correlated with increasing GPAs. Although you would expect SATs to reflect students' ability, studies such as Haladyna, Nolen, and Haas (1991) and Reames and Bradshaw (2009) support the idea that SAT scores have increased over time without a corresponding increase in student educational achievement. They claim this may be a result of public schools preparing students to take standardized tests. High school rank, reflecting student preparedness and motivation (Westrick et al. 2015), is insignificant in five departments in the first period (Ag. Leadership, Horticulture, Recreation and Parks, Soil and Crops, and Wildlife Management), but is only insignificant in three departments in the second period (Recreation and Parks, Soil and Crops, and Wildlife Management). As expected, the percentage of students receiving a no grade is generally correlated with lower class GPAs. Barker and Pomerantz (2000) state dropping a course may suggest poor performance and indicate responsible behavior by students who are considering their academic futures. Five coefficients are significant and positive, and two are significant and negative for student load considering both periods. These findings weakly suggest motivated students and students with less free time do not procrastinate and organize their time more wisely,

resulting in better study habits leading to higher grades. The changes previously discussed that may influence student load may be leading to this characteristic being insignificant in many departments.

6 Conclusions and Discussions

Differences in class average GPAs for periods 1989–2004 and 1989–2019 among twelve departments within COALS at TAMU are examined through addressing two objectives.

Objective 1. To determine if potential grade inflation has been occurring by department and if it differs over time.

A significant and positive coefficient for trend indicates potential grade inflation, but it must be noted missing variables may be contributing to the trend coefficient. Potential grade inflation occurred in four departments in the first period (1989–2003). In the second period (2004–2019), the number of departments experiencing potential grade inflation doubled to eight out of the twelve departments. Three departments, Ag. Economics, Ag. Engineering, and Soil and Crops had potential grade inflation in both periods. In contrast, in each period, only one department had potential grade deflation (Poultry Science in period one and Biochemistry in period two). Poultry Science experienced grade decreases in the first period and increases in the second period.

Although not in the model, the change in the number of departments experiencing potential grade inflation roughly corresponds to factors previous studies suggest as reasons for grade inflation, including tuition and fee increases, increase in the use of teaching evaluations, and student generation. The second period roughly corresponds to the time when Generation X were ending their student careers and millennials attended college. By the end of period two, Generation Z started to enroll in college. Howe and Strauss (2000) mention millennials were raised by their parents to succeed. In addition, Curran and Hill's (2019) meta-analysis shows recent generations of college students feel more pressure to excel than students in the 1990s. This need to excel could be one driving force behind students' complaints on grading and could foster grade inflation. Additional research on impacts of generation cohorts on grading patterns is warranted.

Grades show a decline in both Ag. Leadership and Ag. Engineering around 2006; however, grades crawl back up by the end of the second period. Discussion with the Ag. Engineering former department head indicated an attempt to increase rigor in their department. These observations imply grades are hard to reduce and/or maintain at lower levels.

The second objective is:

Objective 2. Examine factors influencing mean class GPA among different departments in COALS to provide information on factors correlated with these differences and explore if the correlations have changed over time.

Results show that there are differences in grading patterns among departments in COALS and even within the same department between time periods. It appears differences in GPAs are mainly driven by specifics of each department. This is in line with Yeritsyan, Mjelde, and Litzenberg (2022), who find significant departmental differences. Departmental culture, subject matter, job market prospects, and student expectations may be some of the reasons for departmental differences. These differences may manifest themselves in the magnitude of the coefficients differing although sign and significance are the same. Although departmental differences may be the main driving force, some differences are noted and discussed. Furthermore, because of these differences, one must be careful in comparing students and their GPAs between majors—an unfortunate inference for employers and graduate school recruiters.

In terms of ranking from the largest to smallest GPA between periods, only three departments had a change of more than two places in its ranking. Ag. Engineering changed from fourth to seventh in its ranking. As noted earlier, Ag. Engineering made a conscious attempt to add rigor to their program. No reason is found for the other two departments' change in ranking. Wildlife Management went from seventh to twelfth, with a significant decrease in GPA between periods. Plant Pathology, with the largest increase in GPA between periods, went from tenth to sixth. The remaining discussion concentrates on period two; as noted earlier, this may be the most relevant period.

Weak evidence exists that supports previous studies' claims that differences exist between STEM and non-STEM-designated departments. Seven of the eight non-STEM departments experienced potential grade inflation while two (Plant Pathology and Ag. Engineering) of the four STEM-designated departments (Ag. Engineering, Biochemistry, Entomology, and Plant Pathology) experienced potential grade inflation. As noted earlier, changes in Ag. Engineering grading may have more to do with changes in the departmental policies than STEM designation. One STEM department (Biochemistry) shows grade deflation and one no change (Entomology) in GPA. Over time, grade dispersion among all departments reduced from a GPA range of 2.72–3.50 in 1989 to 3.05–3.52 in 2019, making it more difficult to differentiate students' abilities.

Issues remain on why are there differences between departments. Discussions with departments indicated no clear departmental grading policies, and differences are mostly the result of subject matter differences. After controlling for instructors, characteristics associated with instructors are generally insignificant, implying these characteristics are not the reason for differences. Signs and significance of student characteristics are similar among departments, but magnitudes vary. Simple correlation between estimated coefficients on high school rank for twelve departments and average high school rank in those departments is 0.75. Such a moderate to strong correlation indicates the effect of preparation as given by high school rank is stronger in classes that have a higher average rank than classes with lower average rank. Correlations between the absolute value of the estimated coefficients and average values for student gender (0.38) and SAT scores (0.42) show weak-to-moderate relationships. Although the effect of students' characteristics such as preparedness, motivation, and gender are similar, having a larger percentage of better-prepared students, for example, has a larger impact (magnitude) on grades. More research is warranted on these relationships.

Institutional characteristics do not present as clear of a picture. Characteristics other than total students enrolled in a class and high credit show no consistent patterns. Correlation between estimated coefficients and the average number of high credit classes is very weak to nonexistent, at -0.16. Negative correlation between estimated coefficients and average number of students in a class shows an inverse, moderate to significant relationship (-0.68). Although increasing the number of students decreases grades, it appears at some point adding additional students has less of an effect. This indicates the relationship between the number of students and grades may be nonlinear. At some point, increasing the number of students may have little to no effect on class GPA. Again, more research is necessary on this relationship.

Questions not addressed include: (1) should grade reform be undertaken and (2) are departments willing to consider grading reform? These are complex, difficult questions involving issues such as enrollment, finance, and employment. Because administrators may not have a lot of control over individual instructors' grading standards, they may introduce the idea of "individual gain" (McGowen and Davis 2022). Individual gain is a numeric value calculated based on the initial test and a final test at the end of the class that can be used to complement grades on students' transcripts. Such a numeric value, however, would be a confusing addition to transcripts, especially until all universities adopt the idea.

Denning et al. (2022) show grade inflation has led to an increase in college graduation rates, one goal of accountability and proposed policy changes. Compared to education expenditures, grade inflation may be a low-cost policy option to ensure higher graduation rates and earlier graduation. However, the

long-term consequences of such a policy, such as decline in quality of college graduates or university image deterioration needs to be considered. Future research should calculate the costs and benefits that come with increasing grades. Benefits comprise higher rates of completing college, which results in graduates who compete for better employment opportunities. Costs include lower preparedness of those graduates.

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Teaching and Educational Methods

A Brief History of Giffen Behavior and an Applicable Student Example

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Keywords: Giffen behavior, intermediate microeconomic theory, procrastination

Abstract
Giffen behavior is covered in various intermediate microeconomics textbooks, but debates arise over its existence. Given particular assumptions, Giffen behavior arises for students waiting until the end of the term to study. For some students, the available time for studying diminishes, but non-academic pursuits are available after the term (the time constraint becomes steeper). While the total possible time for the course decreases, some students study more. Instructors may demonstrate this type of example to students in hopes that it will be more relatable and gain a greater knowledge of the Giffen good concept.

1 Introduction/Background

A fundamental topic taught in an intermediate microeconomics course is consumer theory. One addendum to this topic is the concept of the Giffen good, introduced and named by Marshall in his third edition of *Principles of Economics* (Dooley 1985). A Giffen good is defined as a good which, when the own price of a good increases, the quantity demand for that good increases. Currently, most intermediate microeconomic textbooks discuss Giffen goods, but the perceptions of the concept vary by author. Varian (2009) and Mansfield and Yohe (2003) explain the theory of Giffen goods but do not give any examples. Perloff (2020) presents a hypothetical situation for a Giffen good to exist (consumer chooses between going to basketball games and watching movies). Another intermediate microeconomics textbook uses a hypothetical situation, but notes that "Though intriguing, the Giffen good is rarely of practical interest because it requires a large negative income effect" (Pindyck and Rubinfeld 2018, p. 122). Landsburg (2014) cites an example wherein a Giffen good exists in an experimental setting, but he states that it can never exist in the real world. A well-known example of a Giffen good, potatoes during the Irish potato famine of the mid-1800s, is discussed and discredited by both Frank (2021) and Goolsbee, Levitt, and Syverson (2020). However, Goolsbee et al. (2020) mention a study by Jensen and Miller (2008) that demonstrates that rice was a Giffen good for particular households in rural areas of China's Hunan province.

A common misconception is that Sir Robert Giffen is attributed to alleging that potatoes during the Irish potato famine were Giffen goods (Stigler 1947; McDonough and Eisenhauer 1995). When Giffen proposed the idea that quantity demand may increase when price increases, he actually used the example of bread (Stigler 1947). Stigler (1947) analyzed the per capita consumption and price of wheat in the UK from 1889 to 1904. Based on the data from the relevant years, bread did not exhibit Giffen behavior during this time. Rosen (1999) examines the potato market during the famine and refutes that Giffen behavior existed at that time. However, in Cork, Ireland, from 1846 to 1849, consumers of bacon pigs exhibited Giffen behavior (Read 2017). Read (2017) explains that when the price of bacon pigs increased, the quantity purchased increased because the pricier substitute good (beef) was also rising, while consumers wanted to maintain their current standard of living.

Although research has demonstrated that potatoes and bread are not Giffen goods, other studies identify the Giffen behavior does exist. Services, such as insurance (Hoy and Robson 1981; Briys, Dionne,

and Eeckhoudt 1989; and Hau 2008) and the family service industry in Beijing (Zheng et al. 2016), have been identified as Giffen goods. Kerosene consumption exhibits Giffen behavior for both the United States (Bopp 1983) and in Nigeria (Arawomo 2019). In an experimental setting, Battalio, Kagel, and Kogut (1991) demonstrate that quinine is a Giffen good for "poor" rats. Some researchers have discovered that Giffen behavior exists for consumers that are experiencing subsistence consumption. Rice consumption in rural parts of Bangladesh exhibits Giffen behavior (Lekhe et al. 2014). Jensen and Miller (2008) demonstrate that rice and wheat are Giffen goods for the "poor-but-not-too-poor" in particular parts of China. Another example of subsistence consumption exhibiting Giffen behavior is Russian consumers switching from less affordable meat and fish (prices of these goods decreased) to potatoes and bread (prices of these goods increased during the early 1990s; Shachmurove and Szyrmer 2011). Some students learning about Giffen goods may relate to any of these examples. However, it is possible that some students will not be able to relate to any of the examples in the literature.

This commentary is to demonstrate an example of Giffen behavior that exists in academic learning. Since the example deals with academic learning, students learning about Giffen goods may relate easier to this example and gain a greater knowledge of the principle. The amount of time a student must study for a course may diminish throughout the term. Many students that have not performed well over the term will devote more of their time toward the course at the end of the term. That is, since the time a student can spend on the course diminishes as the term progresses, given other concurrent commitments, the fear of passing or getting a desired grade in the course tends to increase toward the end of the term. In addition, for some students the fear of missing out by not engaging in non-academic pursuits does not increase since those activities may be consumed after the final exam. Thus, when the student starts to increase the time spent studying at the end of the term, the study time "consumed" exhibits Giffen behavior.

2 Student Behavior

Students have many various activities that they may spend their time doing. There are activities that will always be available to the student (e.g., playing video games, watching movies, watching sports games, surfing the internet, and spending time with family/friends). As some of these activities become more defined, they become only available during the duration of the semester (i.e., watching a certain movie in the theater, watching or attending a particular sporting event, and attending a grandmother's funeral). Additionally, if a student is starting a job at the end of the semester, they will start to devote more time to other activities since they are aware their time will be more constrained after the end of the semester. This paper will compare the time the student has for learning in one class with activities that are not limited (accessible activities) and are not restricted to other post-term commitments, as those mentioned previously.

Most students know that learning exam material throughout the term is requisite to receive a good grade in a course. The information can be learned utilizing two different approaches. The first approach is to attend classes, whether this means to attend all or some of the classes. The other approach is to go over the exam material outside of the classroom using class notes, the course textbook, online resources, etc. From the perspective of most teachers, students should be utilizing both approaches. Applying both or either of these approaches demonstrates that the student is spending time on the course. Although the student is learning the material throughout the term, the student will reconsider whether the current amount of time spent learning will be enough to receive the desired grade or if more time is required.

Each student has a finite amount of life; therefore, they have a time constraint. As the student progresses through the term, the quantity of available time to study decreases, and as a result, the time (budget) constraint for a given period of time (e.g., the amount of time left in the term) for studying approaches zero. Students likely believe that they will be living many more years. Students without post-

term commitments may consume accessible activities after the term, and their expected lifetime after the term is much larger than the time of the term. Thus, it is assumed that the total possible quantity of time engaging in other accessible activities does not change or remains relatively constant throughout the term. The price for the time constraint is fear. A student may feel fear that they are missing out when they do not engage in the accessible activity. Many students experience an increased amount of fear when the realization sets in that there is a limited amount of time left in a course for studying and related activities, especially if the final exam is cumulative.

3 Procrastination

Students waiting until the end of the term to study are procrastinating. Studies have identified procrastination as a negative characteristic of individuals (Akerlof 1991; O'Donoghue and Rabin 2001). Procrastinators demonstrate time-inconsistent behavior and do not necessarily maximize utility overtime, especially if the task that is required does not get accomplished. However, studies have identified that there are diverse types of procrastinators, and not all procrastinators exhibit Giffen behavior.

Multiple tests exist that measure motives for various types of procrastinators (Ferrari 1992). Given the tests, Ferrari (1992) classifies procrastinators as avoidant or arousal. Other studies define avoidant as passive and arousal as active procrastination (Cao 2012; Seo 2012). The avoidant procrastinator does not want to complete a task and will fill their schedule with other tasks until the project needs to be completed. According to Ferrari (1992), the avoidant procrastinators put off to protect their self-esteem or are afraid of failure. On the other hand, the active procrastinator delays the task to receive a "thrill" from working against a deadline. The active procrastinator feels that they work better under pressure. Cao (2012) proposes that for students to be successful in college they must turn from being a passive (or avoidant) procrastinator to an active procrastinator. Seo (2012) finds that active procrastinators reach a higher level of academic achievement than passive procrastinators. Thus, when the active procrastinator puts off studying until the end of the term, it is likely that their utility will increase.

An increase in utility from procrastinating for active procrastinators suggests that study time is not exhibiting Giffen behavior for these individuals. Thus, the only type of student that exhibits Giffen behavior when studying is the passive procrastinator. In addition to protecting self-esteem and fearing failure (Ferrari 1992), the student may put off studying because they can engage in other activities. The student is hoping that they can learn the material and pass the course at the end of the term while their fear (price) of not obtaining their desired grade is increasing.

4 Teaching Demonstration

Typically, an instructor teaching about utility maximization will draw an indifference curve and a budget constraint with the variable x labeled on the horizontal axis and y labeled on the vertical axis. The variables x and y are usually represented as two goods. However, the model may be expanded to measure students' time. The average amount of time spent studying is denoted on the horizontal axis and the average amount of time spent doing other accessible activities is denoted on the vertical axis. If both axes are scaled the same, this results in a steep curve because the average time a student may spend studying in a lifetime for a particular class is a small fraction of their lifetime. Since most people do not spend most their life as a student the vertical axis has been scaled to reflect a utility maximization problem as shown in Figure 1.

As the term progresses, the total time spent studying for a particular course diminishes, and thus the budget constraint becomes steeper. However, it is possible that at the beginning of the term a student decides not to spend much time studying for the course. To pass the course, the amount of time dedicated to studying for the course needs to increase. The time constraint gets steeper since the fear of

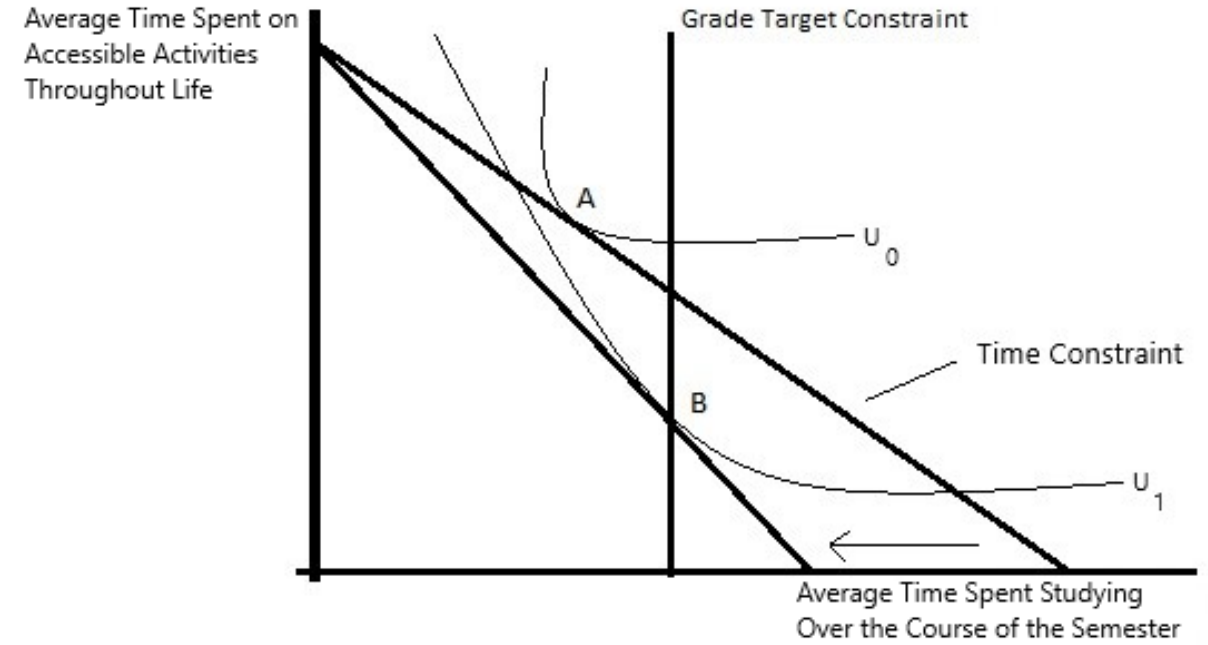

Figure 1: Effect of Time for Student Delaying Studies

passing the course is greater than the fear of not engaging in other activities. A student will then study more (increasing the average amount of time studying), although the time constraint is getting steeper. Given the student is a passive procrastinator, their level of utility goes down (they are on a lower indifference curve). The passive procrastinator student type that demonstrates this type of behavior is treating studying as a Giffen good.

It is possible that students may get confused between a Giffen good and Giffen behavior. Traditional economic theory suggests that a Giffen good exists when consumers buy more of a good when the price increases, ceteris paribus. Giffen behavior exists when the price of a good increases, but is due to another constraint. Many examples in the literature have demonstrated the existence of Giffen behavior, given that the consumer is subject to at least one other constraint. Creedy (1990) solves Marshall's transportation problem in general from utilizing two constraints. The hypothetical traveler would prefer to travel by train rather than boat since it is quicker. When the price of boat travel increases, the traveler will travel farther by boat due to both the budget and distance constraints. Adding a subsistence constraint to the budget constraint demonstrates Giffen behavior for potatoes (Gilley and Karels 1991; Davies 1994; Shachmurove and Szyrmer 2011), bread (Shachmurove and Szyrmer 2011), and rice (Jensen and Miller 2008).

In the model for studying, the student is constrained by time and what Allgood (2001) calls the grade target constraint (see Figure 1). A student will exert as little effect as possible to receive the highest grade or their target, or in some cases the minimal effort, to pass the course. Since study time is compared to all other accessible activities, the grade target constraint, which represents the minimum average amount of time required to reach an individual's grade target, is a straight line and perpendicular to the time spent studying axis. Unlike the budget constraint, to satisfy the students' grade target, study time must be at or above the constraint.

Students who study hard all term are beyond the grade target constraint. As the term progresses, the diligent student exceeds the grade target constraint and thus the average study time will decrease

closer to finals week. Studying becomes a normal good for this type of behavior. Students who put off studying are not reaching the grade target constraint. Not all students who realize that more time studying is required will make the final push toward the end of the term. The type of student who simply gives up treats study time as a normal good.

As shown in Figure 1, students may exhibit Giffen behavior for studying. However, study time might be an inferior good. The type of good will depend on the students' outcome. Students that intend to study but do not meet the constraint treat study time and related activities as inferior behavior. If students study strong at the end of the term when the price (fear) is increasing, the grade target constraint is satisfied.

In consumer theory, a price change leads to two effects, namely the substitution and the income effect. As the price for learning increases, the substitution effect is negative. Given more time, students who engage in a conscientious effort to comprehend the exam material throughout the term study less because they have already invested much time into the class. Students that do not put in an adequate amount of time learning the exam material throughout the term do not spend additional time studying if it was given to them throughout the semester. The income effect will also be negative. The students who persist with the subject matter throughout the term know their time (income) will decrease through the term and plan accordingly so that they will not have to cram at the end. Although the time that can be devoted to the subject is diminishing, students may not devote more time of their own free will. Based on the conditions mentioned above, study time is a normal good for both types of students. However, as one walks around the campus dorms at night during finals week, one will see that many students are desperately learning the exam material for the final exam. From Figure 1, the time constraint becomes steeper toward the end of the semester, but the students increase their time studying, resulting in the average amount of time studying to also increase. Since the grade target constraint is satisfied, study time for this type of student is exhibiting Giffen behavior.

Students that realize they are not attaining the grade target constraint and therefore increasing the time spent on learning may do so to maintain their current monetary income. For instance, the student will lose their scholarship, financial aid, and/or financial contributions from their parents. Even students who are not receiving financial assistance and who put off learning will converge to the grade target constraint because they will want to stay in school, since it is highly probable that their lifetime income will decrease if they get dismissed. If understood by the student, not only does the problem help explain the economic theory of Giffen behavior, but it also helps understand the dynamics of studying. Since students may be aware of other students putting off studying, they will easily relate to the problem.

For students that treat studying as Giffen behavior, the amount of time out of their budget spent studying is modest until the end of the term. As mentioned earlier, the student that devotes a large amount of time throughout the term is not likely to study hard until the end of the term. Jensen and Miller (2008) suggest that Giffen behavior is more likely to occur when the consumer is already spending a large portion of their income on the Giffen good. However, in this case the student has not consumed much (little time spent studying) until the end of the term.

5 Conclusions

Students faced with a time constraint may focus on other activities until the end of the term. Once the time that can be spent on studying diminishes, the student will need to spend more time in their studies to obtain their desired grade. The average amount of time dedicated to studying over the semester increases. Since the student is spending more time learning with less time available, students may exhibit Giffen behavior when studying for the final exam. However, this is not true for all students that put off their studies. Students that are active procrastinators will put off their studies to increase their utility level and have greater enjoyment than if they spaced out their time.

This commentary does not address whether procrastinators are passive or active procrastinators. Further research could identify whether students are more likely to be passive or active procrastinators. If most of the students do not exhibit a particular procrastination type, then what student characteristics are more likely to be passive procrastinators? Another issue to be addressed is that many students are not in college for the opportunity to learn. For these types of students, they view college as a steppingstone for a job. They do not understand that they are learning tools that will help aid them in their chosen profession. Once a student understands the benefits of college (other than a degree), their time spent will change. However, if the student knows they can receive a good grade with minimal effort, this creates an incentive to exhibit Giffen behavior in the future, as well as in their career.

Many students may find it difficult to comprehend Giffen behavior or misinterpret the principle. Identifying studying for the final exam as exhibiting Giffen behavior helps the student understand the exam material better because it is something the student can relate to. Students may also think about their study habits and find a different approach that allows more success for future courses.

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Teaching and Educational Methods

Benefit-Cost Analysis Decision Criteria: Reconciling Conflicting Advice

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Abstract
Net present value (NPV), benefit: cost ratio (BCR), and internal rate of return (IRR) are fundamental concepts of benefit-cost analysis (BCA), providing helpful criteria for decision making about investments. However, textbooks on BCA are remarkably inconsistent in the advice they provide about which of these decision criteria should be used, potentially creating confusion among teachers and students. We present an existing conceptual framework that clarifies which of the three criteria should be used in particular decision contexts, depending on whether the projects in question are independent or mutually exclusive, and on whether the projects are resourced from a fixed pool of funds. The framework reveals that some of the advice provided by particular textbooks is incorrect, and some is correct only in certain decision contexts. Some books dismiss the use of BCR in general, but we show that it is the preferred criterion in certain cases and clarify how it should be calculated. The argument that BCRs can be manipulated by moving costs between the denominator and the numerator is fallacious. Recognizing that these decision criteria should not be applied mechanistically, we argue that the framework presented has the potential to improve decision making in many cases.

1 Introduction

The idea of comparing benefits and costs of a project or investment has a long history. Even before benefit-cost analysis (BCA)[1] was established as a distinct method of analysis, decision makers down the millennia have presumably weighed up the benefits and costs of their options in at least an intuitive way. Then in 1936, the Flood Control Act in the United States stated that projects should be supported "if the benefits to whomsoever they accrue are in excess of the estimated costs," and this kicked off the widespread use of BCA to assess publicly funded projects (Pearce 1983). In 1950, the U.S. Federal Inter-Agency River Basin Committee produced the *Green Book*, which laid down guidelines for comparing costs and benefits (Pearce 1983). Since then, BCA has flourished, and today it is used around the world in a wide variety of contexts, including to assess projects to build new transport infrastructure, conduct public health campaigns, expand agricultural production, or introduce environmental regulations. There are dozens of textbooks available for students of the technique, and many governments around the world have produced their own BCA guidelines, sometimes for specific contexts, such as transport, and sometimes general.

In BCA, a core issue is the use of a set of standard criteria to summarize results and guide decision making. Different textbooks present different decision criteria, but most include net present value (NPV), benefit: cost ratio (BCR), and internal rate of return (IRR).

[1] Or, equivalently, cost-benefit analysis (CBA).

The three decision criteria are conceptually simple. The NPV is calculated as

$$NPV = B - C \quad (1)$$

where B is the aggregate present value of the stream of benefits generated by the project, and C is the aggregate present value of the project's costs. We will look at alternative ways to calculate the BCR, but the approach that is most commonly presented in textbooks is

$$BCR = B / C \quad (2)$$

IRR has no unique formula but equals the discount rate at which the NPV = 0 or BCR = 1.

Numerical Example

The Department of XYZ is considering whether to fund three projects. The benefits and costs of the projects are shown in Table 1, together with their NPV, BCR, and IRR, calculated as described above.

Table 1: Benefits and Costs of Three Example Projects

	Year	0	1	2	3	4	5	Present value*	NPV*	BCR*	IRR
Project 1	Benefit	$0	$100	$300	$500	$500	$400	$1,451	$1,080	3.90	78%
	Cost	$200	$200	$0	$0	$0	$0	$372			
Project 2	Benefit	$0	$0	$300	$500	$600	$600	$1,588	$1,216	4.27	70%
	Cost	$200	$200	$0	$0	$0	$0	$372			
Project 3	Benefit	$0	$0	$500	$700	$800	$1,000	$2,381	$1,637	3.20	54%
	Cost	$400	$400	$0	$0	$0	$0	$744			

We reviewed a large number of BCA textbooks and guidelines (see Appendix) and found that, in most respects, they are consistent in the advice they provide. However, their advice on the appropriateness of using the different criteria (NPV, BCR, and IRR) is highly inconsistent, and sometimes in direct contradiction. For example, some textbooks advise their readers to rely primarily on NPV for decision making and to avoid the use of BCR (e.g., Gramlich 1990; Boardman et al. 2018; de Rus 2021). Others encourage the use of BCR, particularly where the task of decision makers is to rank projects subject to a budget constraint (e.g., Layard and Glaister 1994; Fuguitt and Wilcox 1999; Campbell and Brown 2016). Still others prefer IRR over BCR in the budget-constrained scenario (e.g., Gittinger 1972; Brent 2003), conflicting with those who advise against using the IRR at all (e.g., Hanley and Barbier 2009). The potential for confusion is great, and we observe that confusion often continues when students of BCA graduate and start applying the technique.[2]

We aim to clarify these issues for teachers, students, and practitioners. We show that there are different decision contexts within which use of the three decision criteria needs to be considered. We identify some fallacies in the arguments presented in some textbooks and guidelines regarding the appropriateness of using particular decision criteria, particularly the BCR. This leads to clear and

[2] The advice provided in BCA guidelines from public agencies is similarly diverse and contradictory. Some recommend using the BCR to rank projects in the budget-constrained scenario (U.S. Environmental Protection Agency 2010; HM Treasury 2022), some express a general preference for using the NPV over the other two criteria (e.g., Commonwealth of Australia 2006), and some fail to even mention BCR (e.g., Asian Development Bank 2013).

unambiguous rules for when particular decision criteria should and should not be used and, in the case of BCR, how it should be calculated. Thus, there need be no contradictions, or even ambiguity, in the advice given about the standard decision criteria.

2 Conflicting Advice

As noted above, a number of textbooks advise readers to rely primarily on NPV to guide decision making. For example, Boardman et al. (2018, p. 35) say, "we recommend that analysts avoid using benefit–cost ratios to rank policies and rely instead on net benefits [NPV]." Some textbooks fail to even mention BCR as a potential decision criterion (e.g., Marglin 1967; Ray 1984; Dinwiddy and Teal 1996). Arguments presented against the use of BCR include that it can bias decision making toward small-scale projects (e.g., Brent 2017; Boardman et al. 2018) and that it is sensitive to whether costs are included in the denominator or subtracted from the numerator (e.g., Johansson and Kriström 2015; Nas 2018).

On the other hand, the use of BCR is widely supported in other textbooks. Some point out that, for an individual project, the decision criterion NPV > 0 is equivalent to BCR > 1, so that either can be used (e.g., Brent 1998). "It should be clear that when: NPV ≥ 0, then BCR ≥ 1" (Campbell and Brown 2016, p. 48).

Others argue that if there is a limited budget available to fund projects, the way to maximize overall NPV is to rank the candidate projects according to BCR, selecting those projects with the highest BCRs until the budget is exhausted (e.g., Abelson 1979; Nas 2018): "there is the problem of capital rationing, where the correct approach is to select projects in order of their present value per unit of constrained costs until the cost constraint is exhausted" (Layard and Glaister 1994, p. 43).

IRR too is favored by some authors. "The internal rate of return is the best index when there is a capital constraint" (Brent 2003, p. 43) (contradicting the authors cited in the previous paragraph). "When one can consider projects independently, and there are no technical difficulties ... with IRR, the three criteria [NPV, IRR, BCR] are equivalent (one rule implies the other two)" (Brent 1998, p. 32).

The technical difficulties referred to by Brent (1998) are raised by some authors as barriers to the use of IRR: "many projects can generate multiple IRRs from the same data set, so the analyst does not know which to select as the decision-making criterion" (Hanley and Barbier 2009, p. 6), and IRR makes assumptions about income generated by a project that may not be realistic (Renshaw 1957). Even without those technical difficulties, some argue that the scope for using IRR is limited. "There is general agreement that the IRR should not be used to rank and select mutually exclusive projects" (Pearce, Atkinson, and Mourato 2006, p. 73), and IRR "fails generally to maximize present values because … it is biased towards low capital projects" (Abelson 1979, p. 43).

Finally, there is inconsistency in the formula for calculating the BCR. As well as the version in Equation (2), some textbooks (e.g., Bergstrom and Randall 2016; Campbell and Brown 2016) present the following as an alternative formula:

$$BCR = (B - C_o) \,/\, C_k \tag{3}$$

where C_o is the aggregate present value of operating costs and C_k is the aggregate present value of capital costs.

With so much inconsistency and so many contradictions, it is not surprising that people get confused.

3 Reconciling the Differences

A key to clarifying the roles of the different decision criteria is recognizing that they each perform better or worse in particular decision contexts. This was established in the 1950s (e.g., Lorie and Savage 1955; Hirshleifer 1958), and the insights that were derived more than six decades ago are still applicable today. Often the contradictions noted above arise because authors have not recognized that different advice is needed in different contexts.

There are two key factors that influence the performances of different decision criteria in BCA. The first factor is whether BCA is being used to inform decisions that are subject to a funding constraint. A typical scenario would be where an organization has an allocated budget of a fixed size from which it will resource a selected subset of projects from a set of candidate projects. The budget is not sufficient to resource all the candidate projects, so prioritization is necessary. This scenario is common, for example, where a government body (national, state, or local) is making decisions about funding many competing projects from a particular funding program. The simplest case is where there is a single funding constraint.

Alternatively, for some decisions it may be considered that there is no binding budget constraint. For a national government, for example, if a project is worth funding, it could be funded by raising taxes or borrowing money.

The second factor is whether the projects being considered are independent. If two projects are independent, then the benefits and costs of each project are unaffected by whether the other project is implemented. For example, a project to reduce traffic congestion in one city and a project to reduce water pollution in a different city would probably be independent. Where projects are not independent, their degree of dependence may vary along a continuum. The simplest case is the extreme one where all the candidate projects are mutually exclusive, meaning that only one out of the set of projects can be funded. An example would be a set of discrete project options, each of which would be implemented on the same piece of land (e.g., a car park, a building, or a garden). If any one of the projects is implemented, the others are automatically ruled out.

4 Context-Sensitive Recommendations

Combining these two factors, in their simplest forms, gives a two-by-two matrix of cases for which recommendations about BCA decision criteria are needed (Table 2). The need to use different decision criteria in the different quadrants of the table was recognized by Lorie and Savage (1955), who provided correct recommendations about each of the four cases.[3] Hirshleifer (1958) also recognized that, "the solutions for optimal investment decisions vary according to a two-way classification of cases. The first classification refers to the way market opportunities exist for the decision-making agency [i.e., budget-constrained versus unconstrained]; the second classification refers to the absence or presence of the complication of non-independent productive opportunities [i.e., independent versus mutually exclusive projects]" (Hirshleifer 1958, p. 342).

For these four quadrants, clear and relatively simple decision criteria are identified. The overarching objective of the decision maker is assumed to be maximization of the total NPV from the investments undertaken.

If there is no constraint on the budget and the candidate projects are independent, there is no project ranking to be done, only a yes-no decision for each project. Each criterion works equally well for that purpose: NPV > 0, BCR > 1, and IRR > the discount rate, are equivalent (Dryden 1962; Prest and Turvey 1965; Schwab and Lusztig 1969), barring "technical difficulties" with IRR (outlined below).

[3] Their advice for the independent/constrained quadrant went beyond the simplest case, considering nondivisible projects (those which must be funded in full or not at all) and multiple constraints, but Table 2 focuses on the simplest case.

Table 2: BCA Decision Criteria That Maximize Overall NPV

	All projects independent	All projects mutually exclusive
Funding unconstrained	Fund all projects with NPV > 0, BCR > 1, or IRR > discount rate (all are equivalent). No ranking required.	Choose the project with the highest NPV.
Project costs subject to one funding constraint	Rank projects by BCR.	Select the project with the highest NPV that is feasible (does not exceed the funding constraint)

Numerical Example continued.

For the example projects in Table 1, if the projects are independent, and there is no budget constraint, then all three projects are assessed as being worth funding, whichever of the three decision criteria are used. The three NPVs ($1,080, $1,216, and $1,637) are all greater than zero; the three BCRs (3.90, 4.27, and 3.20) are all greater than 1.0, and the three IRRs (78 percent, 70 percent, and 54 percent) are all greater than the discount rate of 5 percent.

The criticisms that are sometimes made of BCR do not apply in this case. Although the BCR can be altered by moving costs between the denominator and the numerator, this does not affect whether the BCR is greater than one, which is the relevant decision criterion. And although lower-cost projects may be favored if projects are ranked using BCR relative to NPV, the ranking of projects is irrelevant because the decision rule is to fund *all* projects with NPV > 0, BCR > 1, or IRR > discount rate. Campbell and Brown (2016, p. 48) proposed that "when it comes to comparing or ranking two or more projects, again assuming no budget constraint, the BCR decision-rule can give incorrect results." However, this advice is not relevant—if there is no budget constraint, there is no need to rank independent projects, and the decision rule BCR > 1 does not give incorrect results.

Under a constrained budget, ranking independent projects by BCR is superior to ranking by NPV, even though the overarching objective is to maximize the total NPV (Lorie and Savage 1955; Hoskins 1974).

Numerical Example continued.

Consider the three project options offered in Table 1. Suppose that all the costs for these potential projects would be drawn from a particular pool of funds, and that the pool contains $800. If we rank the projects by NPV, Project 3 is preferred, and the total NPV from the investment is $1,637. However, if we rank them by BCR, Projects 1 and 2 are preferred, and both can be afforded within the $800 budget constraint. The total NPV in that case is $1,080 + $1,216 = $2,296, so this is clearly the better ranking method. For a budget of $800, ranking by IRR also leads to funding Projects 1 and 2 as it provides the same ranking, and therefore the same total NPV as does ranking by BCR.

Now suppose that the budget is only $400. For the sake of this example, assume that if a project is partly funded, its benefits are scaled down linearly in proportion to the level of funding: half the funding leads to half the benefits. Now ranking by NPV leads to funding half of Project 3, with NPV of $1,637 / 2 = $819. Ranking by BCR results in funding Project 2, with NPV of $1,216, and ranking by IRR results in funding Project 1, with NPV of $1,080. Ranking by BCR is the best option.

Consider whether the common criticisms of BCR are applicable in this decision context. The criticism that ranking projects using BCRs biases decisions toward supporting small projects (e.g., Commonwealth of Australia 2006) seems potentially relevant, since ranking is required to prioritize the projects. However, the example in Table 1 shows that the relatively favorable assessment of projects with smaller costs is not a bias in this scenario—it is an accurate reflection of the relative merits of the competing projects when there is a budget constraint. Indeed, a more pertinent observation in this case would be that NPV is biased toward supporting large projects.

The other criticism is that BCR is an unreliable decision metric because its magnitude is sensitive to how costs are allocated between the numerator and the denominator of the BCR, and the allocation is arbitrary. For example, Lund (1992) provides a numerical example in which the BCR of a project ranges from 1.38 to infinity depending on which of a set of costs are added to the denominator or subtracted from the numerator. He concludes that this "demonstrates some particularly severe problems of the benefit-cost ratio." While it is true that the allocation of costs between the denominator and the numerator does affect the BCR, for the independent/budget-constrained case, it is not correct that the allocation is arbitrary. Given our objective of maximizing overall NPV, the appropriate allocation of costs is clear: the denominator should contain all costs that are subject to the constraint (i.e., they are drawn from the fixed available pool of funds), and all other costs should be subtracted from the benefits in the numerator. No other allocation of costs results in a ranking of the projects that would maximize the overall NPV. The argument that BCRs are unreliable because the allocation of costs is arbitrary is a fallacy for this decision context.

Thus, the correct formula for the BCR for ranking projects in the independent/budget-constrained case is:

$$BCR = (B - C_u) \,/\, C_c \tag{4}$$

where C_u is the aggregate present value of unconstrained costs, and C_c is the aggregate present value of constrained costs. Unconstrained costs potentially include project implementation or operating costs drawn from sources other than the pool of funds being allocated by the decision maker, in-kind costs, the excess burden of taxation, and any unintended negative impacts of the project.

This insight into the correct calculation of BCR was recognized by Bain (1960): "the government should, if constrained as to budget for capital outlay or operations or both combined, rank and choose among investment opportunities [based on] a maximum excess [i.e., benefit] net of unconstrained costs, over constrained costs." Since then, it has rarely been fully recognized and correctly expressed in BCA textbooks or government guidelines. Most authors do not discuss how to rank projects if only some of the project costs are from a constrained pool of funds, with Layard and Glaister (1994) one of the rare exceptions (on p. 43). The formulation in Equation (3) with capital costs in the denominator and operating costs in the numerator (e.g., Campbell and Brown 2016) is correct if all capital costs, and only capital costs, are subject to a budget constraint.

Numerical Example continued.

Suppose that the costs shown in Table 1 would be borne by the Department of XYZ and are subject to a budget constraint of $400, but that there are additional costs borne by others that are not subject to any budget constraint, as shown in Table 3. With these costs and the benefits shown in Table 1, the overall NPVs are $758 for Project 1, $785 for Project 2, and $962 for Project 3. Using the BCR formula in Equation (2) (all costs in denominator), the BCRs are 2.09 for Project 1, 1.98 for Project 2, and 1.68 for Project 3. Using the BCR formula in Equation (4) (constrained costs in denominator), the BCRs are 3.04 for Project 1, 3.11 for Project 2, and 2.29 for Project 3.

Ranking the projects using Equation (2) results in XYZ choosing to fund Project 1, with a resulting NPV of $757.94, but this is not the best decision because it fails to account for the fact that only some of the costs are drawn from the constrained budget. Ranking the projects using Equation (4) results in Project 2 being preferred, giving a higher NPV of $784.55. In general, Equation (4) performs best for ranking projects when only some of the costs are constrained.

Table 3: Revised Costs of the Three Example Projects, Consisting of Costs to the Department of XYZ (Subject to a Budget Constraint of $400) and Other Costs (Not Subject to a Budget Constraint)

	Year	0	1	2	3	4	5	Present value
Project 1	Cost to XYZ (constrained)	$200	$200	$0	$0	$0	$0	$372
	Other cost (unconstrained)	$0	$0	$100	$100	$100	$100	$322
Project 2	Cost to XYZ (constrained)	$200	$200	$0	$0	$0	$0	$372
	Other cost (unconstrained)	$0	$0	$500	$0	$0	$0	$432
Project 3	Cost to XYZ (constrained)	$400	$400	$0	$0	$0	$0	$744
	Other cost (unconstrained)	$0	$0	$400	$400	$0	$0	$675

Note: In the BCRs reported in the text, the benefits are the same as in Table 1. Discount rate = 5 percent.

There are, however, limits to the applicability of the decision rule to rank by BCR in the independent/budget-unconstrained scenario. It strictly holds only if *all* the projects under consideration are independent, and if there is only a single constraint affecting the decisions—one fixed pool of funds from which funds are drawn. Also, it assumes that the marginal project (the one with the lowest BCR that lies partly within the budget envelope) is continuously scalable and that benefits scale in proportion to costs. Situations where these conditions are not met may require a constrained optimization algorithm (e.g., integer programming, nonlinear programming) to identify the optimal decision (Dryden 1962), or an acceptance that ranking by BCR provides an approximately optimal solution. If optimization is used, the recommendation from Table 2 that most closely matches the actual decision context could be used as a starting value, if required by the optimization algorithm.

If the candidate projects are mutually exclusive, the decision rule is straightforward: choose the project with the highest NPV that does not exceed the funding constraint (if there is one). This is the situation where the criticism that BCR is biased toward smaller projects is valid, and it should not be used. For similar reasons, choosing the mutually exclusive project with the highest IRR may also favor relatively small projects and lead to inferior decisions in this context.

Numerical Example continued.

If the projects described in Table 1 are mutually exclusive, it means that only one of them can be chosen for funding. In that case, the preferred project is the one with the highest NPV, Project 3, which produces an NPV of $1,637. Ranking by BCR would indicate support for Project 2 as it has the highest BCR of 4.27, but it delivers an NPV of only $1,216. Ranking by IRR would lead to support for Project 1, with the highest IRR of 78 percent but the lowest NPV of $1,080.

The recommendation to use NPV for decisions about mutually exclusive projects only strictly holds if *all* of the projects under consideration are mutually exclusive. If the projects under consideration are a mix of mutually exclusive projects and independent or partially dependent projects, none of the simple decision criteria will lead to ideal decision making. A constrained optimization algorithm would be needed.

4.1 Issues with IRR

IRR appears only in the independent/unconstrained-budget quadrant of Table 2, in which it is recognized that the decision rule IRR > discount rate can be equivalent to NPV > 0 and BCR > 1. There is no decision context for which the use of IRR leads to superior decisions compared with the other two criteria, and in three of the four contexts, it is inferior. Thus, even in the absence of any technical difficulties, there is no advantage in using IRR to guide decision making.

How serious are the technical concerns that have been raised about IRR? One concern is that the way that the IRR is calculated implies that positive cash flows will be reinvested at the IRR (Renshaw 1957), and this may be unrealistic.

Numerical Example continued.

Project 1 in Table 1 has an IRR of 78 percent, and it has $500 net benefits in year 3. The implicit assumption in calculating the IRR is that the $500 generated in year 3 will be invested at a 78 percent annual rate of return for the remainder of the evaluation period. It may be that there are no other investment opportunities available that offer a 78 percent rate of return. Perhaps the best available rate of return is 5 percent in a bank account, in which case IRR overstates the overall performance of the investment.

On the other hand, if we restrict the use of IRR to the independent/unconstrained-budget case, this issue is no longer a concern because the only question is whether the IRR exceeds the chosen discount rate. The discount rate should in principle reflect realistic investment opportunities.

The possibility of unrealistic reinvestment rates would be of a concern if IRR were used to rank competing independent projects that are subject to a budget constraint, or to rank alternative mutually exclusive projects. As noted earlier, its use in the latter context is likely to bias decision making toward smaller projects that are less beneficial overall. If ranking independent projects, as well as the reinvestment-rate issue, IRRs are unable to account for the fact that some costs are constrained and others unconstrained, leaving BCR calculated according to Equation (4) as the preferred ranking criterion.

The second and more frequently raised technical concern is that a project can have multiple valid IRRs, leaving decision makers uncertain about which IRR to use for decision making. Multiple IRRs are possible (though not certain) if the stream of net benefits for a project has multiple changes of sign over time (e.g., from negative to positive and back to negative). This is not a concern with most projects, but it can occur. “In real life there may of course be few projects for which the net returns stream changes sign

more than once, except in industries where there may be heavy terminal costs (such as filling in mines or decommissioning nuclear power plants and so on)" (Layard and Glaister 1994, p. 43).

Numerical Example continued.

Consider a project with the following stream of net benefits (benefits minus costs in each year), including a large terminal cost: –65, 25, 50, 75, 120, –220. Net benefits change from negative to positive and back to negative. Given these numbers, the relationship between discount rate and NPV is shown in Figure 1. There are two discount rates at which the NPV = 0, and hence two valid IRRs: 9 percent and 32 percent.

Having multiple changes of sign in the stream of net benefits does not necessarily result in multiple IRRs. Figure 2 shows the equivalent graph for a slightly modified stream of net benefits: –65, 25, 50, 75, 120, –200. In this case, there is only one IRR, and the usual interpretation is valid.

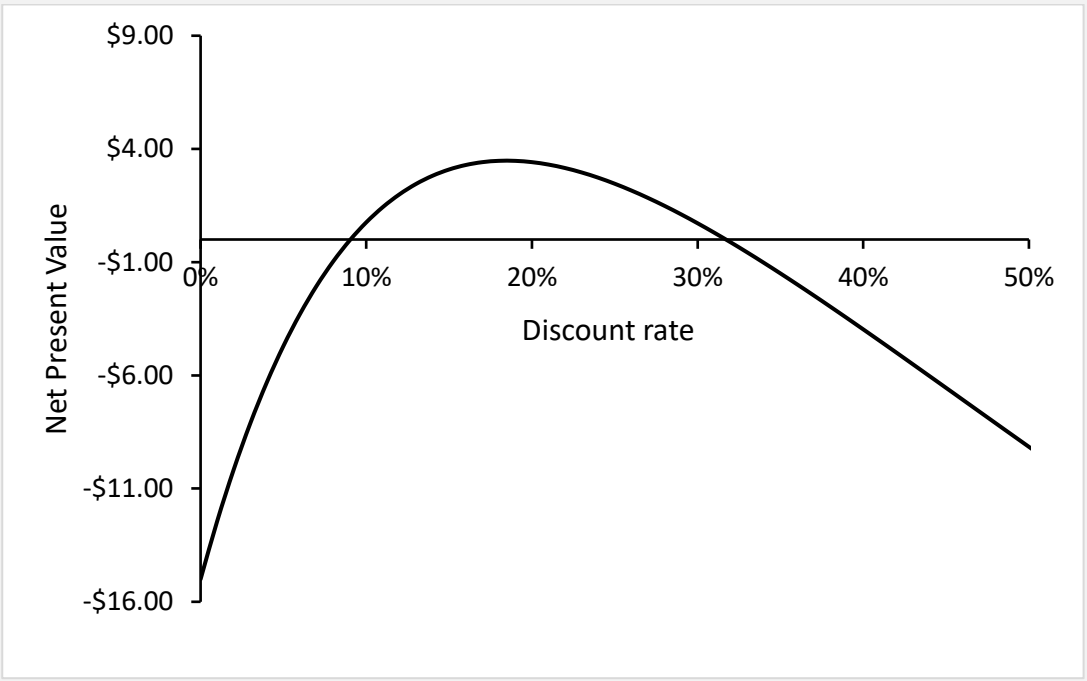

Figure 1: NPV versus Discount Rate for the Stream of Net Benefits, –65, 25, 50, 75, 120, –220

Viewing Figure 1 clarifies how the two IRRs should be interpreted for decision making. If the chosen discount rate is between the two IRRs, the NPV is positive and the project is desirable. Applying the usual decision criterion (IRR > discount rate) to the lower IRR would be misleading, and even applying it to the higher IRR could be misleading (if the discount rate is below 9 percent). Thus, if there are multiple IRRs, it is not a matter of deciding which of them to use; the issue is whether the discount rate lies between two IRRs that bound a positive section of the NPV curve.

Given that spreadsheet software provides only one IRR and does not indicate whether there are multiple IRRs, users of IRR need to take care (Rosbaco 1999; Hazen 2003). They probably need to create a graph like Figures 1 and 2 to check whether there are multiple IRRs within a realistic range of discount rates, and if so, use the graph to assist with their interpretation (Bey 1998). Given the level of knowledge and effort required, basing decisions on NPV or BCR is probably more convenient.

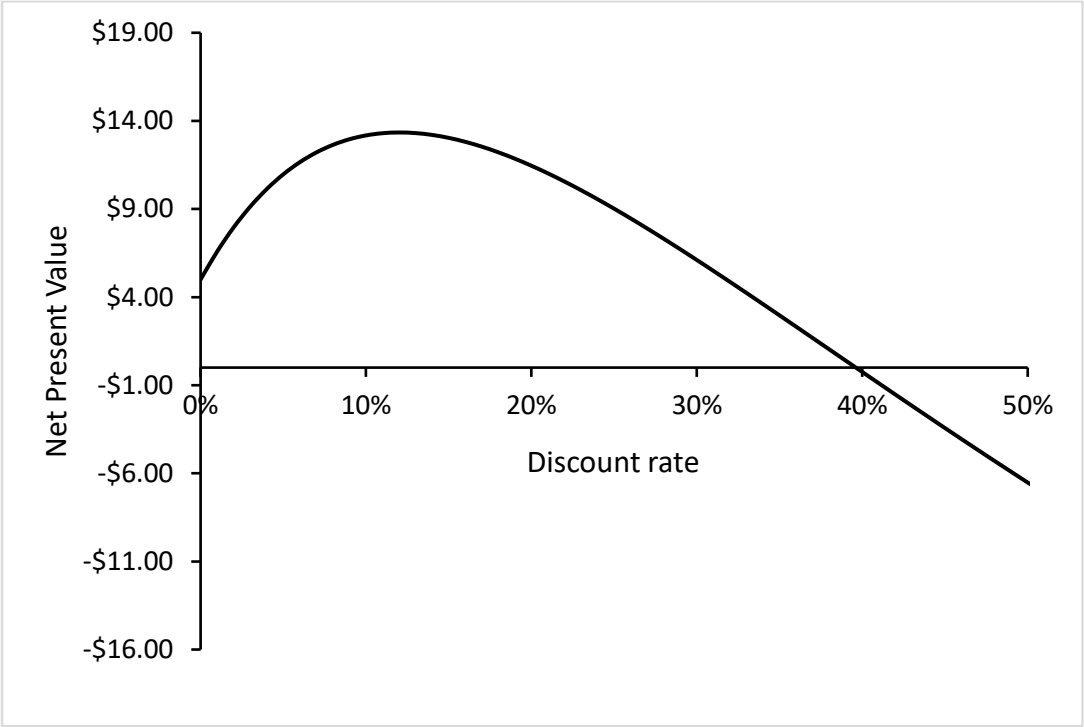

Figure 2: NPV versus Discount Rate for the Stream of Net Benefits, –65, 25, 50, 75, 120, –200

5 Limits of the Standard Criteria

The four decision scenarios presented in Table 2 represent specific decision contexts for which the advice to use one or more of the standard decision criteria can be made with confidence. However, they are, in a sense, extreme cases. In practice, most real decisions are made in circumstances that do not exactly match any of these four contexts. For example, the candidate projects might be a mix of independent, partially dependent, and mutually exclusive projects. There might be more than one constraint on the selection of projects, such as a constraint on capital costs and a different constraint on operating and maintenance costs, or a constraint on the availability of a nonfinancial resource. Projects might not be scalable or might scale nonlinearly.

In these cases, no simple decision criterion can be assured of generating an optimal set of decisions. Depending on how similar the real decision-making context is to these idealized contexts, it may be judged that one of the contexts in Table 2 is sufficiently close for a particular decision criterion to provide approximately optimal results. If that is not the case, an alternative is to develop a constrained optimization model that fully captures the specific decision context.

In practice, we rarely observe the latter happening. Most commonly, in cases where BCA results are directly utilized in decision making, decision makers select the decision criterion that they judge to be most suitable and base their decisions on that, often with adjustments for other factors that have not been captured in the BCAs. Given the time and resource constraints that typically apply to decision making, this seems a pragmatic approach.

However, given the inconsistencies and contradictions we have identified in BCA textbooks and guidelines, we wonder how often decision makers are relying on decision criteria that are not the best fit for their decision context. For example, we have observed decision makers using NPV or IRR to rank independent projects subject to a budget constraint, or BCR to select from a set of mutually exclusive projects, all of which are inconsistent with Table 2. We recommend that decision makers use the framework in Table 2 as the starting point in their deliberations.

6 Conclusion

Every BCA textbook and guideline describes how to calculate a NPV and most describe BCR and IRR. They also typically provide advice on which of these decision criteria should be used, either at all or in particular contexts.

Unfortunately, as we have seen, this advice is highly inconsistent between textbooks, which unavoidably means that some of it is incorrect. We have reconciled the conflicting advice using an existing framework that describes different decision contexts and the decision criteria that perform best in those contexts. Only a small minority of existing textbooks use this framework, or something close to it (e.g., Sassone and Schaffer 1978; Pearce and Nash 1981; Layard and Glaister 1994; Fuguitt and Wilcox 1999; Campbell and Brown 2016).

We have explained the reasons for preferring particular decision criteria in each context, and in the process debunked some widely believed fallacies, particularly regarding BCRs. We have highlighted the correct formula for calculating the BCR when the costs are partially drawn from a constrained budget—a formula that is absent from most textbooks.

The insights presented here are relevant to decision making about public projects, programs, and policies of any type, in any country. We recognize that when BCA results are used to inform real decision making, a pragmatic approach is often needed. Nevertheless, we believe that wider awareness and application of the decision criteria framework (Table 2) would help to improve the quality of many decisions about public investment in policies, programs, and projects.

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Acknowledgments: The authors thank Michael Burton and Graham Marshall for their participation in debates and discussions that ultimately led to this paper.

Appendix: The Benefit-Cost Analysis Resources Reviewed

This table lists the textbooks and guidelines reviewed in the preparation of this paper.

Table A1. Benefit-Cost Analysis Resources

Reference	Resource Type
Abelson, P. 1979. *Cost Benefit Analysis and Environmental Problems*. Farnborough UK: Saxon House.	Textbook
Asian Development Bank. 2013. *Cost-Benefit Analysis for Development: A Practical Guide*. Manilla, Philippines.	Guideline
Atkinson, G., N.A. Braathen, B. Groom, and S. Mourato. 2018. *Cost-Benefit Analysis and the Environment: Further Developments and Policy Use*. Paris: OECD Publishing.	Guideline
Bergstrom, J.C., and A. Randall. 2016. *Resource Economics: An Economic Approach to Natural Resource and Environmental Policy,* 4th ed. Northampton MA: Edward Elgar.	Textbook
Boardman, A., D. Greenberg, A. Vining, and D. Weimer. 2018. *Cost-Benefit Analysis: Concepts and Practice,* 5th ed. Cambridge UK: Cambridge University Press.	Textbook
Brent, R.J. 1998. *Cost-Benefit Analysis for Developing Countries.* Northampton MA: Edward Elgar.	Textbook
Brent, R.J. 2003. *Cost-Benefit Analysis and Health Care Evaluations.* Northampton MA: Edward Elgar.	Textbook
Brent, R.J. 2006. *Applied Cost-Benefit Analysis,* 2nd ed. Northampton MA: Edward Elgar.	Textbook
Brent, R.J. 2017. *Advanced Introduction to Cost-Benefit Analysis.* Northampton MA: Edward Elgar.	Textbook
Campbell, H., and R. Brown. 2016. *Cost-Benefit Analysis: Financial and Economic Appraisal Using Spreadsheets,* 2nd ed. New York: Routledge.	Textbook
Commonwealth of Australia 2006. *Handbook of Cost Benefit Analysis.* Canberra.	Guideline
Dasgupta, A.K., and D.W. Pearce. 1972. *Cost-Benefit Analysis: Theory and Practice*. London: Macmillan.	Textbook
de Rus, G. 2021. *Introduction to Cost-Benefit Analysis: Looking for Reasonable Shortcuts,* 2nd ed. Northampton MA: Edward Elgar.	Textbook
Department of Treasury and Finance. 2013. *Economic Evaluation for Business Cases.* Melbourne: Victorian Government.	Guideline
Department of Treasury and Finance. 2014. *Guidelines for the Evaluation of Public Sector Initiatives. Part B: Investment Evaluation Process.* Adelaide: Government of South Australia.	Guideline
Dinwiddy, C., and F. Teal. 1996. *Principles of Cost-Benefit Analysis for Developing Countries*. Cambridge UK: Cambridge University Press.	Textbook

Table A1 continued.

Dobes, L., J. Leung, and G. Argyrous. 2016. *Social Cost-Benefit Analysis in Australia and New Zealand: The State of Current Practice and What Needs to be Done*. Canberra: ANU Press.	Textbook
European Union. 2015. *Guide to Cost-Benefit Analysis of Investment Projects: Economic Appraisal Tool for Cohesion Policy 2014–2020.* Luxembourg.	Guideline
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Georgi, H. 1973. *Cost-Benefit Analysis and Public Investment in Transport: A Survey*. London: Butterworths.	Textbook
Gittinger, J.P. 1972. *Economic Analysis of Agricultural Projects,* 2nd ed. Baltimore MD: Johns Hopkins University Press.	Textbook
Gramlich, E.M. 1990. *A Guide to Benefit-Cost Analysis,* 2nd ed. Englewood Cliffs NJ: Prentice-Hall.	Textbook
Guerriero, C. 2019. *Cost-Benefit Analysis of Environmental Health Interventions*. San Diego: Elsevier.	Textbook
Hanley, N., and E.B. Barbier. 2009. *Pricing Nature: Cost-Benefit Analysis and Environmental Policy*. Northampton MA: Edward Elgar.	Textbook
Hanley, N., and C. Spash. 1993. *Cost-Benefit Analysis and the Environment*. Aldershot: Edward Elgar.	Textbook
HM Treasury. 2022. *The Green Book: Central Government Guidance on Appraisal and Evaluation.* London.	Guideline
Howe, C.W. 1986. *Benefit-Cost Analysis for Water System Planning, Water Resources Monograph 2.* Washington DC: American Geophysical Union.	Textbook
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Newton, T. 1972. *Cost-Benefit Analysis in Administration*. London: Allen and Unwin.	Textbook
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Perman, R., Y. Ma, M. Common, D. Maddison, and J. McGilvray. 2011. *Natural Resource and Environmental Economics,* 4th ed. New York: Pearson Addison Wesley.	Textbook
Potterton, P. 1995. *Introduction to Cost-Benefit Analysis for Program Managers,* 2nd ed. Canberra: Department of Finance, Australian Government.	Guideline
Queensland Government. 2015. *Project Assessment Framework: Cost-Benefit Analysis.* Brisbane: Queensland Government.	Guideline
Ray, A. 1984. *Cost-Benefit Analysis: Issues and Methodologies*. Baltimore MD: Johns Hopkins University Press.	Textbook
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Case Study

Adopting Precision Input Management: A Teaching Case Study

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JEL Codes: D14, Q12
Keywords: Case study, exercise, partial budgeting, precision agriculture

Abstract
Students are introduced to a framework for individual-farmer evaluation of the net benefits of adopting precision agricultural technologies (PATs). A young farmer is considering whether to use a PAT bundle. He is advised by a crop consultant. Students adopting the role of the farmer should analyze the basic economics associated with using the PAT. The focus is on identifying what differs from traditional application and that under PAT, finding information necessary to analyze the net effect, conducting sensitivity analysis, and factoring in qualitative considerations. Students should use partial budgeting analysis to calculate net change in profits expected from adopting a single PAT bundle.

"*Farming looks mighty easy when your plow is a pencil, and you're a thousand miles from the corn field*."
—President Dwight D. Eisenhower (Bradley University, Peoria, Illinois, September 25, 1956)

1 Introduction

Dakota Levy and his parents farm 2,400 acres in southeastern North Dakota, growing soybeans, corn, wheat, and sunflowers. His mom, Jacqueline, has a full-time job as a teacher at the local school, and his dad, Arnold, farms and runs a one-man custom welding shop during the winter. Dakota just graduated with a two-year degree in agronomy from the local community college. As he graduated just before Christmas, he is currently helping his dad in the welding shop as he explores his options.

Dakota and Arnold went to a precision agriculture technology (PAT) workshop put on by North Dakota State University Extension staff. In addition to the extension team, there were a PAT equipment manufacturer and two regional PAT data software sales and services firms at the workshop. A crop consultant and dealership who both offer PAT services, including collecting and analyzing drone imagery, soil testing, variable rate application of fertilizers, and variable rate seeding, were also present. Dakota and his dad were excited to learn more about the farming technologies they had heard and read about, and it was good to take a break from the welding shop, as it had been a busy month.

Arnold had kept up on PATs from daily coffee at the local café and reading farm magazines and newspapers, as well as following two farming blogs. Dakota heard quite a bit about the potential of PATs in school over the past year and learned to fly a commercial drone, but did not take any classes that specifically considered the economics of PATs. Hearing about advances in the PATs and talking with other farmers who have had positive experiences increased their interest in considering the use of PATs on their farm.

As they drove home from the workshop, Arnold and Dakota discussed the possibilities. Arnold was particularly curious about how adopting these PATs would affect yields and if spending the extra money on additional soil testing and specialized equipment was worth the cost savings on inputs. "This is a problem that can be addressed using a partial budget," said Dakota. "We learned how to do partial budgets in our farm management course." Dakota went on to explain to his father that the starting point is to identify potential PATs for their operation. They would then compare recent revenues and costs on the land to those they could expect if they adopted a PAT bundle. During the workshop, the North Dakota State University Extension staff indicated they could identify data sources to use in these "what if" scenarios. Dakota was anxious to get started on the problem and share the answers with his father.

2 Farm Background and Plans

Dakota plans to take over the family farm one day although he has two younger brothers, 17 and 13, and a younger sister, 15. His parents are only in their late forties, and his dad has not mentioned any plans to retire. Dakota's parents are supportive of him one day taking over the farm, but have encouraged him to work off the farm for a few years to get some work and decision-making experience, gather new ideas, and otherwise expand his horizons. He has been participating in farm planning and decision making with his parents, increasingly so since he started attending college.

Dakota has been adamant that he wants to farm and has started looking for employment within a forty-minute drive of the farm. He also has hinted to his dad that they might grow the welding business to support two families during the winter. With his parents co-signing his operating loan, Dakota was able to sign a three-year lease on a quarter section of land (160 acres) from a retired neighbor. The farm is adjacent to one of his family's fields and within a mile of the home farm. This farm has some soil variability and moderate topography. Dakota's parents agreed that he can use the equipment from their home farm but will be responsible for paying fuel costs. Another condition is that Dakota must make all production, marketing, and other decisions on his 160 acres. Dakota has been talking with his parents and others as he makes plans for spring planting. So far, he has decided to focus his efforts on one crop this year.

Given current markets and the storage capabilities on the farm, Dakota decided to plant all his acres to corn the first year. He developed a marketing plan, and his plan is to sell portions of his crop at four different times during the year following harvest, unless there are considerable changes in the crop market. He plans to store his corn after harvest and lock in prices with forward contracts with the local elevator.

2.1 Precision Agriculture Technology Adoption Decision

Dakota was finalizing his input purchases as he shared lunch with Joe, who was two years ahead of him in high school and graduated the previous spring from North Dakota State University with a degree in Agricultural Systems Management and a minor in Agribusiness. Joe started working for a local crop consulting firm right out of school. He had interned with them the previous summer, and they are interested in Joe growing the PAT part of the business. It is clear Joe believes in the potential for PATs to allow farmers to, as he repeated several times during lunch, "optimize their input use."

Dakota had a fuzzy recollection from his one economics class that a farmer should optimize input use rather than aim for the highest yield. However, he also knows that his father will be very supportive of getting the most out of the land. Regional farmers generally plant to maintain or improve on their current yields and to maintain their actual production history (APH) yields. Dakota mentioned to Joe that any recommendation would need to include a yield goal similar to the land's APH yield, regardless of input and output prices.

Joe recommended that Dakota try using variable rate application of fertilizers and a variable seeding rate based on yield monitor and soil sampling data.[1] He suggested that the first year, Dakota hire out the soil sampling and zone mapping, and custom hire the variable rate application of fertilizers. Joe knew that Dakota's parents had a variable rate seeder so he could use digital prescription maps to variable rate seed using their own equipment.

Joe used the National Agriculture Imagery Program (NAIP) and Normalized Difference Vegetation Index (NDVI) imagery along with yield and soil sampling data the neighbor provided from prior years of operating on his 160-acre tract to create five management zones for the quarter-section (Figure 1). Joe explained that the NAIP is a U.S. Department of Agriculture program that captures digital imagery. And that the NDVI uses graphics to identify plant locations and characteristics, allowing for example, the

[1] Variable application is designed to optimize inputs such as fertilizer and seeds based on variable crop needs throughout the field rather than apply a constant rate across the field.

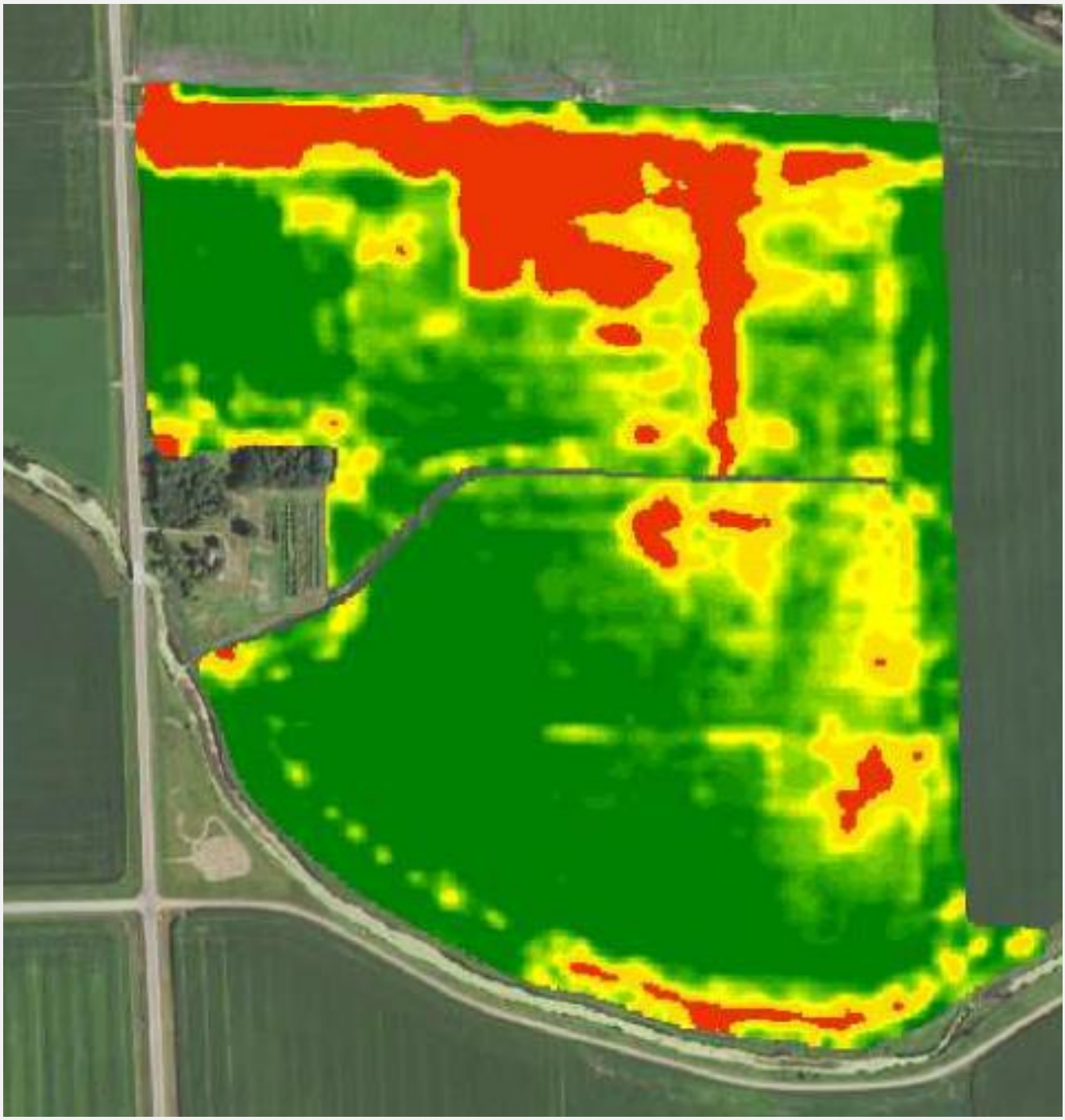

Figure 1: Recommended Zones for Variable Rate MAP Application[2]

monitoring of crop health and yield predictions. He proposed he would then more aggressively soil sample each management zone after harvest to refine fertilizer and seeding recommendations for the following year.

Joe showed Dakota the yield goals and recommended input use values he had come up with in Table 1. He pointed out that the first two rows identify the zones and the target yield for these zones. The following rows list average seeding rate and fertilizer input recommendations for each zone. He

[2] "MAP" abbreviates monoammonium phosphate fertilizer (NH4H2PO4). It is used as a source of nitrogen and phosphorous.

noted that applications and seeding rate would vary within each zone as well, but that level of detail can be left up to the planter, sprayer, and spreader custom operations. The overall average yield goal, seeding rate, and fertilizer application level was calculated as a weighted average over the five zones. The last column shows the retiring farmer's historic rate of fertilizer application and seeding rate on this land. Dakota was pleased to see that the proposed yield goal was slightly higher than the land supported previously.

Table 1: Sample Corn Input Recommendations per Acre by Management Zone*

Value/Zones	1	2	3	4	5	Weighted average	Traditional
Acres	3.7	14.1	27.8	51.2	62.2		
Yield goal (bushels)	120	150	160	195	210	189.0	185
Seeding rate (1,000)	24	27	29	31	35	31.7	32
Nitrogen, urea (lbs)	195	215	268	270	295	272.8	325
Phosphorus, MAP (lbs)	0	19	50	100	140	97.4	100
Potassium, potash (lbs)	0	0	70	74	75	65.4	100
Sulfur, AMS (lbs)	20	47	51	60	66	58.7	75
Pop-up fertilizer, 6-24-6 (gallon)	3.0	3.0	4.5	4.5	5.0	4.5	5.0

3 Economics

Dakota was excited about the possible yield gain while at the same time using a lower seeding rate and applying less fertilizer. He asked Joe what this would all cost. Joe motioned him to the table and emphasized that the primary cost savings would be in the form of reduced application of fertilizers and reduced overall seeding rate. He noted that savings by applying less fertilizer should really pay off this year because fertilizer prices are high. Joe ambitiously pointed out that eventually expanding use of precision agriculture to the overall family operation would increase savings even more because of its greater soil variability and the higher input costs. He recommended that Dakota use costs from December 2020 when he calculates out the net effect of adopting the precision agriculture bundle recommended because of recent dramatic increases in the market (Table 2), providing a more conservative estimate of the value of adoption.

Table 2: Fertilizer, Seed, and Corn Prices ($), December 2020

Input/Output	Cost/Price
Corn (bushel)	$4.14
Seed (1,000)	$3.00
Nitrogen, urea (lbs)	$0.28
Phosphorus, MAP (lbs)	$0.27
Potassium, potash (lbs)	$0.18
Sulfur, AMS (lbs)	$0.20
Pop-up fertilizer 6-24-6 (gallon)	$2.69

Note: Unless indicated, input use is noted in pounds.

Dakota liked the potential for significant cost savings but reiterated his question about what this would cost. He wanted to know what additional costs he would encounter by adopting this PAT bundle. Joe indicated that those were easier to estimate because Dakota would be hiring custom applicators. Additional or higher costs associated with transitioning to the PAT bundle include those due to smaller-grid soil sampling, zone mapping, fertilizer recommendations, dry fertilizer application, and a hydraulic pump. Joe provided a per acre estimate of new or increased costs

Joe's proposal seems like it might work, but Dakota will have to run the numbers and think about his options. He also wonders if any other costs Joe didn't mention might change and how that might affect the decision. He remembers something was said in the workshop about how harvest and post-harvest costs may change with yields.

Dakota is thankful for the agricultural management and finance classes he had at the community college. They learned how to set up a problem in Excel and calculate profit and other financial indicators. He wants to have a plan ready when he approaches his parents with his proposal, although ultimately the decision is his for the 160 acres he rented.

To get started, Dakota reviews his notes from his courses about developing a partial budget. His instructors emphasized that an analysis can only be as good as the assumptions and data it uses. Dakota will use assumptions and costs provided by Joe as a starting point. Should it turn out that adopting PAT is likely to be profitable and his parents support the change, Dakota is ready to implement this in the spring on a trial basis.

Table 3: Cost Differences Between Precision Agriculture and Traditional Application Rates ($/Acre)

Costs	With PAT[a]	Without PAT
Soil Sampling	2.5	1.25
Zone Mapping	3	-----
Fertilizer Recommendation	6	-----
Dry Fertilizer Application	10	8
Hydraulic Pump	1	-----

[a]PAT is "Precision Agriculture Technology."

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CRediT author statement:
Cheryl Wachenheim: Conceptualization, methodology, formal analysis, investigation, data curation, writing-original draft, writing-editing and review, visualization, supervision, project administration, funding acquisition. Erik Hanson: Conceptualization, methodology, formal analysis, investigation, data curation, writing-editing and review, and testing.

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Case Study

Market Power in the U.S. Beef Packing Industry

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JEL Codes: L1, L2, L4, L13
Keywords: Beef packing industry, marketing margins, oligopoly, oligopsony, price-fixing

Abstract
This case study is motivated by recent developments in the U.S. beef packing industry involving allegations of an illegal exercise of buyer and seller market power by the four largest beef packers in the markets for fed cattle and beef products, respectively. In 2019, fed cattle producers and beef buyers filed class action antitrust lawsuits against these companies alleging that they engaged in an unlawful conspiracy with the purpose of decreasing fed cattle prices and increasing wholesale and retail prices of beef as early as January 2015 and violated Section 1 of the Sherman Act. The case study focuses on applications of economic models that may explain conduct and performance of the beef packing industry using the perspectives of plaintiffs and defendants in the ongoing cattle and beef antitrust litigation. The case study also introduces a basic empirical analysis of beef production, beef values, and marketing margins in the beef supply chain based on publicly available data reported by the U.S. Department of Agriculture. The intended audiences are undergraduate and graduate students. The teaching note summarizes student learning objectives and teaching strategies. It also includes multiple-choice questions, as well as suggested answers and guidance to analytical, discussion, and multiple-choice questions.

1 Introduction

The U.S. fed cattle price dynamics beginning in 2010 attracted increased attention of industry participants and policy decision makers (U.S. Government Accountability Office 2018).[1] In the period of 2010–2015, fed cattle prices, while volatile, increased steadily from approximately $90 per hundredweight (cwt) in early 2010 to approximately $170 per cwt by the end of 2014. Fed cattle prices then collapsed in 2015, falling to approximately $125 per cwt by the end of 2015 and to $100 per cwt by the end of 2016 (U.S. Government Accountability Office 2018; Figure A1 included in Appendix 1).[2]

In 2019, fed cattle producers and beef buyers filed class action antitrust lawsuits against the four largest beef packers in the country: Tyson Foods, JBS USA, Cargill Meat Solutions, and National Beef Packing Company. The plaintiffs alleged that these companies engaged in an unlawful conspiracy with the purpose of decreasing fed cattle prices and increasing wholesale and retail prices of beef as early as January 2015 and thus violated Section 1 of the Sherman Act (1890) (Brown 2019; Douglas 2019). The coordinated supply restraints (reduced slaughter rates, plant capacity underutilization, plant closures, and reduced purchases of fed cattle in the spot market) were claimed to be the primary method of

[1] Fed cattle are heifers and steers raised to produce high-quality beef products. Beef packers purchase fed cattle to slaughter and process them into boxed beef and various beef cuts sold to wholesalers, retailers, and final consumers (U.S. Government Accountability Office 2018).

[2] Fed cattle prices, as many agricultural commodity prices, fluctuate due to a natural agricultural (fed cattle) price cycle (Kohls and Uhl 2002). Fed cattle prices respond to expansion and contraction in the production of fed cattle (U.S. Government Accountability Office 2018; Figure A1 included in Appendix 1). Fed cattle prices typically increase in the periods of decreasing fed cattle inventory (decreasing fed cattle quantity produced). Fed cattle prices typically decrease in the periods of increasing fed cattle inventory (increasing fed cattle quantity produced).

implementing this price-fixing conspiracy.

The objective of the case study is to explain recent developments in the U.S. beef packing industry involving allegations of an illegal exercise of buyer and seller market power by the four largest beef packers by analyzing relevant economic, business, and legal issues. The case study focuses on applications of economic models that may explain conduct and performance of the beef packing industry (changes in beef production; farm, wholesale, and retail values of beef; farm sector share; and marketing margins) using the perspectives of plaintiffs and defendants in the ongoing cattle and beef antitrust litigation. The case study also introduces a basic empirical analysis of beef production, beef values, farm sector share, and marketing margins in the beef supply chain based on publicly available data reported by the U.S. Department of Agriculture. Table 1 summarizes student learning objectives.

Table 1: Student Learning Objectives

	Student Learning Objectives (SLOs)
SLO #1	Students should be able to explain the U.S. beef packing industry structure and alternative marketing arrangements for fed cattle.
SLO #2	Students should be able to discuss competition issues related to market power of the four largest beef packers raised during the ongoing antitrust litigation, using the perspectives of plaintiffs (fed cattle producers and beef buyers) and defendants (the four largest beef packers).
SLO #3	Using a graphical analysis, students should be able to explain two theoretical frameworks, which may describe conduct and performance of the beef packing industry (changes in input and output quantities and prices, and marketing margins) in the two situations. In the first situation, the beef packing industry behaves as an imperfectly competitive industry (oligopsony/oligopoly forming an input and output price-fixing cartel). In the second situation, the beef packing industry behaves as a competitive industry adjusting input and output quantities in response to increasing marginal cost (increasing fed cattle prices).
SLO #4	Students should be able to perform a basic empirical analysis to evaluate changes in the market and price behavior in the beef supply chain between the period of the alleged price-fixing cartel and a prior, more competitive period.
SLO #5	Students should be able to discuss legal (antitrust) issues involved and explain the role of the Sherman Act in regulating conduct of beef packers in the analyzed industry setting.

2 U.S. Beef Packing Industry Background

This section discusses the beef packing industry's structure and fed cattle marketing arrangements used by fed cattle producers and beef packers.

2.1 U.S. Beef Packing Industry: Structure

The U.S. beef packing industry is a highly concentrated industry.[3] The combined market share of the four largest firms (beef packers) in fed cattle slaughtering and beef sales is in the range of 80 to 85 percent (Greene 2016, Figure 1; Pollard 2021; U.S. Department of Agriculture, Agricultural Marketing Service

[3] A commonly used measure of market concentration is the combined market share of N largest firms in the industry, which is also referred to as the N-firm concentration ratio (Besanko et al. 2006). CR4 (N = 4) is the most frequently used measure. It is considered that if CR4 exceeds 75 percent, industries are conducive to collusion and present competition concerns (Hovenkamp 2005). If CR4 is smaller than 40 percent, industries are not likely to present competition concerns.

2022; MacDonald, Dong, and Fuglie 2023).[4] While several economically significant acquisitions took place in the industry in the two recent decades, these acquisitions did not alter the number of the largest beef packers. Some of these acquisitions affected the ownership of the largest beef packers.

In 2001, Tyson Foods (now the largest U.S. meat processor) acquired Iowa Beef Processors, then the largest U.S. beef packer (Ward 2010). In 2007, JBS S.A. (a Brazilian company, the world's largest meat processor) acquired Colorado-based Swift Foods Company (then the third largest U.S. beef processor). As of 2007, the four largest beef packers in the United States were Tyson Foods (market share of 23.6 percent), Cargill Meat Solutions (market share of 22.0 percent), JBS USA (market share of 14.6 percent), and National Beef Packing Company (market share of 11.4 percent). Smithfield Beef Group was the fifth largest beef packer (market share of 6.5 percent; Congressional Research Service 2009, Table 1). In 2008, JBS S.A. acquired Smithfield Beef Group (Johnson 2009). In 2018, Marfrig (a Brazilian company) purchased the controlling ownership interest in National Beef Packing Company (National Beef Newsroom 2018).

2.2 U.S. Beef Packing Industry: Fed Cattle Marketing Arrangements

The U.S. beef packing industry has a high degree of vertical coordination (Adjemian et al. 2016; Greene 2016). Fed cattle producers and beef packers use a variety of fed cattle marketing arrangements (Greene 2019). While the spot (cash) market for fed cattle had been the dominant marketing arrangement in the industry prior to the 2000s, the use of alternative marketing arrangements, and in particular the use of forward and formula contracts, increased in the two recent decades (Greene 2019; Peel et al. 2020).[5] For example, the share of fed cattle sold in a traditional negotiated spot market setting decreased from approximately 55 percent in 2004 to 23 percent in 2019 (Greene 2019, Figure 1). In contrast, the share of fed cattle sold using forward and formula contracts increased from approximately 31 percent in 2004 to 70 percent in 2019 (Greene 2019, Figure 1).

Forward and formula contracts are essential for business planning: output (fed cattle) marketing for fed cattle producers and input (fed cattle) procurement for beef packers (Bolotova 2022b). Forward and formula contracts are also a form of risk management for fed cattle producers and beef packers, as compared with traditional spot markets. Beef packers benefit from using forward and formula contracts because they can secure the constant flow of the required quantity of fed cattle with the essential quality characteristics to their meat processing plants. Fed cattle producers also benefit from using forward and formula contracts because they can secure in advance a marketing outlet for their fed cattle and reduce marketing and price risks.

Both forward and formula contracts establish a price determination method for the price to be determined later, when fed cattle are delivered to the beef packing plants (Adjemian et al. 2016; Greene 2016, 2019).[6] Forward contracts use the Chicago Mercantile Exchange live cattle futures contract prices

[4] For comparison, the combined market shares of the four largest broiler chicken processors and the four largest pork processors in 2020 were 52.7 percent and 64.2 percent, respectively (Bolotova 2022a). The combined market shares of the ten largest broiler chicken processors and the ten largest pork processors in 2020 were 79.7 percent and 85.9 percent, respectively (Bolotova 2022a). A comprehensive discussion of concentration and competition in U.S. agribusiness, including crop seeds, meatpacking, and food retailing, is presented in MacDonald, Dong, and Fuglie (2023).

[5] A local livestock auction is an example of the spot market for fed cattle. Alternative marketing arrangements for fed cattle are the alternatives to the spot market: forward contracts, formula contracts, packer-owned fed cattle (vertical integration), and fed cattle sold using a negotiated grid method (Adjemian et al. 2016; Greene 2016, 2019; Peel et al. 2020).

[6] In contrast, a negotiated spot price for fed cattle is determined by interaction (negotiation) between seller and buyer; discounts and premiums are applied to the base price by taking into account directly observed quality of fed cattle (Rhinehart 2009; Parish, Rhinehart, and Anderson 2009; Ward, Schroeder, and Feuz 2017). In the case of a negotiated grid method, a base price for fed cattle is determined by interaction (negotiation) between seller and buyer; the base price includes premiums and discounts specified in a grid (Rhinehart 2009; Parish, Rhinehart, and Anderson 2009; Ward, Schroeder, and Feuz 2017). The grid with fed cattle quality premiums and discounts is either developed using data reported by the U.S. Department of Agriculture or data collected at the processing plant. The actual price for fed cattle is determined based on the quality of

as a base (or a reference price) to determine the actual price paid to fed cattle producers. Formula contracts use spot market prices as a base (or a reference price) to determine the actual price paid to fed cattle producers. The spot market prices used in the formula contracts are typically spot market prices reported by the U.S. Department of Agriculture, Agricultural Marketing Service.

3 Alleged Beef Packer Input and Output Price-Fixing Cartel

This section discusses competition (business conduct) issues raised in the ongoing cattle and beef antitrust litigation (2019–present).

3.1 The Perspective of Fed Cattle Producers and Beef Buyers

The perspective of fed cattle producers and beef buyers is that a price-fixing conspiracy of the four largest beef packers affected the fed cattle and beef price dynamics beginning in 2015 (*In Re Cattle Antitrust Litigation: Ranchers Cattlemen Action Legal Fund United Stockgrowers of America et al. v Tyson Foods, Inc. et al. 2019* [cattle producers' complaint]; *Pacific Agri-Products v. JBS USA Food Company Holdings et al. 2019* [direct beef buyers' complaint]; *Peterson et al. v. Agri Stats, Inc. et al. 2019* [indirect beef buyers' complaint]; *In Re Cattle and Beef Antitrust Litigation* 2022).[7]

First, the complaints state that the following structural characteristics of the beef packing industry facilitated collusion (a price-fixing conspiracy) of the four largest beef packers and contributed to its continuous success.

- The beef packing industry is a highly concentrated industry in the input (fed cattle) and output (beef) markets. The combined market share of the four largest beef packers in fed cattle slaughtering is in the range of 81 to 85 percent. The combined market share of the next largest beef packers is in the range of 2 to 3 percent. The combined market share of the four largest beef packers in beef sales is approximately 80 percent.
- The beef packing industry has high barriers to entry. At least $250 million is required to construct a new beef processing plant. In addition, it takes about two years to obtain the permits, get the plan and design approved, and build a new plant.
- Beef is a homogenous product, which means that it is indistinguishable among beef packers. Buyers are practically indifferent from which beef packer to buy beef. Demand for homogenous products mostly depends on price, rather than on product quality characteristics and/or customer service. The homogeneous nature of beef products makes it easier for beef packers to coordinate on price and effectively enforce their price-fixing agreement.
- Supply for fed cattle and demand for beef are inelastic. The quantity of cattle supplied is insensitive to short-term cattle price changes, due to a long cattle lifecycle, cattle perishability, and the lack of alternative uses for cattle. The quantity of beef demanded is relatively insensitive to changes in beef prices. While chicken and pork are product-substitutes to beef, according to the existing study, the relative effect of changing chicken and pork prices on the quantity of beef demanded is economically small.[8] Because of inelastic supply for fed cattle and inelastic demand for beef, the farm-to-wholesale margin (the "meat margin") is very sensitive to changes in the aggregate quantity of fed cattle slaughtered. The profitability of beef packers is driven by the "meat margin."

delivered and slaughtered fed cattle, which is used to determine actual premiums and discounts. The negotiated grid pricing method rewards cattle producers producing high-quality cattle and penalizes fed cattle producers producing low-quality cattle.

[7] The complaints against the four largest beef packers were filed in the U.S. District Court, District of Minnesota.

[8] The existing study cited in the complaints is Tonsor, Lusk, and Schroeder (2018). For example, see *In Re Cattle and Beef Antitrust Litigation* 2022.

- There are frequent opportunities to collude in the beef packing industry.
  For example, employees of the four largest beef packers on a regular basis participate in the industry meetings, such as trade association conferences and forums. During these industry meetings, some employees of the four largest beef packers have opportunities to exchange competitor sensitive information and the companies' plans and strategies, and to develop relationships.

Second, the complaints state that the four largest beef packers implemented several allegedly anticompetitive and coordinated supply restraints. The alleged market effects of these supply restraints were to decrease the quantity of fed cattle purchased and slaughtered and consequently the quantity of beef produced, which ultimately decreased fed cattle prices and increased wholesale and retail prices of beef. The allegedly anticompetitive and coordinated supply restraints are summarized below.

- The four largest beef packers periodically reduced fed cattle slaughter volumes to reduce the demand for fed cattle.
- The four largest beef packers periodically decreased the purchase and slaughter of cash cattle (fed cattle purchased in the spot market).
- The four largest beef packers coordinated their procurement (purchasing) practices for cash cattle.
- A decrease in the quantity of cash cattle purchased and coordinated cash cattle procurement decreased the spot price for fed cattle, which consequently caused formula contract prices to decrease (formula contracts use spot prices as reference prices).
- The four largest beef packers simultaneously closed and/or idled plants to further decrease the slaughter capacity, refrained from expanding the plant capacity, and operated some of their plants at a reduced processing capacity (reduced hours, scheduling maintenance shutdowns, etc.).
- The four largest beef packers imported foreign cattle at a loss to reduce domestic demand.

The complaints discuss a significant change in price dynamics throughout the beef supply chain beginning in 2015, which affected the profitability of beef packers. For example, the beef buyers' complaints mention that fed cattle prices steadily increased between 2009 and 2014, and wholesale prices of beef moved in tandem. As a result, profit margins of the beef packers were very small, in the range of 1 to 4 percent. The beef buyers argued that the beef packers implemented coordinated supply restraints to increase their profit.

In 2015, while fed cattle prices began to decrease, wholesale and retail prices of beef were increasing, causing marketing margins to increase. Tyson and JBS (both are public companies) discussed in the Earning Calls with their investors increased profit margins, in the range of 4 to 8 percent, obtained due to their visibility into the beef supply chain and their ability to balance fed cattle supply and beef demand. Tyson and JBS emphasized that their goal was to operate a "margin business," rather than a "market share business."

3.2 The Perspective of the Four Largest Beef Packers

The perspective of the four largest beef packers is that agricultural supply and demand conditions, not a price-fixing conspiracy, affected fed cattle price dynamics (*In Re Cattle Antitrust Litigation: Memorandum of Law in Support of Defendants' Joint Motion to Dismiss the Consolidated Amended Class Action Complaint* 2019).

Prior to 2015, fed cattle prices increased in response to a decrease in the fed cattle supply due to a drought. In response to increasing fed cattle prices, fed cattle producers increased the supply of fed

cattle, which caused fed cattle prices to decrease beginning in 2015. The beef packers quoted the U.S. Government Accountability Office (2018) explaining fed cattle price dynamics in the period of 2013–2016 based on an extensive investigation. The U.S. Government Accountability Office (2018) concludes that several interrelated supply and demand factors affected the national changes in fed cattle prices in this period: a drought, increasing feed costs, and a decreasing beef demand. In addition, the U.S. Government Accountability Office (2018) informs that the competition level among beef packers did not seem to affect the national fed cattle price changes. However, fed cattle prices tended to be lower in the geographic areas with less competition among beef packers.

The beef packers argued that the allegedly anticompetitive practices described in the complaints filed by fed cattle producers and beef buyers in the court were the elements of a lawful independent competitive behavior. The arguments of the four largest beef packers explaining their conduct are summarized below.

- Periodic slaughter reductions took place in the period of a declining fed cattle supply, which was prior to 2015, the beginning of the alleged price-fixing conspiracy. The slaughter volumes increased beginning in 2015. Figure 1 depicts yearly beef production in the United States for the period of 2000–2019, which reflects changes in the annual slaughter volumes (U.S. Department of Agriculture, Economic Research Service 2022a).

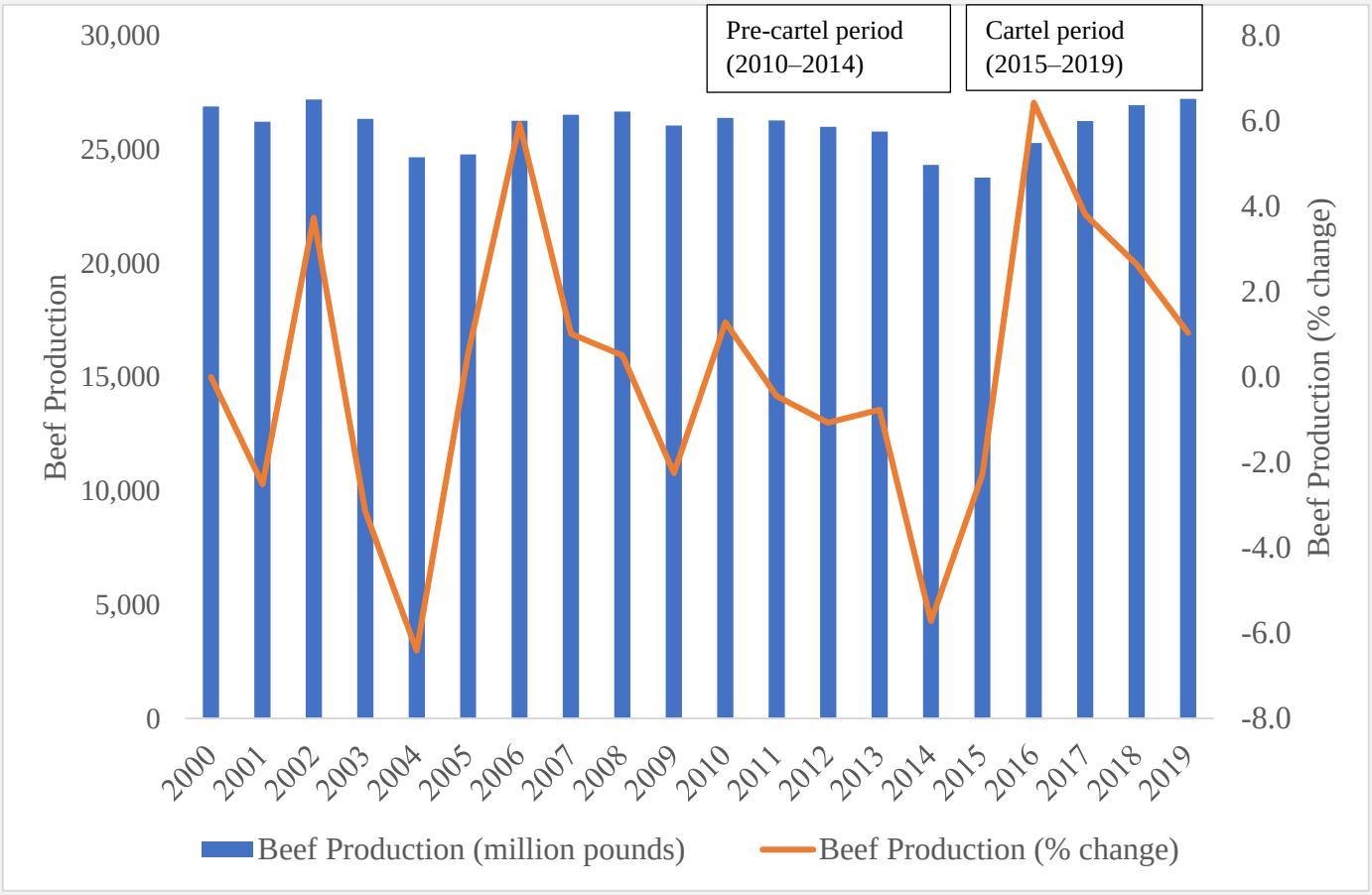

Figure 1: U.S. Yearly Beef Production, 2000–2019

Source: U.S. Department of Agriculture, Economic Research Service (2022a)

- Reduced purchases of cash cattle also took place in the period of a declining fed cattle supply, which was prior to 2015. Given that approximately 70 percent of fed cattle are purchased using forward and formula contracts, it is economically rational for beef packers to decrease purchases of fed cattle in the cash market in the period of a declining fed cattle supply.
- The types of allegedly coordinated fed cattle procurement practices used in the spot market were consistent with lawful competition, based on the past court analysis and economically rational behavior of beef packers.
- Three out of the four alleged plant closures took place before the beginning of the alleged price-fixing conspiracy. These plant closures were not simultaneous.
- A slight increase in the import of fed cattle from Canada and Mexico was observed since 2015, because it was economically rational for the beef packing plants located near the borders with Canada and Mexico to import foreign cattle rather than domestic cattle from distant geographic areas.

4 Theoretical Frameworks

This section presents a graphical analysis of two alternative economic models, which may explain conduct and performance of the beef packing industry (changes in input and output quantities, prices, and margins) using the perspectives of plaintiffs (fed cattle producers and beef buyers) and defendants (the four largest beef packers) in the ongoing cattle and beef antitrust litigation.

4.1 Beef Packing Industry Is an Imperfectly Competitive Industry

Given a high concentration level, the beef packing industry is oligopsony in the input (fed cattle) market and oligopoly in the output (beef) market. The perspective of fed cattle producers and beef buyers is that the beef packing industry behaves as an imperfectly competitive industry illegally exercising buyer and seller market power. Figure 2 is a graphical representation of an economic model incorporating a marketing margin framework, which is used to demonstrate market and price effects of buyer and seller market power of the beef packers in the beef supply chain.[9] The beef supply chain structure corresponding to Figure 2 is presented in Appendix 2 (Figure A2.2).

Figure 2 depicts three curves: farm fed cattle supply, wholesale beef demand, and retail beef demand. These curves are graphical representations of the price-dependent supply and demand functions. The fed cattle price is a function of the fed cattle quantity (the fed cattle quantity determines the fed cattle price). The beef price is a function of the beef quantity (beef quantity determines wholesale and retail prices of beef).

Figure 2 also depicts quantities, prices, and margins for two scenarios. The first scenario is a competitive industry scenario, in which beef packers do not have any market power. The second scenario is a generic market power scenario referred to as the beef packer cartel, in which beef packers exercise buyer and seller market power.

[9] Graphically, this economic model is a simplified version of the economic models explaining the profit-maximizing behavior of industries with seller market power (oligopoly and monopoly) and industries with buyer market power (oligopsony and monopsony). These economic models are discussed in standard microeconomics and industrial organization textbooks (Besanko and Braeutigam 2002; Carlton and Perloff 2004). For simplicity, the marginal revenue curve for monopoly and the marginal expenditure curve for monopsony are not shown in Figure 2 (Figure A2.1, presented in Appendix 2, reproduces Figure 2 with these two curves depicted in it). Blair and Angerhofer (2021) apply economic models of monopoly and monopsony to explain market power of beef packers under different collusion scenarios in light of the ongoing cattle and beef antitrust litigation. Kohls and Uhl (2002) and Tomek and Kaiser (2014) discuss marketing margin frameworks, as applied to agricultural and food industries. MacDonald (2009) uses a simplified version of the economic model depicted in Figure 2 to demonstrate quantity and price effects of market power in the food system in light of antitrust issues.

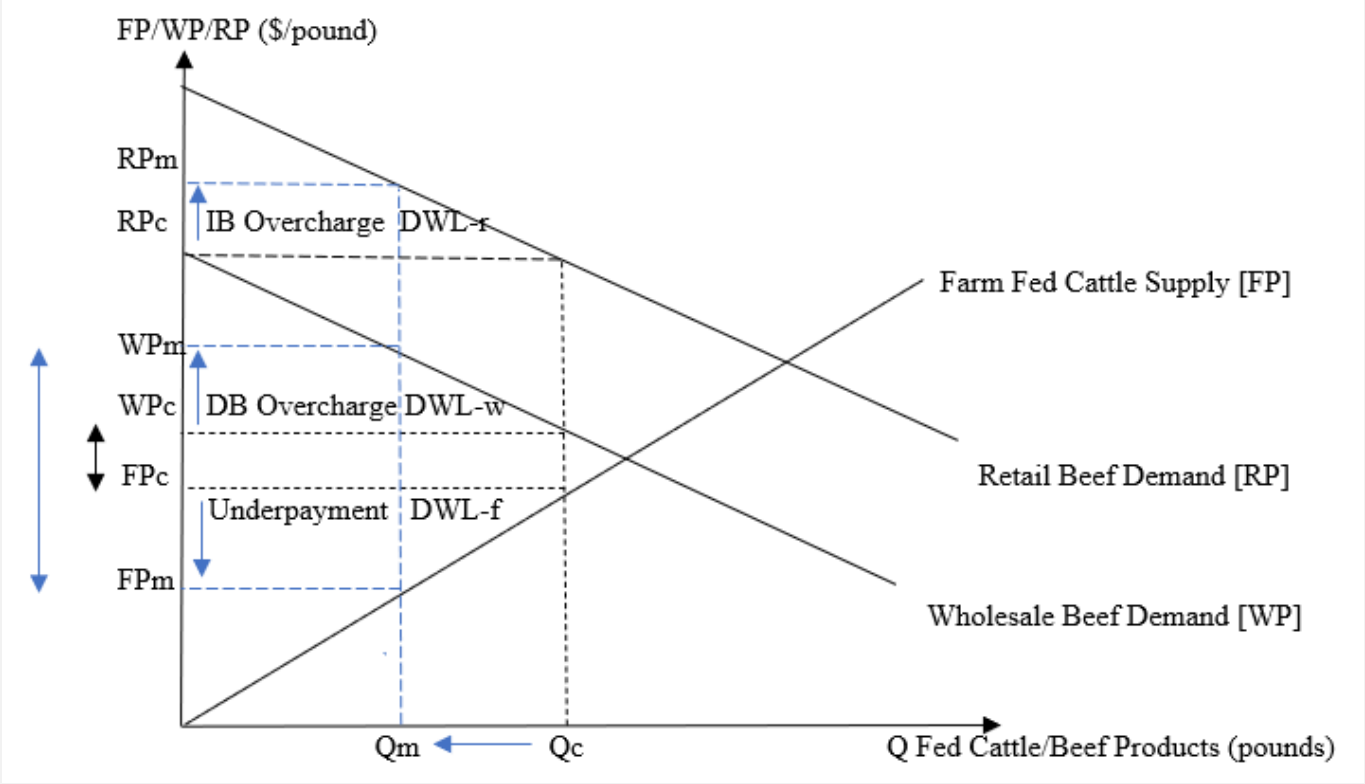

Figure 2: The Beef Packing Industry Is an Imperfectly Competitive Industry: The Buyer and Seller Market Power Effects on Quantities, Prices, and Margins

As compared with a competitive industry, to maximize *joint* profit, the beef packer cartel decreases the quantity of fed cattle purchased and the quantity of beef produced and sold from Qc to Qm.[10] This quantity reduction causes the fed cattle price (farm price) to decrease from FPc to FPm (buyer market power of beef packers affecting inverse supply for fed cattle) and wholesale and retail prices of beef to increase from WPc to WPm and from RPc to RPm, respectively (seller market power of beef packers affecting inverse demand for beef products).[11] Consequently, farm-to-wholesale margin (the "meat margin"), measured in $ per pound, increases from (WPc - FPc) to (WPm - FPm), and farm-to-retail margin, measured in $ per pound, increases from (RPc - FPc) to (RPm - FPm). Figure 3 depicts monthly farm, wholesale, and retail values for beef for the period of 2000–2019, which are proxies for prices depicted in Figure 2 (Hahn 1991, 2004; U.S. Department of Agriculture, Economic Research Service 2022b).

[10] The fed cattle quantity can be thought of as a retail equivalent of the beef quantity. This is the reason the same Q is used to denote fed cattle quantity and beef quantity in Figure 2. Qc is not at the intersection of the farm fed cattle supply and wholesale beef demand curves because the farm supply is for fed cattle, and the wholesale demand is for beef. The vertical distance between these two curves is the farm-to-wholesale margin (the "meat margin") measured in $ per unit.

[11] Note that the retail price is also affected by output (beef) pricing strategies of food (beef) retailers and their seller market power.

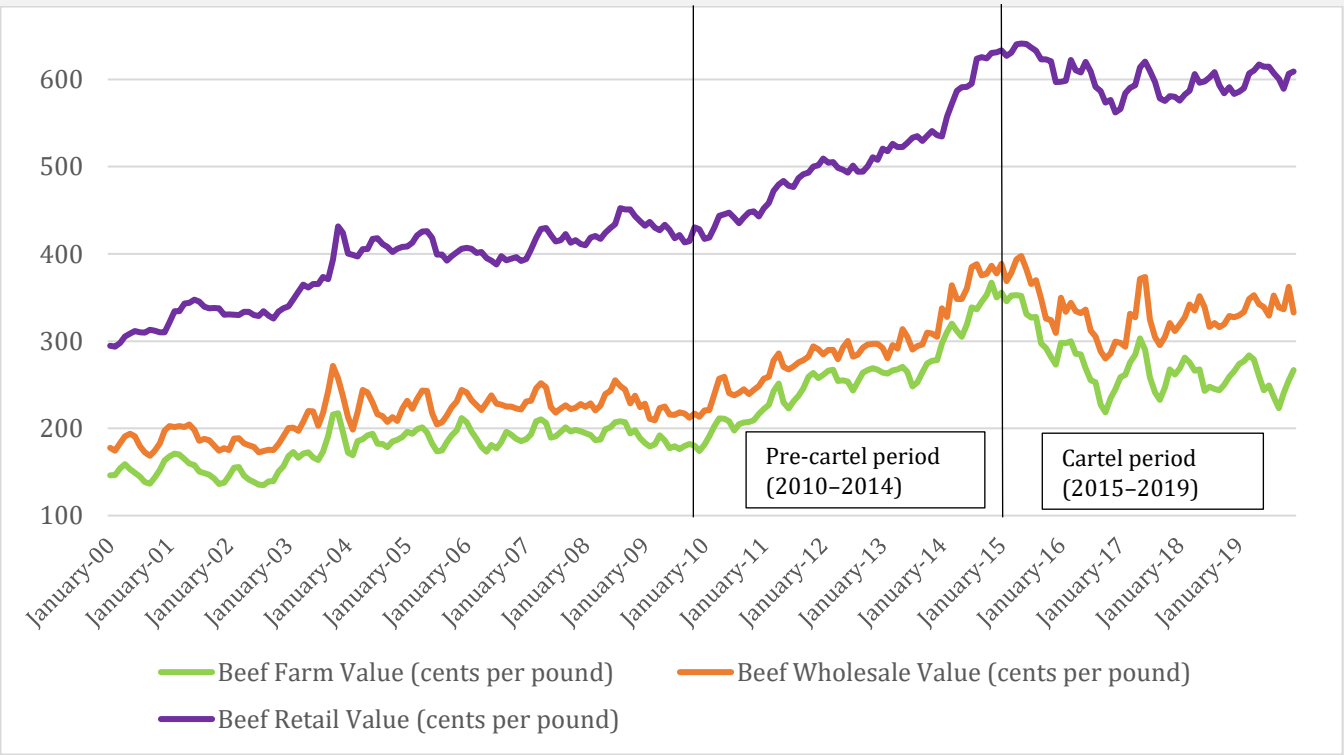

Figure 3: U.S. Monthly Farm, Wholesale, and Retail Values of Beef, 2000–2019

Source: U.S. Department of Agriculture, Economic Research Service (2022b)

The farm-to-wholesale margin includes slaughtering, processing, and packing costs, and profit of beef packers. The farm-to-retail margin is the sum of farm-to-wholesale margin and wholesale-to-retail margin. The latter includes retailing costs and profit of beef retailers. The farm-to-wholesale margins measured in $ per unit are indicated with double-sided arrows in Figure 2. Figure 4 depicts yearly farm sector share, farm-to-wholesale margin (the "meat margin"), and wholesale-to-retail margin expressed as a percentage of the retail value of beef for the period of 2000–2019 (U.S. Department of Agriculture, Economic Research Service 2022b).

The buyer market power increases profit of beef packers by the amount of underpayment to fed cattle producers. The seller market power increases profit of beef packers by the amount of overcharge attributed to beef buyers. The total $ underpayment and overcharge are the basis for damages that fed cattle producers and beef buyers, respectively, aim to recover during the ongoing cattle and beef antitrust litigation.

The underpayment measured in $ per pound is the input (fed cattle) price decrease due to the input (fed cattle) quantity decrease, due to the exercise of buyer market power by the beef packer cartel. The underpayment to fed cattle producers measured in $ per pound is (FPc - FPm) in Figure 2. The total $ underpayment to all fed cattle producers is the "Underpayment" rectangle in Figure 2, which is the underpayment measured in $ per pound times the quantity of fed cattle purchased by beef packers (Qm). Fed cattle producers, who sell fed cattle to beef packers, sell a smaller fed cattle quantity and receive lower fed cattle prices. There are also fed cattle producers who do not sell fed cattle due to reduction in the fed cattle quantity purchased by the beef packing industry. These fed cattle producers are represented by the deadweight loss attributed to the fed cattle sector (DWL-f triangle in Figure 2).

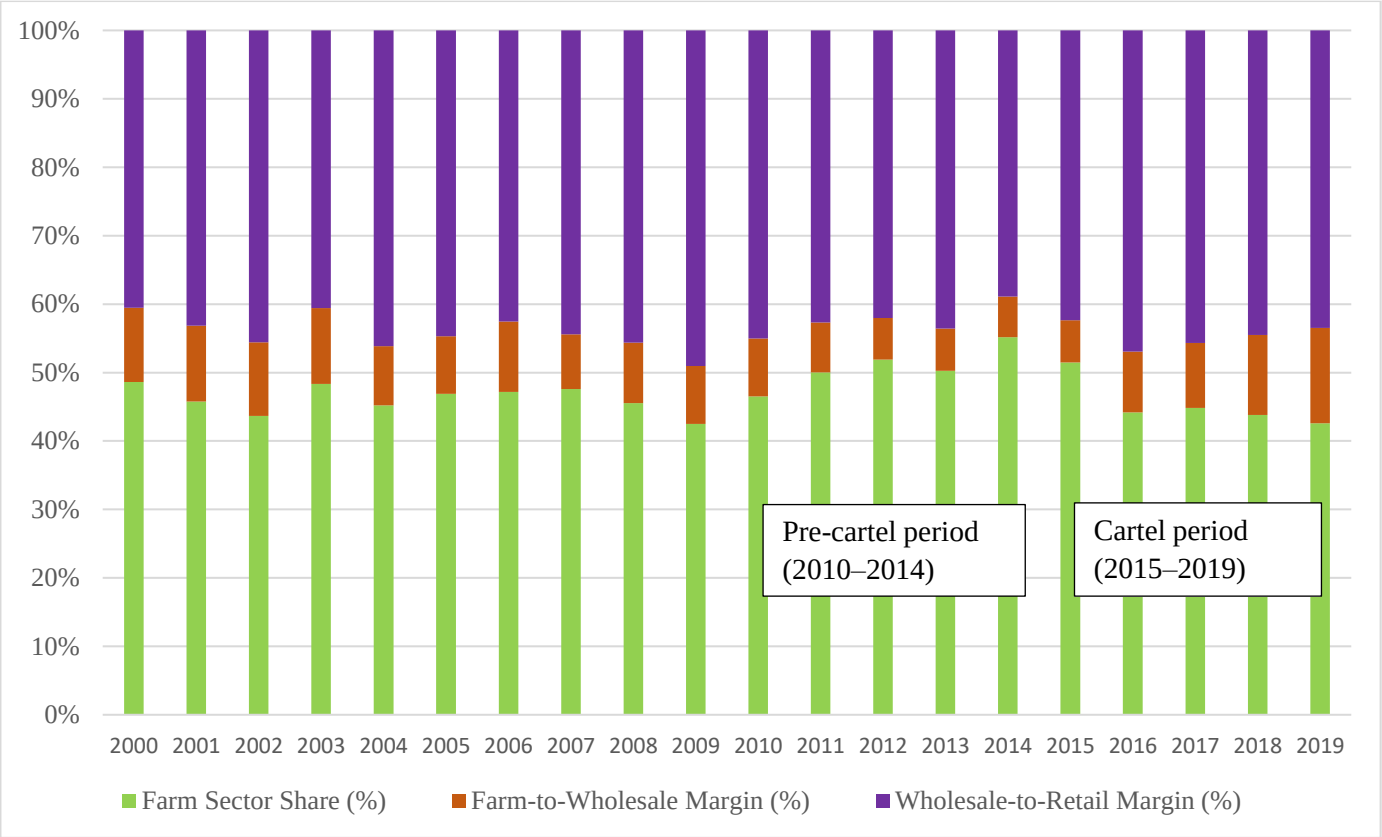

Figure 4: U.S. Yearly Farm Sector Share, Farm-to-Wholesale Margin, and Wholesale-to-Retail Margin Expressed as a Percentage of the Retail Value of Beef, 2000–2019

Source: U.S. Department of Agriculture, Economic Research Service (2022b)
Note: The measures depicted in the figure are calculated by the author using farm, wholesale, and retail values of beef reported in this source.

The overcharge measured in $ per pound is the output (beef) price increase due to the output (beef) quantity decrease, due to the exercise of seller market power by the beef packer cartel. The overcharge attributed to direct buyers of beef (for example, beef retailers purchasing beef directly from beef packers) measured in $ per pound is (WPm - WPc) in Figure 2.[12] The total $ overcharge attributed to all direct buyers is the "DB Overcharge" rectangle in Figure 2, which is the overcharge measured in $ per pound times the quantity of beef sold by beef packers (Qm).

The overcharge attributed to indirect buyers (for example, final consumers) measured in $ per pound is (RPm - RPc) in Figure 2.[13] The total $ overcharge attributed to all indirect buyers is the "IB Overcharge" rectangle in Figure 2, which is the overcharge measured in $ per pound times the quantity of beef sold by beef packers (Qm).

Direct and indirect buyers of beef, who purchase beef, purchase a smaller beef quantity and pay higher beef prices. There are also direct and indirect buyers who do not purchase beef due to reduction in the beef quantity produced and sold by beef packers. These direct and indirect buyers are represented

[12] Direct buyers (purchases) are buyers who purchase a cartelized product directly from defendants in the lawsuit (Hovenkamp 2005).

[13] Indirect buyers (purchasers) are buyers who purchase a cartelized product indirectly from defendants (Hovenkamp 2005). For example, indirect buyers are those who purchase the cartelized product from a firm, who is not a defendant in the lawsuit, but who purchased the cartelized product from defendants in the lawsuit to resell this product.

by the deadweight loss attributed to these buyers (DWL-w and DWL-r triangles, respectively, in Figure 2).

The economic model explained in this section reflects the reasoning of the U.S. Department of Justice explaining the effects of buyer and seller market power of beef packers (*U.S. and Plaintiff States v. JBS S.A. and National Beef Packing Company, LLC.,* 2008).

> *"With the price of fed cattle representing most of the cost of beef production,* ***packer profitability is determined largely by the 'meat margin,'*** *or the spread between the price packers pay for fed cattle and the price packers charge for beef, including USDA-graded boxed beef.*
>
> *This meat margin is highly sensitive to changes in the aggregate output levels of fed cattle packers. All else being equal,* ***when the meat packing industry reduces production levels, feedlots and cattle producers are paid less for fed cattle because fewer fed cattle are demanded and customers pay more for USDA-graded boxed beef because less is available for purchase.***
>
> ***Because the supply of fed cattle and the demand for USDA-graded boxed beef are relatively insensitive to short-term changes in price, even small changes in industry production levels can significantly affect packer profits****." [emphasis added]*

4.2 Beef Packing Industry Is a Competitive Industry

The perspective of the four largest beef packers is that the beef packing industry behaves as a competitive industry adjusting fed cattle quantities purchased and beef quantities produced in response to changing fed cattle prices. Figure 5 depicts a competitive industry scenario from Figure 2 as the original scenario. The fed cattle price is a major variable cost component for beef packers. Prior to 2015, fed cattle prices were increasing. An increase in the fed cattle price is equivalent to an inward (left) parallel shift of the fed cattle supply curve in Figure 5; this is Scenario 1. The fed cattle price increases from FPc to FP_1.

To pass the cost increase on the buyers of beef to maintain the same profitability level (the one of the original competitive industry scenario), the beef packing industry decreases the quantity of fed cattle purchased and the quantity of beef produced from Qc to Q_1. Consequently, wholesale and retail prices of beef increase from WPc to WP_1 and from RPc to RP_1, respectively. The farm-to-wholesale margin (the "meat margin") does not change. The farm-to-wholesale margins measured in $ per pound are indicated with double-sided arrows in Figure 5.

Fed cattle prices started decreasing in 2015. A decrease in the fed cattle price is equivalent to an outward (right) parallel shift of the fed cattle supply curve back to the original scenario in Figure 5. To pass the cost decrease onto the buyers of beef to maintain the same profitability level as in Scenario 1, the beef packing industry increases the quantity of fed cattle purchased and the quantity of beef produced. Consequently, wholesale and retail prices of beef decrease. The farm-to-wholesale margin (the "meat margin") does not change.

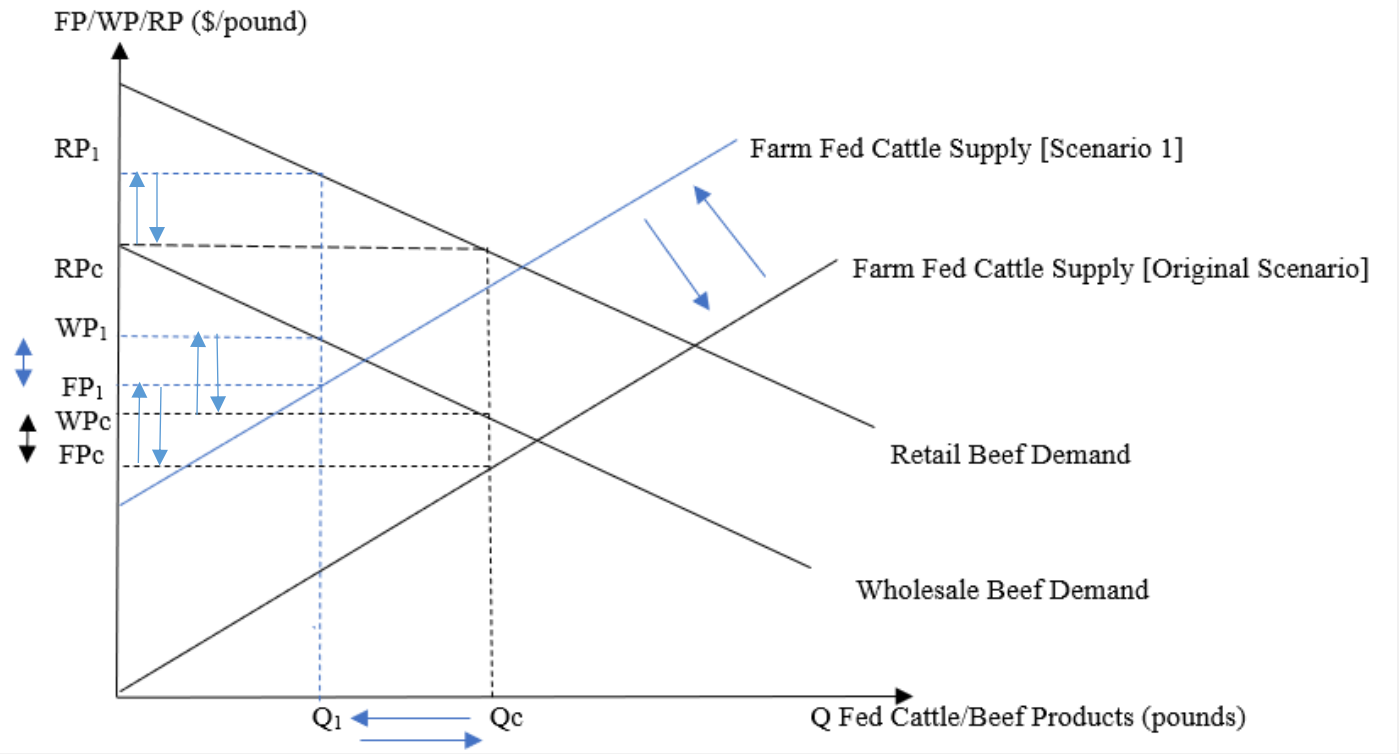

Figure 5: The Beef Packing Industry Is a Competitive Industry: The Effects of Increasing and Decreasing Fed Cattle Prices (Costs) on Quantities, Prices, and Margins

5 Antitrust (Competition) Issues

In their complaints filed in the court beginning in 2019, fed cattle producers and beef buyers claimed that the alleged input and output price-fixing cartel of the four largest beef packers violated Section 1 of the Sherman Act (1890). This section declares illegal contracts, combinations, and conspiracies in restraint of trade in interstate commerce. Price-fixing agreements (cartels or conspiracies) aim to increase, decrease, or fix (stabilize) product prices, and can be verbal, written, or inferred from the conduct of firms (Federal Trade Commission 2022). Section 1 equally applies to output price-fixing cartels (which participants illegally exercise seller market power) and input price-fixing cartels (which participants illegally exercise buyer market power).

Private parties (individuals and firms) pursue violations of the Sherman Act by filing civil (private) lawsuits. Private parties who sell products to cartel members and private parties who purchase products directly from cartel members file private lawsuits under the Clayton Act (a federal law), according to which they are entitled to recover treble damages. In seller-cartel cases, the damage is the overcharge imposed on buyers of the cartelized product. In buyer-cartel cases, the damage is the underpayment to sellers of the cartelized product.

Fed cattle producers, who sold fed cattle to the beef packers (*In Re Cattle Antitrust Litigation: Ranchers Cattlemen Action Legal Fund United Stockgrowers of America et al. v Tyson Foods, Inc. et al. 2019*), and direct buyers of beef, who purchased beef directly from the beef packers (*In Re Cattle and Beef Antitrust Litigation* 2022), aim to recover treble damages under Section 4 of the Clayton Act. The $ value of the underpayment rectangle in Figure 2 is the basis for damages incurred by fed cattle producers, who aim to recover three times the underpayment. The $ value of the DB Overcharge rectangle in Figure 2 is the basis for damages incurred by direct buyers of beef, who aim to recover three times the overcharge.

Private parties who purchase products indirectly from cartel members (indirect purchasers) file private lawsuits in selected states, where state-level consumer protection laws, antitrust laws, or unjust enrichment laws allowing indirect buyers of the cartelized products to recover damages exist. The size of damages that indirect buyers can recover depends on a particular state. Typically, these damages range from one to three times the overcharge (Ewing 2006/2007). The indirect buyers of beef, who purchased beef indirectly from the beef packers (for example, final consumers purchased beef products from beef retailers; *Peterson et al. v. Agri Stats, Inc. et al.* 2019), aim to recover damages in selected states. The $ value of the IB Overcharge rectangle in Figure 2 is the basis for damages incurred by indirect buyers of beef.

In September 2020, the lawsuits filed by fed cattle producers and beef buyers were dismissed (Tovar 2020). However, the plaintiffs were given three months to amend their complaints. The Judge stated that the originally filed complaints did not present direct evidence or a parallel conduct evidence with sufficient detail necessary to support an inference of a price-fixing conspiracy (an *agreement* among the four largest beef packers) violating Section 1 of the Sherman Act (*In Re Cattle Antitrust Litigation: Memorandum Opinion and Order Granting Defendants' Motions to Dismiss* 2020).

Proving an agreement among competitors violating Section 1 of the Sherman Act represents the main challenge for plaintiffs during antitrust litigations (Baker 1993; Hovenkamp 2005). Direct evidence of this agreement is usually not available, and the agreement must be established using circumstantial evidence. The circumstantial evidence includes the presence of a parallel conduct of the defendants and additional plus factors. The examples of parallel conduct are parallel pricing and parallel output reductions. The examples of plus factors are market structures and business practices facilitating collusion.

The plaintiffs filed amended complaints in the court in December 2020. During the subsequent court hearings, the defendants' motions to dismiss these lawsuits permanently was denied (Henderson 2021; *In Re Cattle Antitrust Litigation: Memorandum Opinion and Order* 2021). The Judge stated that in their revised complaints the plaintiffs included sufficiently detailed direct evidence (information provided by the two witnesses) to plausibly allege that the defendants engaged in a price-fixing agreement violating Section 1 of the Sherman Act.[14] In addition, the plaintiffs strengthened the evidence on plus factors (market structural characteristics and information on the investigations conducted by the U.S. Department of Justice and the U.S. Department of Agriculture) and parallel conduct of the four largest beef packers to coordinate slaughter reductions and reductions of purchases of fed cattle in the spot market with the purpose of decreasing fed cattle prices and increasing beef prices.[15] The cattle and beef antitrust litigation is ongoing and may end up with either large settlements or continue to trial.

At the beginning of 2022, JBS reached a $52.5 million settlement agreement with buyers, who had purchased beef products (boxed or case-ready beef) directly from JBS (Beef Direct Purchaser Class Action 2023). At the beginning of 2023, JBS reached a $25 million settlement agreement with commercial and institutional buyers, who had purchased beef products (boxed or case-ready beef) indirectly from JBS (Beef Antitrust Litigation Settlement 2023). In the settlement agreements JBS denied any wrongdoing.

[14] In their revised complaints, the plaintiffs provided more details about the two witnesses, in particular about their job responsibilities, positions in their companies' hierarchy, and job interactions that may have allowed them to acquire knowledge of alleged agreement among the defendants to reduce fed cattle slaughter volumes and purchases of fed cattle in the spot market (*In Re Cattle Antitrust Litigation: Memorandum Opinion and Order* 2021).

[15] In their revised complaints, the plaintiffs provided defendant-specific data (in contrast to the aggregate industry data provided in the original complaints) to demonstrate that the defendants slaughter reductions moved in tandem reflecting their coordinated conduct beginning in January 2015 (*In Re Cattle Antitrust Litigation: Memorandum Opinion and Order 2021*). These data were provided on a quarterly basis for the period of 2012–2019.

6 Discussion and Analytical Questions

The teaching note provides additional guidance for selected discussion and analytical questions, and suggested answers to all questions. The teaching note also includes multiple-choice questions that can be used as in-class assignments, quizzes, and exam questions.

1. Discuss the U.S. beef packing industry's structure and fed cattle marketing arrangements used by fed cattle producers and beef packers.

2. Discuss competition (business conduct) issues related to allegedly illegal exercise of buyer and seller market power by the four largest beef packers in the markets for fed cattle and beef, respectively, which are raised during the ongoing cattle and beef antitrust litigation.
- **2.1.** Discuss these competition issues using the perspective of fed cattle producers and beef buyers (plaintiffs).
- **2.2.** Discuss these competition issues using the perspective of the four largest beef packers (defendants).

3. Using a graphical analysis, explain economic models that describe conduct and performance of the beef packing industry (changes in input and output quantities and prices, and marketing margins) in the three market situations (note that fed cattle are "input" and beef products are "output").
- **3.1.** In the first situation, assume that the beef packing industry behaves as an imperfectly competitive industry (oligopsony/oligopoly) exercising buyer market power in the market for fed cattle and seller market power in the market for beef. Explain changes in the beef quantity; farm, wholesale, and retail prices; and marketing margins in the beef supply chain in the market power scenario, as compared to a competitive industry scenario.
- **3.2.** In the second situation, assume that the beef packing industry behaves as a competitive industry facing *increasing* cost represented by *increasing* fed cattle prices. Explain changes in the beef quantity, wholesale and retail prices of beef, and industry profit as the industry responds to this cost *increase*.
- **3.3.** In the third situation, assume that the beef packing industry behaves as a competitive industry facing *decreasing* cost represented by *decreasing* fed cattle prices. Explain changes in the beef quantity, wholesale and retail prices of beef, and industry profit as the industry responds to this cost *decrease*.

4. Familiarize yourself with the U.S. Department of Agriculture, Economic Research Service data sources used to collect economic variables utilized in the empirical analysis presented in the case study: Figures 1, 3, and 4, and Table A2 included in Appendix 2. The data used to generate these figures and table are included in the teaching note Excel file. The teaching note provides additional guidance.
- **4.1.** Use the U.S. Department of Agriculture, Economic Research Service, Food Availability Data System (Red Meat) to download yearly beef production for the period of 2000–2019, depicted in Figure 1 (U.S. Department of Agriculture, Economic Research Service 2022a).
- **4.2.** Use the U.S. Department of Agriculture, Economic Research Service, Historical Price Spread Data for Beef, Pork, Broilers to download monthly farm, wholesale, and retail values of beef for the period of 2000–2019, depicted in Figure 3 (U.S. Department of Agriculture, Economic Research Service 2022b).

5. Evaluate the U.S. beef industry dynamics in the period of 2010–2019 by analyzing data presented in Table A2, included in Appendix 2 and depicted in Figures 1, 3, and 4 (U.S. Department of Agriculture, Economic Research Service 2022a, 2022b). Table A2 summarizes yearly averages for beef production and monthly averages for farm, wholesale, and retail values of beef; farm-to-wholesale margin, wholesale-to-retail margin, and farm sector share for the cartel period (2015–2019; the period of the alleged price-fixing cartel), and the pre-cartel period (2010–2014; a prior, more competitive period).[16]

5.1. Use the monthly average farm, wholesale, and retail values of beef reported for the pre-cartel and cartel periods in Table A2 and the formulas reported in this table, to reproduce calculations of the monthly average farm-to-wholesale margin, wholesale-to-retail margin, and farm sector share for the two analyzed periods.

5.1.1. Reproduce calculations of the monthly average farm-to-wholesale margin and wholesale-to-retail margin measured in cents per pound.

5.1.2. Reproduce calculations of the monthly average farm-to-wholesale margin, wholesale-to-retail margin, and farm sector share expressed as a percentage of the retail value of beef.

5.1.3. Reproduce calculations of the monthly average farm-to-wholesale margin (the "meat margin") expressed as a percentage of the wholesale value of beef.

5.2. Calculate changes in the averages in the cartel period, relative to the pre-cartel period, for the economic variables reported in Table A2 and record them in this table.

5.3. Describe the results of your analysis. Are changes in beef production; farm, wholesale, and retail values of beef; and farm sector share, farm-to-wholesale margin, and wholesale-to-retail margin in the cartel period, relative to the pre-cartel period, consistent with a market power scenario (alleged input and output price-fixing cartel of the four largest beef packers) or a competitive industry scenario? Explain your reasoning.

6. Explain the reasons that fed cattle producers and beef buyers filed antitrust lawsuits against the four largest beef packers in the United States. Discuss the role of Section 1 of the Sherman Act in regulating conduct of beef packers in the analyzed industry situation.

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[16] The period of 2015–2019 is selected as the cartel period. According to the complaints filed in the court, allegedly anticompetitive conduct of the four largest beef packers began in 2015 and continued until "present" (the moment the complaints were filed in 2019). Therefore, January 2015 and December 2019 are selected as the beginning and ending dates of the cartel period. The period of 2010–2014 is selected as the pre-cartel period because it has the same length as the cartel period.

Appendix 1

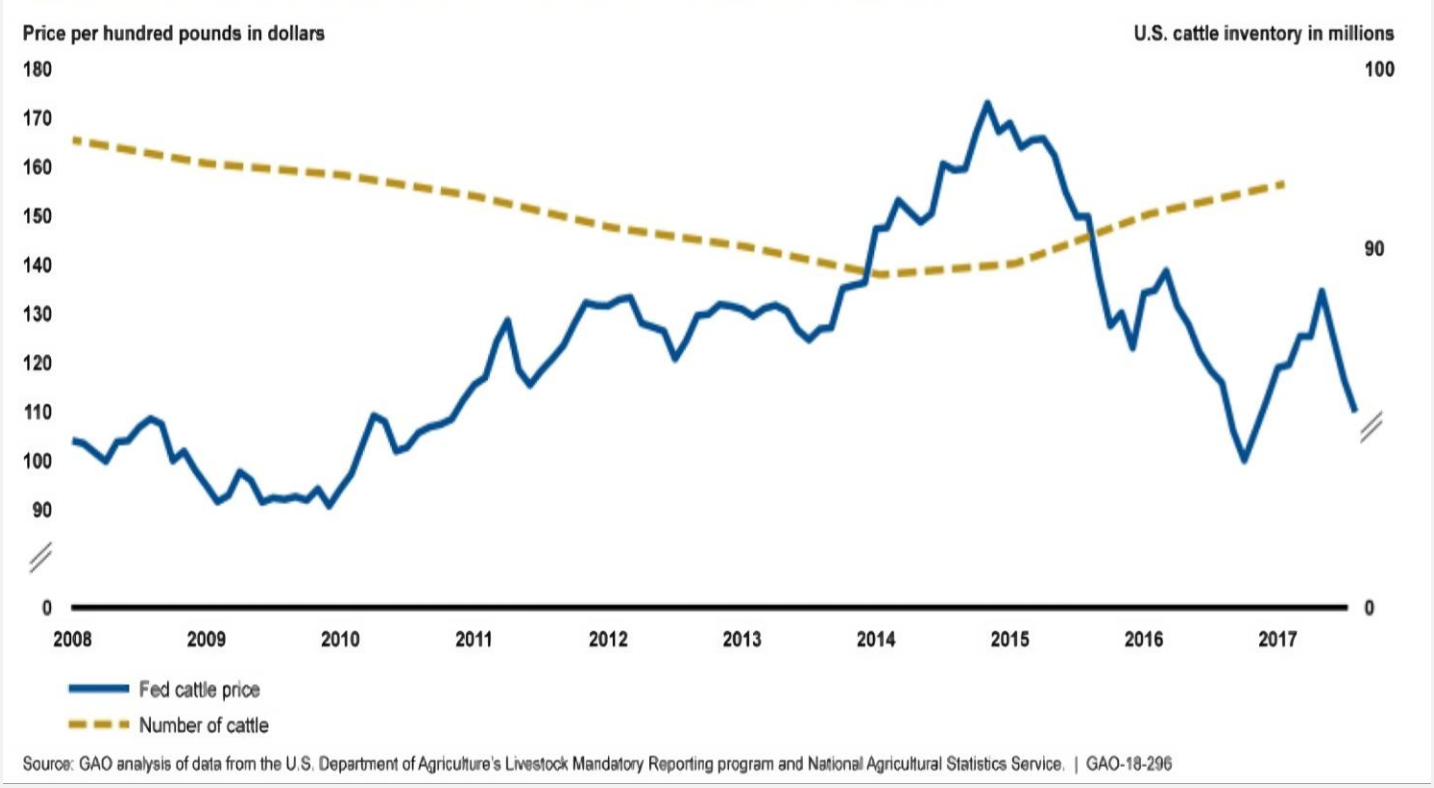

Figure A1: U.S. Fed Cattle Prices and Cattle Inventory, 2008–2017

Note: This chart is copied from the U.S. Government Accountability Office Report (2018).

Appendix 2

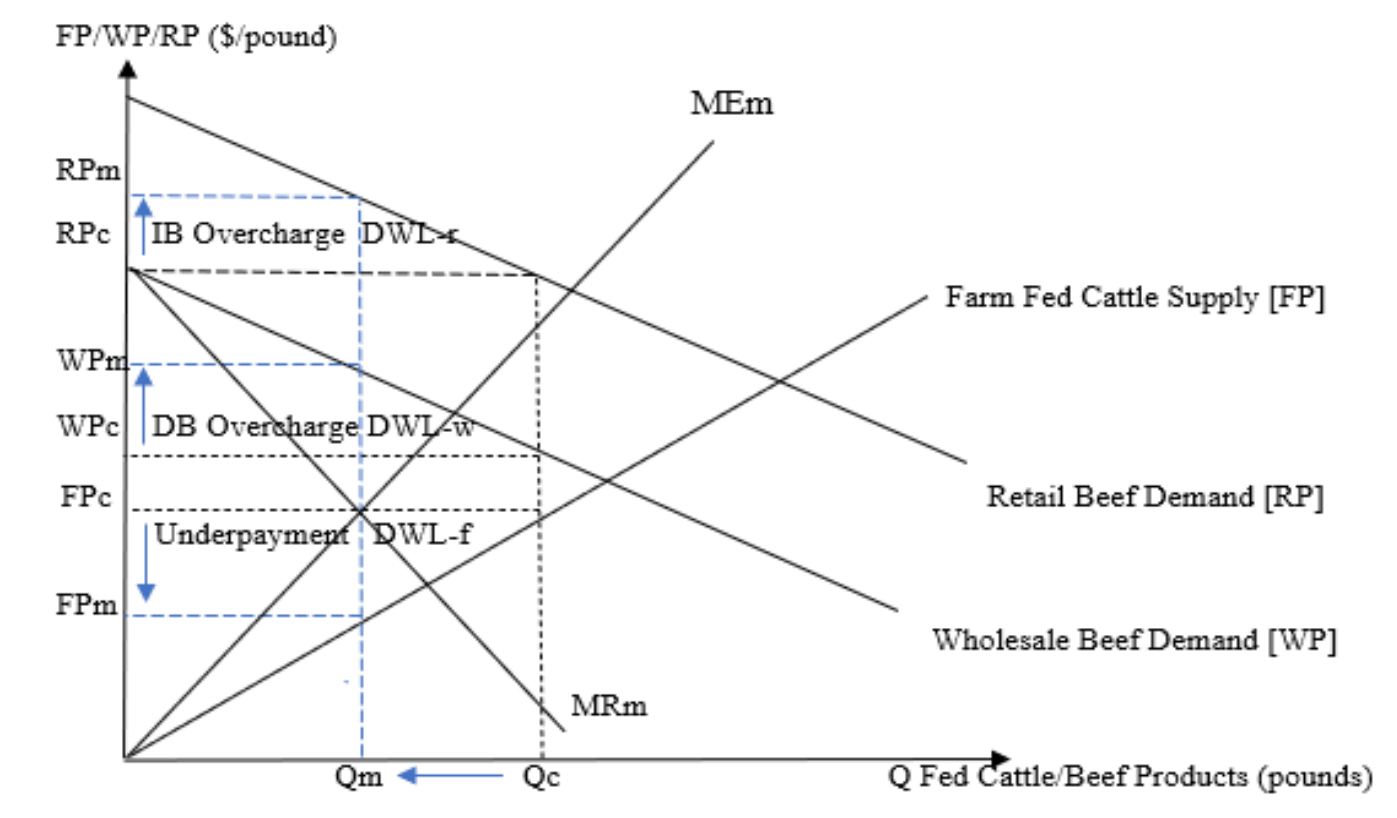

Figure A2.1: The Beef Packing Industry Is a Monopsony/Monopoly: The Buyer and Seller Market Power Effects on Quantities, Prices, and Margins

Note: Subscripts "c" and "m" indicate a competitive industry scenario and a monopsony/monopoly scenario, respectively. MRm and MEm are marginal revenue for monopoly and marginal expenditures for monopsony.

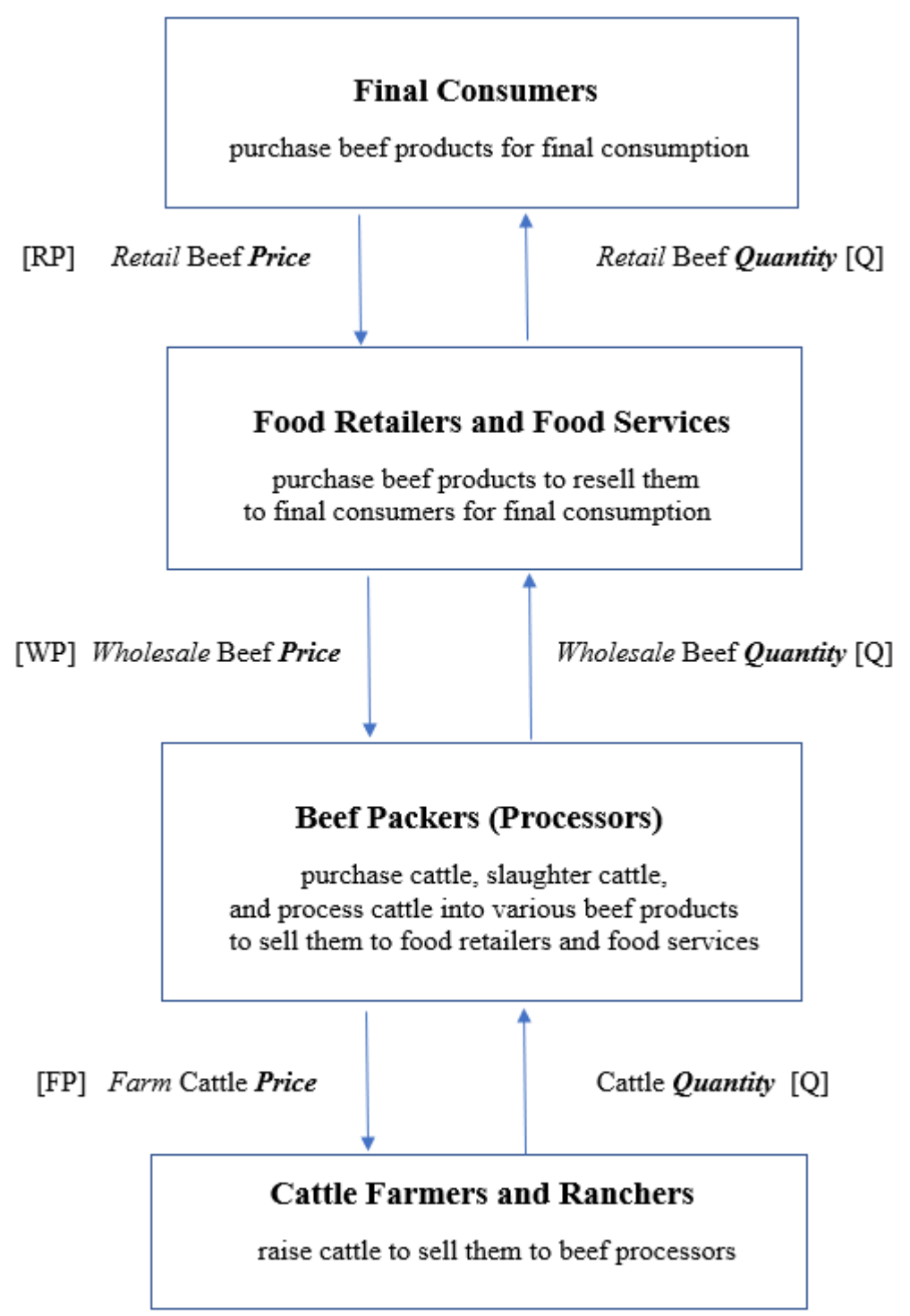

Figure A2.2: The Beef Supply Chain Structure

Note: Farm cattle price and cattle quantity: Farm fed cattle supply in Figure 2. Wholesale beef price and wholesale beef quantity: Wholesale beef demand in Figure 2. Retail beef price and retail beef quantity: Retail beef demand in Figure 2.

Table A2: U.S. Beef Industry Quantity; Farm, Wholesale, and Retail Values; Farm Sector Share; and Margins: Descriptive Statistics for the Pre-Cartel Period (2010–2014) and the Cartel Period (2015–2019)

Variable	Notation	Formula	Pre-cartel Period (2010–2014) Average	Cartel Period (2015–2019) Average	Change in the Average in the Cartel Period, Relative to the Pre-cartel Period	
					Units	Percent
			1	2	2 - 1	[(2-1)/1]*100
Quantity of beef (million pounds)			25,750.74	25,892.20	_____	_____
Farm value of beef (cents per pound)	FP		260.06	273.99	_____	_____
Wholesale value of beef (cents per pound)	WP		294.12	334.21	_____	_____
Retail value of beef (cents per pound)	RP		509.38	602.56	_____	_____
Farm-to-wholesale margin (cents per pound)	FWM	WP-FP	34.07	60.22	_____	_____
Farm-to-wholesale margin (% of wholesale value)	FWM	([WP-FP]/WP)*100	11.82	18.12	_____	_____
Farm-to-wholesale margin (% of retail value)	FWM	([WP-FP]/RP)*100	6.78	10.02	_____	_____
Wholesale-to-retail margin (cents per pound)	WRM	RP-WP	215.25	268.36	_____	_____
Wholesale-to-retail margin (% of retail value)	WRM	([RP-WP]/RP)*100	42.44	44.59	_____	_____
Farm sector share (% of retail value)	FSS	(FP/RP)*100	50.77	45.39	_____	_____

Note: The yearly averages are calculated for beef quantity, and the monthly averages are calculated for the rest of the economic variables.
Source: U.S. Department of Agriculture, Economic Research Service (2022a, 2022b)
Farm sector share, marketing margins, and descriptive statistics are calculated by the author.

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AAEA Agricultural & Applied Economics Association

Case Study

Mountain States Oilseeds: Can Contracts Enhance Safflower Seed Procurement?

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JEL Codes: Q12, Q13
Keywords: Agricultural contracting, marketing, safflower seed, strategy

Abstract
This case examines the contracting decisions facing a safflower seed processing company in southern Idaho. Mountain States Oilseeds (MSO) specializes in the procurement, storage, cleaning, drying, packaging, and transportation of safflower seeds. Recent supply chain disruptions coupled with regional drought have greatly decreased safflower seed availability. MSO must adjust their procurement strategy to secure sufficient safflower seed to meet their own commitments to their buyers. This case study illustrates the various hurdles to be overcome in drafting a successful producer-processor agricultural contract (farmer participation, moral hazard, etc.). It also highlights the trade-offs associated with various contractual payment mechanisms common within agricultural contracts (performance payments, acreage payments, and quality adjustments).

1 Introduction

Jason Godfrey, the owner and president of Mountain States Oilseeds (MSO), sits at his desk at the company's headquarters in American Falls, Idaho, following a meeting with his leadership team. Oilseed processing has been a mixed bag for 2022. Consumer demand for processed safflower seed products is currently high, but securing a steady supply of quality safflower seed has been difficult. Jason is under pressure to meet contracts that MSO has previously established with wholesalers and retailers. Without a stable flow of oilseed to the processing facilities, MSO will not be able to meet contractual obligations and could lose important business.

War between Russia and Ukraine has disrupted the supply chain by reducing the amount of oilseeds available on world markets (U.S. Department of Agriculture 2022). In 2021, Ukraine and Russia produced a combined 151,384 tons of safflower seed, which accounted for approximately 24 percent of world safflower production (Food and Agriculture Organization 2023). The war has also led to American farmers experiencing increased costs for fertilizer manufactured in Eastern Europe. Hot weather and persistent drought grip the western United States, forcing growers to rethink crop rotations and focus on allocating water to higher-value crops. These events have pushed U.S. raw safflower seed prices to an unprecedented value of $0.30 per pound.

Despite historically high safflower prices, farmers have been slow to implement it in their crop rotations. Reasons for this hesitance include the ratio of safflower risk to return[1] in the region being low compared to alternatives, unfamiliarity with crop production practices, and the risk involved with producing a crop that sells in a thin market. With the leadership team, Jason has determined that the contracts MSO uses could be updated to include contract mechanisms that increase incentives for grower participation to help stabilize the company's growing need for local safflower production. Jason

[1] Risk to return ratio is defined as the potential loss associated with a given investment divided by the potential gain. In the case of safflower seed, this means that expected profitability per acre is relatively low and that there is a relatively high probability of loss compared with a crop like dryland wheat.

now needs to determine how to structure contracts with farmers to secure high-quality safflower seed while maintaining MSO's own profitability.

1.1 Student Learning Objectives

This case is designed for junior and senior agribusiness and agricultural economic majors. The objective is for students to use agricultural contracting concepts to help a processing plant navigate a thin market and secure its inputs. This study gives students practice working with concepts such as moral hazard, risk sharing, and incentivizing crop attributes. Students should have at least an introductory understanding of agricultural contracting and risk management before attempting the case. More specifically, students should be familiar with the concepts of risk aversion, moral hazard, food attributes, marketing contracts, and production contracts. Student learning objectives are outlined in the following list.

After completing this case, students should:

1. Realize how contract structure shapes price, production, and cost risk between parties.
2. Understand how contracting constraints can impede agricultural contracting.
3. Recognize the various forms of contract payments and how each effects constraints.
4. Gain an understanding of mechanism design and its application to agricultural contracting.
5. Appreciate the impact that changes in markets, production, and supply chains can have on contract structure.

2 Background and Industry Overview

Since its inception in 1974, MSO has continued to grow and prosper. What began as a two-man operation has now grown to 15 employees and three locations. MSO sells safflower, mustard, and flax seed. MSO has become the number one oilseed processor in the United States and one of the world's largest exporters of safflower, mustard, and flax seed. Non-genetically modified organism (GMO) safflower seed is MSO's primary product, averaging 15,000 tons per year. Belgium, Taiwan, and Mexico are the largest buyers of MSO exports.

2.1 Uses and Agronomic Features of Safflower

"Safflower (Carthamus Tinctorus) is an annual thistle-like plant in the sunflower family" (National Integrated Pest Management Database 2016, p. 1). It is harvested for three primary products: oil, meal, and birdseed (National Integrated Pest Management Database 2016). Cultivated varieties are oleic or linoleic according to the type of fatty acids they produce. Seed varieties high in oleic acid are harvested for use as a heat-stable cooking oil that is lower in saturated fatty acids than olive oil and is helpful in the prevention of coronary diseases. Varieties high in linoleic acid are also used for human consumption in salad oils and soft margarine, and as a primary ingredient in moisturizers, soaps, and other cosmetics. This high oil content also makes safflower a potentially attractive input for biodiesel production (Ilkılıç et al. 2011; Yesilurt et al. 2020). Domestic biodiesel production capacity is 2.3 billion gallons per year (Harris 2022). This capacity combined with private and public interest could provide safflower seed another major use in the near future.

As an animal feed, safflower has been valued for improving performance and efficiency in sheep, beef cattle, and dairy cattle. Though striped or partial hulls are higher in oil content, bird enthusiasts prefer crisp, white seed, which is most effectively produced in Utah, Idaho, and California due to the region's warm and dry climate (Bergman and Kandel 2019). Immature safflower can also be grazed or stored as hay or silage material for livestock feed.

Safflower is particularly popular for dryland farming. As a taproot, it does well at extracting moisture from the deeper layers of the soil, up to five feet, and is hardy in Idaho's dry climate. The deep

taproot is exceptionally effective at using limited moisture and residual nutrients throughout the soil profile. This contributes to many benefits for soil health, including "building organic matter, improving soil tilth, and promoting water percolation throughout the soil" (Adjemian et al. 2016). Safflower is used in rotation with other crops to help control grassy weeds like jointed goats-grass. Safflower is immune to herbicides that kill both grass and wheat, making it useful in wheat rotations to improve the effectiveness of chemical weed control mechanisms. The grass seed lifecycle is interrupted in a wheat-safflower-fallow cycle, and no grass usually emerges after six years (Pace et al. 2015).

2.2 World Safflower Production and Trade

Global safflower consumption is increasing, and the raw seed market is expected to reach a compound annual growth rate of 5.7 percent by 2025 (Mordor Intelligence 2021). As of 2020, the United States is one of the top five producing countries, by tonnage, of raw safflower (Figure 1), with more than 50 percent of production occurring in California. Meaningful safflower production also occurs in the Dakotas, Idaho, Montana, and Utah. In 2020, the Food and Agricultural Organization (FAO) of the United Nations estimated world safflower production at approximately 756,663 tons. Safflower was produced in 17 countries, led by Kazakhstan, the Russian Federation, Mexico, the United States, and India. These top five growing nations combine to produce 76 percent of the world's safflower output (Food and Agricultural Organization 2020).

World safflower production decreased from 732,524 tons in 2010 to 645,243 tons in 2019. In 2020, production increased more than 100,000 tons. The FAO has yet to release production values for 2021 and 2022, but with the war in Ukraine disrupting supply chains globally, production is expected to be lower (Food and Agricultural Organization 2020).

2.3 Domestic Safflower Production and Prices

Table 1 displays the annual production and price data for safflower seed production at the national level. While acreage dedicated to safflower seed production has remained relatively constant the past few

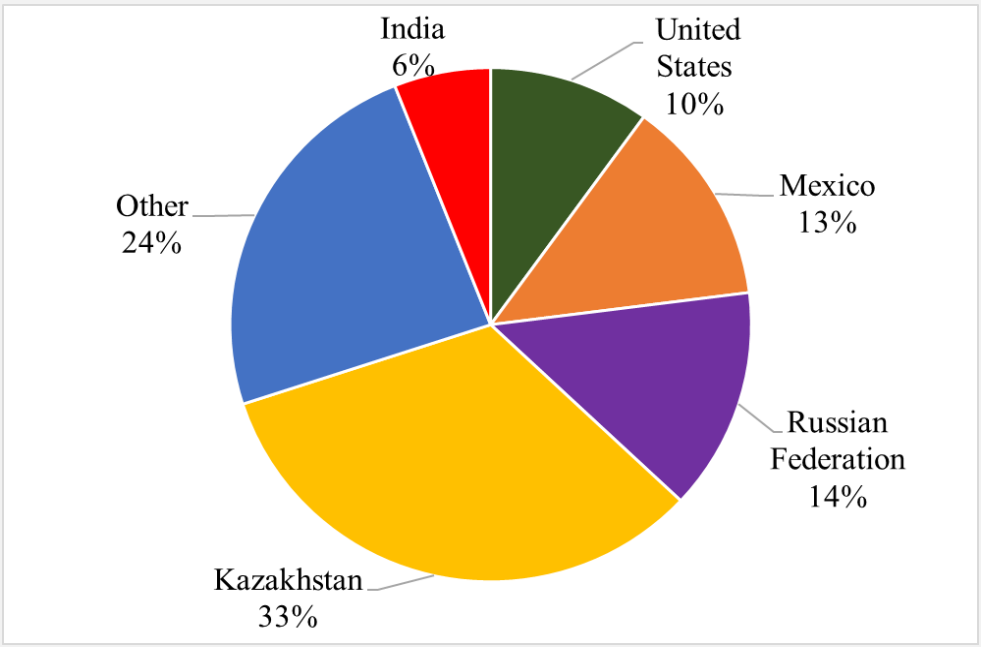

Figure 1: Percentage of World Safflower Production by Country (Source: Food and Agricultural Organization 2020)

Table 1: Historical U.S. Safflower Production Year

Year	Harvested Acreage	Average Yield (lbs/acre)	Total Production (lbs)	Average Price ($/lb)[a]	Value of Production
2016	152,700	1,432	218,625,000	$0.21	$45,170,000
2017	145,200	1,212	176,025,000	$0.19	$32,725,000
2018	156,300	1,512	236,270,000	$0.20	$47,976,000
2019	151,500	1,273	192,900,000	$0.20	$38,335,000
2020	128,400	1,185	152,125,000	$0.22	$32,844,000
2021	135,000	1,001	135,175,000	$0.26	$34,418,000
5-year % change	-11.6%	-30.1%	-38.1%	+23.2%	-23.8%

[a]Price represents the price paid to producers of raw safflower seed in nominal terms.

years, the yield and subsequent total production of safflower seed varies widely across seasons. Safflower seed is typically grown as a dryland crop with over two thirds of production occurring in California, Idaho, and Utah. These states are relatively dry to begin with, which makes dryland crops particularly susceptible to the increasingly common droughts experienced within the region. When the American west experiences drought, domestic safflower output plummets.

Due to MSO's location in southern Idaho, they source much of their seed from Idaho and Utah. Idaho accounts for approximately 11 percent of total U.S. safflower production, with most production occurring in the southern region of the state. The area harvested for safflower has increased from 17,500 acres in 2016 to 31,500 in 2021 (Table 2), yet total production of raw safflower in Idaho has declined recently due to the effects of the prolonged drought. Despite similar harvested acreage in 2019 and 2021, total production fell over 45 percent in that time interval.

Utah accounts for approximately 5 percent of total U.S. production, with most production occurring in the northern region of the state. Trends in Utah have been similar to Idaho with planted acres growing over time but yield per acre declining due to prolonged drought (Table 3).

MSO requires 30,000,000 pounds of safflower annually to run their cleaning, drying, storage, packaging, and transport operation at full capacity and typically has buyer commitments for close to this number every year. They source from Idaho and Utah whenever possible to help manage transportation costs. However, it is often necessary to contract with producers outside of that region to

Table 2: Historical Idaho Safflower Production, 2016–2021

Year	Harvested Acreage	Average Yield (lbs/acre)	Total Production (lbs)	Average Price ($/lb)	Value of Production
2016	17,500	850	14,875,000	$0.17	$2,529,000
2017	21,500	900	19,350,000	$0.17[a]	$3,270,000[a]
2018	21,000	830	17,430,000	$0.17	$2,928,000
2019	28,500	940	26,790,000	$0.18	$4,929,000
2020	26,500	880	23,320,000	$0.20	$4,687,000
2021	31,500	470	14,805,000	$0.23	$3,390,000
5-year % change	+80.0%	-44.7%	-0.5%	+35.3%	34.0%

Note: Price represents the nominal value paid to producers for raw safflower seed.
[a]2017 Idaho price data was unavailable; average of 2016 and 2018 price data used (U.S. Department of Agriculture, National Agriculture Statistics Service 2022).*2017 Idaho price data was unavailable; average of 2016 and 2018 price data used (U.S. Department of Agriculture, National Agriculture Statistics Service 2022).

ensure MSO has sufficient safflower to meet the commitments of their buyers. This has been especially true in recent drought years with the decreased yields in the region. Historically, MSO has sourced

anywhere between 0 percent to 35 percent of their safflower seed from outside of the region. Safflower seed prices have been trending upward (Table 3), with the 2022 price pushing $0.30 per pound. This rally has been driven by supply chain disruptions, drought in safflower producing states, and high commodity prices, which raise the opportunity cost of growing safflower. While a modest price decrease is possible for 2023, Jason predicts that safflower prices will remain above historical averages for the 2023 growing season due to the persistence of the aforementioned factors.

Table 3: Historical Utah Safflower Production, 2016–2021

Year	Harvested Acreage	Average Yield (lbs/acre)	Total Production (lbs)	Average Price ($/lb)	Value of Production
2016	13,500	810	10,935,000	$0.17[a]	$1,859,000[a]
2017	16,500	900	14,850,000	$0.17[a]	$2,495,000[a]
2018	13,000	840	10,920,000	$0.16	$1,769,000
2019	12,700	1,050	13,335,000	$0.17	$2,280,000
2020	22,000	820	18,040,000	$0.19	$3,428,000
2021	16,000	460	7,360,000	$0.22	$1,582,000
5-year % change	+18.5%	-43.2%	-32.7%	+29.4%	-14.9%

Note: Price represents the nominal value paid to producers for raw safflower seed.
[a]Utah price data unavailable for 2016 and 2017; observed Idaho price and estimated Idaho price used for 2016 and 2017, respectively (U.S. Department of Agriculture, National Agriculture Statistics Service 2022).

2.4 Safflower Market and Supply Chain

Securing safflower seed typically requires more coordination between processors and producers than traditional commodity crops. Safflower seed has a limited number of producers and processors. Thin crop markets make spot transactions less desirable because both producers and processors want some assurances from the other before making a commitment such as planting a field or adding processing plant capacity (Adjemian et al. 2016). Attributes are also important for safflower. The price Jason receives from his buyers is influenced by the seed moisture content, GMO status, and amount of debris with the seeds. While MSO has the ability to dry and clean seed, it is prohibitively expensive to clean seed that is too dirty or dry seed that is especially wet.

The complications of safflower seed transactions often require producer-processor contracts (Pace et. al 2015). Agricultural contracting allows both MSO and the farmers they work with to make investments ahead of time knowing they have a partner lined up to deliver or purchase the seed. It also provides additional coordination through which MSO can identify and incentivize production practices that lead to seed attributes that their buyers desire.

3 Methodology for Agricultural Contracting

This producer-processor contracting problem will be examined using intuition from mechanism design. Although students will not be required to set up and solve an optimization problem, the key insights from the constraints to be overcome within an agricultural contract and the payment mechanisms required to satisfy them will be imperative.[3]

3.1 Mechanism Design and Its Application to Processor-Designed Contracts

Mechanism design is a useful method for designing agricultural contracts. Mechanism design problems are solved in reverse of many other economic problems, where a desired outcome is defined and then

[3] Interested students looking to gain additional detail on mechanism design-applied agricultural contracting problems should refer to Hueth et al. 1999; Alexander et al. 2012; Viana and Perez 2013; Yang et al. 2016; Bellemare, Lee, and Novak 2021; and McCarty and Sesmero 2021.

incentives are introduced to achieve that outcome (Hurwicz 1973). From an agricultural contracting perspective, a processor will design a contract to maximize their profit, or risk adjusted profit. Contract design includes both the size and type of farmer payments embedded within a contract. The processor then offers that contract to the producer who will either accept or reject it.

There are numerous obstacles that can cause a contract to fail. These obstacles are referred to as constraints. If any constraint is not overcome or "satisfied" in the final proposed contract, one or both parties will be unwilling to accept the contract, and no transaction will occur. Constraints are addressed through different types of payment mechanisms. A processor will offer a contract where the type and level of mechanisms maximizes their profit, while satisfying the aforementioned contractual constraints. Sections 3.2-3.4 explains the key constraints for a successful producer-processor safflower seed transaction. Sections 4.1-4.5 highlights the key contractual payment mechanisms available to overcome those constraints.

3.2 Farmer Participation Constraint

The farmer participation constraint requires that a contract offered to a farmer must be attractive enough for them to accept. If the proposed contract does not provide the farmer a higher expected return (or risk adjusted return) than their next best alternative, they will not accept it. Figure 2 denotes a budget of costs incurred for producing an acre of safflower seed on unirrigated land within the region. Safflower production requires about $185 per acre to produce, harvest, and deliver.

Because agricultural land has multiple uses, a contract must also cover a farmer's opportunity cost (i.e., provide a better expected return than a farmer's next best alternative). The opportunity cost will vary by region and through time. Within Utah and Idaho, the relevant opportunity cost crop is typically dryland wheat. Dryland wheat is simultaneously a complement and substitute for safflower production. Farmers not growing safflower will usually grow dryland wheat for a year followed by a fallow year to allow moisture to re-accumulate in the soil. Farmers that grow safflower seed in the region typically grow a rotation of wheat, safflower, and fallow. Safflower can be grown in this three-year rotation because its deep taproots allow for water extraction at levels deeper than wheat can reach. These factors demonstrate that the opportunity cost of dryland safflower in Utah and Idaho is expected to be relatively low; it is not zero.

Given that wheat prices are expected to remain high into 2023, Jason expects farmers would require at least another $35 per acre on top of the total costs reported in Figure 2 to make it comparably attractive to a conventional dryland wheat rotation. Additionally, reported spot prices for safflower seed sold on spot markets have recently been trading at $0.30 per pound. Not only will a contract have to be attractive enough to convince farmers to add safflower into their crop rotations, it will also have to convince them selling safflower to MSO is a better deal than selling it on the spot market at harvest.

Another factor influencing a farmer's willingness to accept a contract is the level of risk exposure. Most farmers are risk averse and, all else equal, will prefer a contract that exposes them to less risk. Prices, costs, and output are all sources of risk for producers. The scale of MSO is sufficient that Jason believes they can consider exploring contract options that transfer a limited amount of risk (e.g., through a fixed selling price or acreage payments) from the farmer to MSO as the processor, reducing grower risks and incentivizing contract participation. With this in mind, farmers will only accept a contract that offers them a sufficiently attractive risk-return profile relative to their next best alternative. With winter wheat trading at relatively high prices around $8.25 per bushel in Idaho (U.S. Department of Agriculture, National Agriculture Statistics Service 2022), Jason recognizes that contract options will need to be quite enticing for the coming year to convince farmers to produce safflower seed.

Costs of Non-Irrigated Safflower Northern Utah		Quantity per acre	Unit	Price per Unit	Value per Acre	Sub Total	Total
Inputs and Services							
Fertilizer							
	46-0-0 Urea	40	Units	$0.56	$22.40		
	Application	1	Acre	$5.00	$5.00		
Herbicides					$0.00		
	Sonalan (ethalfluralin)	2	Pints	$8.79	$17.58		
	Application	1	Acre	$5.00	$5.00		
Seed		18	Lbs.	$0.34	$6.12		
Labor		1	Acre	$8.56	$8.56		
Crop Insurance (NAP)					$1.25		
Subtotal Inputs and Services						$65.91	
Field Operations		Times	Unit	Per Unit	Acre		
	Fall Chisel Plow	1	Acre	$11.00	$11.00		
	Spring Chisel Plow	1	Acre	$11.00	$11.00		
	Planting	1	Acre	$12.00	$12.00		
	Harvesting	1	Acre	$25.00	$25.00		
	Hauling	1150	Lbs.	$0.01	$11.50		
Subtotal Field Operations Cost						$70.50	
Interest on Operating Capital		Rate	Term	Principle			
		5%	0.5	$132.91		$3.32	
Total Input, Service and Field Operation Costs							$139.73
Overhead							
	Accounting, Liability Insurance, Vehicle Cost, Office Expense				$10.00		
	Cash Lease for Land (includes propery tax)				$35.00		
Total Overhead							$45.00
Total Costs							$184.73

Figure 2: Cost Budget for Non-Irrigated Safflower for Northern Utah in 2019 (Pace et al. 2019)

3.3 Moral Hazard Constraint

Despite contracts being popular in coordinating safflower production, they can lead to information imbalances between parties. Unlike spot markets, which pay based solely on performance, agricultural contracts may contain payment provisions independent of crop output level or quality to share risk with the farmer. While this risk sharing helps satisfy the participation constraint, it can lead to a misalignment of incentives between MSO and the farmer when there is unobservable farmer action. Poorly structured contracts may incentivize farmers to avoid following the best possible management practices, such as applying fertilizer or pesticides. This can lead to low yields or low quality, which can hurt MSO. As an example, if safflower output is a function of farmer effort and local pests, which only the farmer views, a contract with weak performance incentives (low amounts of performance-based payments) could lead to farmer shirking and then blaming a low output on pests rather than low effort.

To minimize moral hazard and likelihood of shirking, elements of a complete contract should be observed: (1) the contract must be able to contemplate all relevant contingencies and agree upon a set of actions for every contingency, (2) what constitutes satisfactory performance must be measurable, and (3) the contract must be enforceable (Besanko et al. 2017). In practice, it is not economical or realistic to spell out every possible future contingency or measure every single performance input, but a good contract should consider and plan for likely contingencies. In the context of safflower, the additional revenue that the farmer receives from following unobservable best management practices (applying fertilizer and herbicide) should be greater than the cost of following those practices. In other words, marginal benefit associated with higher yields should be greater than the marginal cost of achieving those yields.

Additionally, it is possible to align incentives by reducing the information asymmetry between parties from the outset. Monitoring entails an agreement between the farmer and the processor, allowing the processor to oversee production and only compensate the farmer if they adhere to the agreed-upon practices. Monitoring has the potential to reduce or eliminate moral hazards. However, there are drawbacks to monitoring, such as its cost, as the processor would need to allocate resources to send workers to inspect the fields. It is also often viewed as an undesirable contract provision by farmers who dislike oversight. It raises the payment threshold required for a farmer to accept a proposed contract.

3.4 Quality Constraints

MSO supplies non-GMO safflower to retailers and wholesalers. Thus, any seed entering the facility must also comply with non-GMO standards. Additionally, the harvested oilseed must be free from GMO contamination by other crops and cultural practices. The land should be clean and free of trash and debris. All equipment and storage facilities should be cleaned appropriately during all phases of the safflower production period to avoid any food safety liability.

Safflower seed supplied to MSO must also comply with the moisture and dockage (e.g., foreign material including dirt, stones, sticks, and other grains) requirements. Raw seed with high moisture levels, excessive dirt, or dockage must undergo drying and cleaning procedures before the seed is ready for processing. As cleaning and drying is expensive, MSO prefers harvested safflower seed contains less than 5 percent foreign material (e.g., other grains, sprouts, dirt, etc.) and have less than 9 percent moisture content. If foreign matter rises above 22 percent or moisture rises above 13 percent, it becomes prohibitively expensive for MSO to clean or dry the harvested safflower. This suggests MSO should consider stipulating cleanliness and dryness standards within grower contracts to help ensure non-GMO, clean, and dry safflower seed is produced. Additionally, they may consider additional per-pound payment provisions that compensate (dock) farmers for safflower seed exceeding (falling short of) a baseline cleanliness or moisture expectation.

4 Decisions Under Consideration (Payment Mechanisms and Other Contract Provisions)

Jason has a lot to consider in the contract that he will offer. He must come up with a contract structure that simultaneously provides the farmer an attractive combination of expected return and risk exposure (farmer participation constraint) and strong incentives to follow best management practices to support high yields (moral hazard constraint). This contract must also incentivize the production of safflower seed that is low in water content, low in foreign matter, and produced organically (quality constraint). This contract needs to do all those things while still maintaining profitability for MSO. This will be a challenge, but with careful consideration and analysis of trade-offs associated with various payment mechanisms, he should be able to create a contract that secures a quality and reliable supply of

safflower seed to process and sell. In the following sub-section, the various types of payments available, along with their relative strengths for satisfying various constraints is laid out.

4.1 Performance Payments: Spot Market Price

The spot market is a financial market where crops are traded for immediate delivery. "Delivery refers to the physical exchange of the commodity with a cash consideration. The spot market is also known as the cash market or physical market because cash payments are processed immediately, and there is a physical exchange of assets" (CFI Team n.d.). There is the potential for farmers to capitalize on high prices, but the spot market is associated with a greater probability of downside risk and loss. MSO could consider spot market contracts wherein payment for production is based upon the spot market price for safflower seed at the time of sale.

Performance Payments: Spot Market Price Characteristics

- Transactions are settled at the spot price or the current market rate.
- Price is not fixed until assets exchange hands.
- Selling price is uncertain for farmers.
- Input cost is uncertain for MSO.
- Tying farmer income to safflower output helpskeep incentives aligned.

4.2 Performance Payments: Fixed Price

Fixed price performance payments are often used in oilseed markets where a farmer and processor agree on a price per pound at the beginning of the year that will be paid at harvest. Fixed price payments eliminate downside price risks to the farmer and allow the processor to lock in the cost of acquiring safflower seed. Conversely, significant market price changes can render contracts untenable for one party. During periods of low market prices, the processor may have an incentive to void or renege on the contractual commitment, while the inverse would be true for the producer in times of high market prices.

Performance Payments: Fixed Price Characteristics

- The pricing system ensures clarity by determining the price early in the year.
- It reduces risks for farmers in price fluctuations and lowers input costs for processors.
- Renegotiation may occur in the future, in response to significant price changes.
  Tying farmer income to safflower output helps keep incentives aligned.

4.3 Acreage Payments

Under this payment mechanism, payments are paid on a per-acre basis. Whether delivered yearly or as an establishment payment, this mechanism provides revenue to the producer regardless of the field's performance. Price and yield risks are removed from the producer and transferred to the processor. All else equal, reducing farmer's risk exposure to growing a crop will help satisfy the farmer participation constraint and bring more land into production. Acreage payment mechanisms shift significant risk to the processor. In bad years, processors get left paying high input costs with few inputs to show for it. This increases costs while simultaneously decreasing expected revenue. Since not all actions of a safflower farmer are directly observable, a strict lump sum acreage payment contract mechanism violates the moral hazard constraint. Contracts should avoid exclusively making payments acreage-based because this can easily lead to a misalignment of incentives between growers and processors.

Acreage Payment Characteristics

- It lowers both price and yield risk for growers, promoting stability in agriculture.
- This method can ease farmer participation constraints.
- With a simple structure, it can be easily adjusted with other mechanisms.
- It may unintentionally create moral hazard scenarios.

4.4 Quality Adjustment Payments

Oilseed attributes are important for MSO's buyers. Foreign matter content must be below 22 percent and water content below 13 percent to ensure MSO can reduce costly drying and cleaning efforts. Yet, as cleaning and drying costs are nonlinear, MSO would really prefer seed with less than 5 percent foreign material and 9 percent moisture. Percentages below these levels require only minimal effort (i.e., cost) on MSO's part. Ensuring that farmers follow practices that produce safflower to these standards requires incentives to pursue the appropriate production practices. This incentive can come in the form of penalties for high foreign material and moisture, bonuses for low levels of foreign material and moisture, contracting provisions that void the agreement for levels of foreign material and moisture above a given level, or a failure to achieve non-GMO status.

Quality Adjustment Characteristics

- Quality adjustments penalties or bonuses subtracted or added to a performance payment.
- They are used to incentivize safflower attributes desirable to MSO.
- They can add additional price risk to the farmer.

4.5 Combinations of Payments

Multiple payment mechanisms can exist within one contract. In other words, it would be possible to offer a contract with a baseline fixed price that is adjusted up or down based upon harvested seed quality. Since different payment types help alleviate different constraints, mixing various payment mechanisms into one contract can help facilitate successful contracts between farmers and processors. Finally, Table 4 presents a concise description of the aforementioned payment types.[3,4]

4.6 Marketing Contracts, Production Contracts, and Coordination

The level of potential coordination between producers and processors can be thought of as falling on a spectrum between buying/selling on a spot market (no coordination) to vertical integration (complete coordination). Agricultural contracting exists between the two extremes. The visualization of this can be seen in Figure 3.

In agriculture, marketing and production contracts play pivotal roles in shaping the dynamics between farmers and processors. These contracts establish price arrangements prior to harvest, but they differ significantly in terms of decision-making authority and input ownership.

[3] Performance payments that are tied to a market price are most commonly used for the good being contracted. However, it is possible to use an index to tie the contracted performance price to other factors such as the cost of inputs or the opportunity cost crop.

[4] Establishment payments are paid at planting to cover upfront costs such as seed.

Table 4: Various Payment Mechanisms MSO Can Offer in a Contract

Type	Definition	Description
Performance payment (market price)[a]	Farmer is paid a per-unit price ($/pound) at harvest. The price is determined by the safflower spot market at harvest.	Performance payments provide incentives to follow best management practices because the farmer is compensated for high output. Performance payments are required for overcoming the moral hazard constraint. The market price component allows the farmer to take advantage of potential rises in safflower prices throughout the growing season but is risky for the farmer because it exposes them to falls in prices. This payment provision exposes the farmer to price, production, and cost risk.
Performance payment (fixed price)	Farmer is paid a per-unit price ($/pound) at harvest. The price is locked in at planting	Being performance-based, this payment provision will also help satisfy the moral hazard constraint. The key difference is that the price, getting locked in ahead of time, eliminates the farmer's price risk and reduces the cost risk for MSO.
Acreage payment	Farmer is paid per acre of safflower grown. Typically paid at harvest but can also be paid as an establishment payment.[5]	This payment provision locks in farmer revenue. All else equal, farmers prefer payments with less risk, so acreage payments are especially effective at inducing farmer participation. It also shifts a considerable amount of risk to the processor.
Quality adjustment payments	The farmer is either paid a per-pound premium for safflower with desirable qualities (low moisture content, low foreign matter content, GMO free). Or is forced to pay a per-pound penalty for safflower with undesirable qualities. The size of any adjustment moves with the quality.	Oilseed attributes are important for MSO's buyers. Seed must be GMO-free. Foreign matter content must be below 22 percent and water content below 13 percent to ensure MSO can reduce costly drying and cleaning efforts. Yet, as cleaning and drying costs are nonlinear, MSO would really prefer seed with less than 5 percent foreign material and 9 percent moisture. Percentages below these levels require only minimal effort (i.e., cost) on MSO's part. Ensuring that farmers follow practices that produce safflower to these standards requires incentives to pursue the appropriate production practices. Having performance incentives in the contract should help satisfy quality constraints.

[a]Performance payments that are tied to a market price are most commonly used for the good being contracted. However, it is possible to use an index to tie the contracted performance price to other factors such as the cost of inputs or the opportunity cost crop.

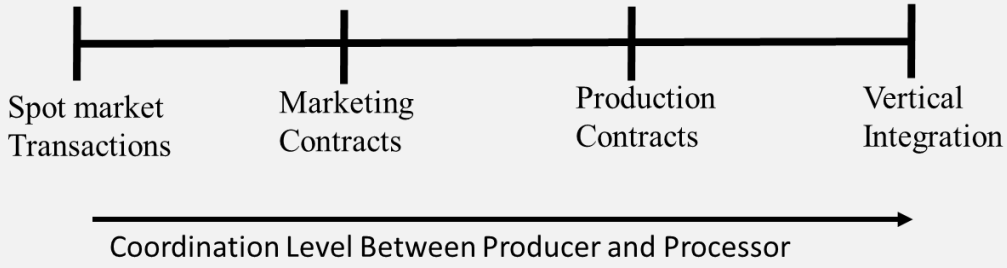

Figure 3: Spectrum of Possible Relationships Between Producers and Processors and the Extent to Which a Given Relationship Is Coordinated Between Parties

Production Contracts: In contrast, production contracts place the bulk of management decisions on the processor's shoulders. Processors dictate the production practices and required inputs for the crop. They often provide or own these inputs. Production contracts serve to mitigate information asymmetry by ensuring the processor's control over inputs. Moreover, they shift production risks from the farmer to the processor.

However, in reality, there can be some overlap between these contract types. For instance, a contract might allow the farmer freedom in certain production decisions, provided they use seed supplied by the processor. In this case, the contract exhibits characteristics of both marketing and production contracts.

The choice between marketing and production contracts is a crucial decision for MSO. MSO must consider factors such as the desire to maintain a non-GMO designation for safflower seed. This designation necessitates specific seed and production practices, which may be better suited for a production contract where the processor provides seed and additional inputs while exerting more oversight. However, this approach comes with added costs due to oversight and input provision, potentially dissuading some farmers who prefer more control over production decisions. Therefore, MSO faces a trade-off between enhancing harvested seed quality and reducing information gaps at the expense of reducing the willingness of farmers to participate.

Another consideration closely tied to coordination is whether to include monitoring in the contract. Monitoring involves sending representatives to the farmer's fields to ensure compliance with specific production practices or input use. While this can also reduce information asymmetry, encourage desired seed attributes, and lower testing costs, it may also discourage farmers who do not appreciate constant oversight. Embedding monitoring in a contract could even deter farmers from entering into a contract in the first place. In conclusion, marketing and production contracts in agriculture offer distinct approaches to managing the relationship between farmers and processors. The choice between these contracts and the inclusion of monitoring should be made carefully, considering factors such as harvested seed quality, information asymmetry, and farmer preferences. Achieving the right balance is essential to fostering successful partnerships.

5 MSO Strategy Questions

5.1 Reflection

Those who think agricultural processors have it easy have never been tasked with securing 15,000 tons of safflower seed amid the chaos anticipated in the current production environment Jason muses to himself. Acquiring this quantity of safflower seed, while maintaining MSO's seed standards and serving its core goal of maintaining profitability for the company and those farmers they contract with, is going to be even more challenging than usual. Relationships matter in agriculture, particularly in niche markets like safflower seed. Maintaining these relationships through contracts brings many benefits to the transaction but also adds complexity. Drawing up a contract that simultaneously satisfies all contractual constraints while maintaining profitability is going to be challenging but imperative for MSO's continued success.

In Jason's time running MSO, he has built it from a regional level oilseed storage and processing facility, into the largest oilseed storage and processing facility in the United States and a key player in safflower seed internationally. Continued success for MSO and the farmers they work with is going to require innovative solutions for the transactional relationship between the two parties.

5.2 Discussion Conceptualizing the Problem

1. Ignoring risk for a moment, how much would a farmer in Idaho need to be paid per acre to cover both their cost of producing safflower seed along with their opportunity cost of not growing dryland wheat as often? What does this work out to be per pound?

2. Do you think for the same expected return, a farmer would be willing to adopt safflower seed into their dryland wheat rotation? Why or why not? Be sure to consider things such as risk, adoption of a new crop, and agronomic benefits in your answer.

3. The current safflower spot price is $0.30 per pound. To encourage farmers to sell their safflower production to MSO instead of the spot market, how much do you believe they would require as a minimum payment under an MSO contract, taking into account this new information and your responses to questions 1 and 2?

4. From MSO's perspective, would they be better off offering contracts that are more marketing-based or production-based? Which inputs, if any, should MSO provide to farmers, and how much would that cost (recall Figure 2)? Also, how much monitoring, if any, should MSO provide in the safflower production process? Why do you feel these are the correct levels of coordination between MSO and farmers?

Designing a Contract

5. Based upon your answers to questions 1 to 4, what contract structure would you recommend that MSO offer to farmers? Remember that contracts can have multiple payment structures embedded into them (e.g., fixed price performance payment = $X per pound, acreage payment = $Y per acre, and quality adjustment = $Z per percent below a threshold). Write your proposed contract structure and spell out the details? For an example contract, see Appendix A.

6. Does your proposed contract structure for question 5 satisfy the farmer participation constraint? Why or why not? If it does not satisfy farmer participation constraint, update it and

write out a new contract structure that does. (As you update the contract structure, be sure it does not violate previous constraints that have already been solved.)

7. Does your updated contract structure for question 6, satisfy the moral hazard constraint? Why or why not? Expected performance payments ($price \times yield$) should at least be greater than the combined cost of fertilizer, herbicide, and labor (see Table 2) to ensure the farmer is compensated for their unobservable effort. If it does not satisfy incentive compatibility, update it and write a new contract structure that does. Note: If your contract includes monitoring, you can ignore some or all of these costs in calculating the moral hazard constraint, depending on when/how the field is being monitored.
8. Does your updated contract structure for question 7, satisfy the quality constraint and ensure that MSO will receive dry and clean safflower seed? Why or why not? If it does not satisfy the quality constraint, update it and write a new contract structure that does.

Strategy

9. Write out your final contract here, and calculate how much you expect the cost of acquiring one ton of safflower seed to be under that contract. (Be sure to also include any costs of providing inputs or monitoring if that is part of your contract.)
10. Based on your answer to question 9, if it costs MSO an additional $250 per ton to process the seed on top of acquiring it, will they achieve a positive margin if they sell their refined safflower seed for $950 per ton?
11. Based upon your answer to question 10, how confident are you that MSO will maintain a positive margin for the coming year in the face of production, price, and input cost risk?

Contingency Planning

12. A well-thought-out contract will cover all realistic future contingencies ex ante. If domestic growers believed there was a reasonable chance that the Black Sea Grain deal that allows Ukraine to export its safflower to world markets will fall through and raise prices in the future, they may be less willing to accept or stick with a contract over time. What provision or payment may need to be added to your contract (question 9) to ensure farmers will both accept the contract and be willing to stick with it, should that change occur?
13. It is possible for MSO to acquire too much seed. If MSO ends up with more than 30,000,000 pounds of safflower seed, they will not be able to process it all and could be forced to sell that safflower at a loss. Based upon this consideration, would you change anything in your contract structure established (question 9) and/or the amount of acres you would expect MSO to contract? Explain your answer.

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Appendix A: Example of a Proposed Contract Structure for Question 5

Note: The following contract structure is not a suggested solution to question 5; it merely provides an example of how to respond to question 5.

Performance payment (fixed price) = $0.20/lb x lbs. of safflower seed harvested

Acreage payment (paid at planting) = $200/acre

Quality adjustment payment/fee for foreign material percentage = For each percentage point that foreign matter content is below 5 percent, MSO will add a $0.01 per pound premium to performance payments, and for each percentage point that foreign matter is estimated to be above 5 percent, MSO will charge a $0.01 per pound penalty to performance payments (for example, if foreign matter content is estimated by MSO to be 3 percent, then the final performance price would be $0.20/lb + $0.02/lb = $0.22/lb).

Quality adjustment payment for moisture content = For each percentage point that MSO measures seed moisture content to be under 9 percent, they will pay an additional premium to performance payments of $0.01 per pound. For each percentage point moisture content is above 9 percent, MSO will charge a $0.01 per pound penalty to performance payment.

Additional details: The farmer will grow safflower seed provided by MSO. Farmers will have no oversight or monitoring in production beyond that. However, MSO will test moisture content, foreign material, and presence of inorganic compounds in the safflower. Any crop tested above 22 percent foreign material, above 13 percent moisture content, or containing residues from inorganic herbicides or pesticides, will constitute contract breech upon which the farmer's crop will be returned to them. In such a case, the farmer is expected to pick their safflower seed harvest up.

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Teaching and Educational Commentary

We Need to Talk About Curriculum Innovation

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Abstract
Is it time to refresh your applied agricultural economics and agribusiness curriculum? How do you know? Where do you start? In this commentary, we review why curriculum updates are challenging and suggest that an information problem is partly to blame. Others highlight our discipline's wide scope, our students' diverse backgrounds, and our employers' high expectations as inherent challenges to curricular planning. We point additionally to an economic challenge, namely that curriculum innovators do not advertise their discoveries and lessons learned at the socially optimal level. To address this public goods problem, we propose that an interested organization (e.g., the Agricultural and Applied Economics Association, AAEA) centrally facilitate information sharing in two ways: (1) inventory the range of curricular diversity regularly and (2) create an annual curricular innovation award.

1 Introduction

The U.S. Council for Higher Education Accreditation requires covered institutions ("Standard 1") to demonstrate "advancement of academic quality and continuous improvement" (Council for Higher Education Accreditation 2021, p. 9). Institutional accreditors require program faculty regularly to assess the strengths, weaknesses, opportunities, and threats facing their programs, as well as engage in appropriate quality improvement efforts in response.

Curricular improvements take many forms. For example, programs might incorporate additional ways or "domains" of learning such as the cognitive (or knowing) domain (Bloom et al. 1956), the affective (or attitudes) domain (Krathwohl 2002), or the psychomotor (or skills) domain (Harrow 1972). Programs might integrate "growth mindset" or "deeper learning" models to help students better understand new problems; persevere through challenges, setbacks, and ambiguity; and take initiative to resolve conflicts (Finegold and Notabartolo 2010; National Research Council 2012; Dweck, Walton, and Cohen 2014). Programs might innovate to include one or more additional "high-impact practices" defined by Kuh (2008) to include, among others, first-year seminars, capstone courses, writing-intensive courses, and learning communities (see also Zilvinski et al. 2022).

In this commentary, we first describe three inherent factors—disciplinary complexity, student diversity, and employer expectations—that make curricular planning challenging for directors of agricultural economics and agribusiness (AEAB) programs. We then identify an additional complicating factor—insufficient information sharing among AEAB program directors—which we characterize as a public goods problem. As such, we recommend that a central organizing group like the Agricultural and Applied Economics Association (AAEA) facilitate information sharing on behalf of its membership. We call for two specific efforts: (1) a regular survey of program directors to identify current curricular diversity and (2) the creation of an award to highlight excellence in curricular innovation. We include recommendations about survey content and award criteria.

2 Three Inherent Complications

One factor that complicates curriculum improvement efforts is the inherent complexity of the AEAB discipline. AEAB resource decisions are made in complex operating environments reflecting well-integrated agricultural network relationships as part of food, fiber, forest, feed, and fuel supply chains within industrialized economies (Davis and Goldberg 1957; King et al. 2010; Boehlje, Roucan-Kane, and Bröring 2011). These networked agricultural entities are complex adaptive systems that incorporate heterogenous interactions that are not easily understood simply by considering separate components (National Research Council 2015). Local, regional, national, and global agricultural economic systems are dynamic systems that need to and do evolve over time. Yet, these systems show increasing resistance to change given recent trends towards increasing vertical integration, growing industrial scales, and increasing structural interdependence.

AEAB curriculum designers must figure out how to cover critical and widely divergent content areas, including risk management, industrial organization, supply-chain management, technology adoption, short- and long-term decision making, among other options (Boehlje et al. 2011). Other required content includes the production of differentiated and value-added farmed products, marketing channels, contracts, and financial services, as well as persistent structural shifts to increasingly larger and larger farm sizes across a broad range of U.S. commodities, geographic regions, and associated supply-chain industries (MacDonald, Korb, and Hoppe 2013; MacDonald, Hoppe, and Newton 2018; MacDonald 2020). Each reader could no doubt add two or three other critical content areas, helping us to make our point; the wide scope of the AEAB discipline complicates curricular planning and innovation.

A second factor complicating curricular innovation in AEAB programs relates to the broad range of prior experience that entering students have with farming, agriculture, work, and life in general. Traditionally, AEAB students learned about agricultural system complexities and applied new knowledge principally through robust class discussions emanating naturally from and rooted in students' real-world case-in-point stories. This worked when there was a relative plentitude of students who grew up living and working on one or more farms. The situation today is inherently different. Many AEAB students have little, if any, real-world agricultural experience beyond perhaps the local retail sector (Swan and De Lay 2014). Overall, the numbers of students and faculty in AEAB academic programs from farming backgrounds and rural areas is declining (Blank 1998; Dyer, Breja, and Andreasen 1999; Blank 2001; McCluskey, Loureiro, and Wandschneider 2002; Labo, Jefferson-Moore, and Turner 2013; Dale, Robinson, and Edwards 2017). Transfer students from other nonagriculture programs (e.g., business or engineering) tend to further dilute levels of prior agricultural knowledge found in AEAB classrooms.

Another kind of prior knowledge diversity among AEAB students further complicates curricular design challenges. Traditionally students enter AEAB programs immediately after high school, but increasingly adult learners with years of prior work and other life experiences are choosing to enter AEAB programs, especially as options for remote learning continue to expand. The U.S. National Center for Education Statistics (2022a) reports that business-related studies are undergraduate students' first choice by far. In that context and with demand for online courses and programs increasing[1] (National Center for Education Statistics 2022b), Gardner et al. (2022) surveyed nontraditional students, looking for patterns between adult learner characteristics and online course preferences. These authors surveyed respondents (n = 7,861) who were over the age of 24 and had never attended college, were pursuing further credentials, or were returning to complete an unfinished degree. Among these

[1] In Fall 2020, 71 percent of postbaccalaureate students took at least one distance education course, with 52 percent of those students enrolling in those courses exclusively (National Center for Education Statistics 2022b). In Fall 2019 (i.e., prior to the Coronavirus Disease 2019 pandemic), these numbers were 42 percent and 33 percent, respectively.

students, those working the most (i.e., full-time) were twice as likely to be enrolled in business courses online compared to those who were not working.

The diversity of students' prior agricultural and work/life experiences complicates curriculum design efforts (Figure 1). Content that was once covered organically and easily through authentic classroom discussions has declined. This dearth presents challenges for delivering engaging classroom discourse that incorporates a breadth of real-world agricultural examples (Barkley 1991). With student and instructor backgrounds increasingly unable to provide real-world context, classroom discussions are left instead to focus on static economic models, concepts, and principles or on aging textbook examples that do not reflect current legal, business, and social protocols or evolving workplace situations.

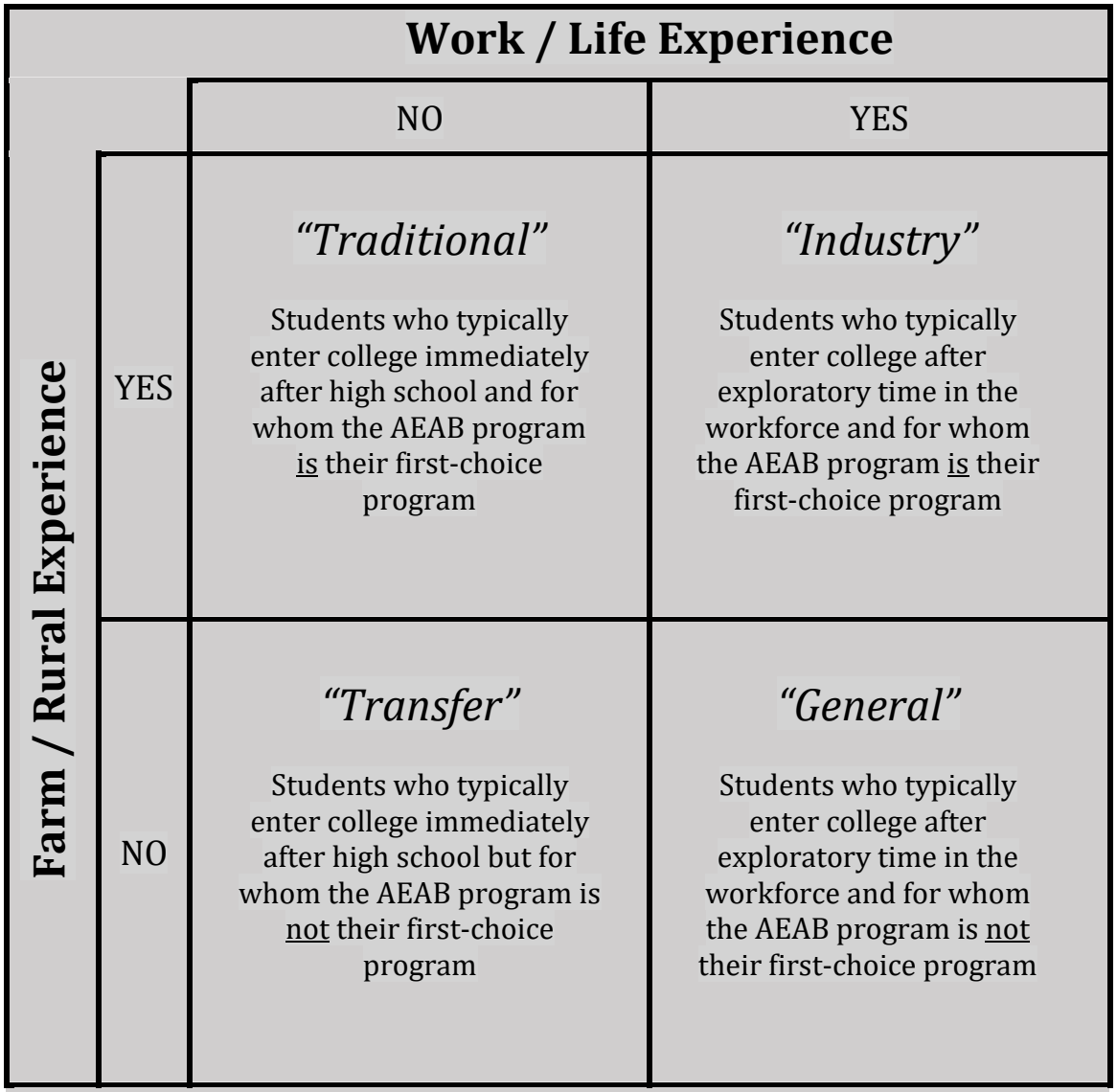

Figure 1. **Four Kinds of AEAB Students**. As a group, students who enroll in agricultural economics and agribusiness (AEAB) programs typically have diverse levels of prior agricultural and work/life experience. This diversity is one factor that inherently complicates curriculum design efforts.

To some extent, scenario-based tools like case studies and simulation exercises may help. Case studies are in-depth, (usually) real-world descriptions of example situations (e.g., a merger decision in business). When all students study the same detailed case or scenario, there is a common starting point for all students. Case studies employ real-world data and situations and, as such, they easily motivate thought-provoking discussions among students about how best to address those complex situations, respond to diverse interests, and craft recommendations supported by AEAB principles. Sterns, Schweikhardt, and Peterson (1998) rigorously examine case study methodology as a general strategy for socioeconomic research that is applied to complex, dynamic, and interdependent systems.

Like case studies, simulation games and scenario models also give students a common and detailed starting point. Simulation models present instructional scenarios where learners are placed in decision "realities" and invited to interact with other students to achieve complex learning outcomes. These pedagogical tools enable all students, even those without agricultural backgrounds or experiences, to discuss and debate problems related to farm production, supply centers, cooperatives, retail chains, and financial markets (Boehlje and Eidman 1978; Babb 1985; Dahlgran 1986; Dobbins et al. 1995; Fisher et al. 2000). Still, even as partial solutions, creating case studies and other simulation tools is costly work with weak incentives, two recurring issues that we address in our analysis and recommendations that follow.

A third factor complicating curricular innovation in the AEAB space is the high expectations of target employers. Generally, these employers want programs to develop both analytical (hard) skills and human interaction (soft) skills in students. In an early study, Litzenberg and Schneider (1987) collected graduate competency feedback data using a national survey of 543 entry-, middle-, and top-level managers at agribusiness firms across 41 U.S. states to evaluate emerging needs for undergraduate and graduate programs.[2] These authors presented agribusiness and agency survey responses that ranked six categories of skills and characteristics important to managers who hire AEAB graduates. The authors found that interpersonal characteristics and communication skills ranked above business, economic, technical, computer, and quantitative management information system skills, as well as previous work experience. Barkley (1991) later reported survey responses from alumni (n = 288) who ranked oral communication, people skills, and problem solving as the career skill competencies most important in their current position.[3] Boland and Akridge (2004) reported feedback from an industry steering committee of executive-level food and agribusiness organization professionals (n = 26) who shared similar sentiments about the importance of interpersonal and critical thinking skills, which they considered essential for new employees to develop.[4]

Bampasidou et al. (2016) more recently presented evidence from survey and interview responses that alumni, employers, and students (n = 105) value high-impact learning activities such as student club leadership, competitive academic teams, and mentored career pathway events.[5] These respondents said these activities improved career skill competencies, which included critical and analytical thinking, time management, and communication. However, undergraduate students indicated that they valued the communication and professional networking relatively less than other study participants. In a study of

[2] Respondents were identified by their membership in ag-based industry associations. Represented firms were from twelve different industries (e.g., co-ops, ag banking, seed production, food wholesale/retail, and grain production/marketing) and varied widely both by size (e.g., 35 to 1,000+ employees) and sales volume (e.g., less than $10 million to more than $1 billion).
[3] This was a mail survey of 5,023 College of Agriculture students who had graduated from Kansas State University between 1978 to 1988. The survey yielded a 30 percent response rate (n = 1,539). Of those respondents, 19 percent were agricultural economics graduates, and 49 percent were employed in agribusiness.
[4] According to these authors, the 26 surveyed senior executives represent "a broad range of food and agribusiness organizations, with eight 'food' and twelve 'agribusiness' executives from a variety of multinational and regional investor-oriented firms and cooperatives" with "six other leaders from various industry associations and government and nongovernment organizations that have frequent contact with graduates of agribusiness programs" (p. 568).
[5] These authors surveyed 304 students enrolled in and 117 alumni recently graduated from the Food and Resources Economics undergraduate program at the University of Florida.

employers, alumni, faculty, and students (*n* = 11,428) identified with the help of 32 universities from across the United States, Crawford and Fink (2019) found gaps between academic program outcomes and student skills that are needed for employment in a number of different critical competency categories such as areas of student persistence, ambiguity, change, and conflict resolution. Their study indicated that AEAB programs could improve student employability and early career success by helping students improve their: (1) awareness of entry-level roles in the workplace, (2) tolerance for accepting critiques, (3) listening effectiveness in the communication process, (4) realization of decision consequences, and (5) ability to build professional networks.

The above studies focus on employer demands in AEAB disciplines specifically. Other surveys look regularly at employer demands for college graduates across all disciplines. The National Association of Colleges and Employers (NACE), for example, surveys its employer members each year and publishes a list of top attributes that employers seek on student resumes in addition to a high grade point average (GPA). The 2022 NACE survey showed that employers (*n* = 246) most desire that students have: (1) problem-solving skills, (2) an ability to work in teams, (3) a strong work ethic, (4) analytical and quantitative skills, and there was a tie for (5a) written communication skills, and (5b) technical skills.[6] As such, the NACE survey (National Association of Colleges and Employers 2023) mirrors the AEAB-specific studies and shows that employers generally, like those who recruit from AEAB disciplines specifically, prefer graduates from programs that cultivate students with a wide range of skills, both technical and interpersonal. This wide range of employer demands—along with the discipline's complexity and students' diverse backgrounds—are the three factors that we think make curriculum innovation in the AEAB space inherently challenging.

3 An Economic Complication: Information Sharing

In addition to these three inherent factors, we identify one economic factor that complicates curriculum innovation for AEAB programs, namely a suboptimal level of information sharing among AEAB program directors about their curriculum innovation efforts. We surmise there must be a significant amount of curricular innovation occurring regularly for two reasons. One, institutional accreditors mandate regular curricular improvement as noted, and two, there are numerous AEAB programs. We count at least 95 academic institutions on the AAEA website that offer an undergraduate degree program focused wholly or in significant part on the study of applied economics, agricultural economics, and/or agribusiness (Agricultural and Applied Economics Association 2023). Gillespie and Bampasidou (2018) in their study identified 106 state-supported universities with agricultural economics, business, and management programs.

With so much expected curricular innovation happening, it is surprising to see so little related information shared, inventoried, or summarized publicly. We found several related peer-reviewed studies. Gillespie and Bampasidou (2018) reviewed institutional websites for AEAB programs at all U.S. 1862 and 1890 land-grant universities (n = 106) and inventoried which courses were most often selected as required courses for their programs. These authors usefully cited nine other previous studies of AEAB curricula. Litzenberg and Schneider (1987) similarly compared content foci in AEAB programs at 58 institutions with the content foci recommended by employers. The two other works by Boland and various coauthors (Boland, Lehman, and Stroade 2001; Boland and Akridge 2004) are also highly cited. We can also point to two tangential works, one by Perry (2010) looking at "the future of agricultural

[6] NACE reports that "of the 246 total respondents, 150 were NACE employer members, representing 17.4 percent of eligible member respondents" and that the "survey was also distributed to nonmember companies, from which an additional 96 responses were received" with respondents from the Southeast (17.1 percent), the Rocky Mountain/Far West (17.5 percent), and the Great Lakes (22.4 percent) making up the majority (p. 3). Of the 22 industry categories, more respondents were from the "Finance, Insurance, and Real Estate" industry (13.8 percent) than any other with relatively fewer responses from "Food and Beverage Manufacturing" (2.8 percent), wholesale trade (4.1 percent), retail trade (6.1 percent), accounting service (3.7 percent), and management consulting (4.1 percent).

economics departments" and another by Nourse (1916) looking at "what is agricultural economics." Other than these sporadically published studies from the academic literature, we find no other centrally managed or otherwise convenient way for AEAB program directors to find information about the frequent curricular innovation that is occurring.

4 Two Economic Solutions

We consider the lack of information sharing about curricular innovation among public AEAB higher-education programs as a public goods problem, a special case of the collective action problem, since information in this domain is publicly administered and therefore characterized as nonexcludable (Samuelson 1954) and assumed to be nonrival in consumption (Stiglitz 1999). To paraphrase Adam Smith (1776), though it may be in the highest degree advantageous to all AEAB program directors and faculty to have easy access to information about curricular innovations, the benefit of doing so could never repay the individual expense. In short, it is not worth it to any one person to compile and share this information.

There are many theoretical and applied solutions to public goods problems with varying efficiency benefits. The standard solution is for a central organization (or state) to do the work and then collect compensating dues (or taxes) from individual members (citizens). A second solution would be to embed the work into a contest that rewards larger contributions with higher probabilities of winning an appropriately valued prize. The standard solution was first described by Adam Smith in 1776 and appears in any microeconomics principles textbook. The contest solution is described by Kolmar and Wagener (2012).

To fix this public goods problem and make information about curriculum innovation more easily available and accessible, we propose two activities, both requiring the involvement of an interested disciplinary organization (e.g., the AAEA). One activity employs the standard public goods solution and calls on this disciplinary organization to survey AEAB program directors about their curricula improvements and pay for that work from member dues. The other activity employs the contest solution and calls on this organization to sponsor an award (i.e., a contest) to recognize outstanding work in curricular innovation and publish the award nominations.

4.1 The Survey Solution

First, we call for an interested organization (e.g., the AAEA) to administer, centrally, a periodic survey of curricular changes across the AEAB discipline. We and other members of the Teaching, Learning, and Communication section of AAEA have already had preliminary discussions about this idea.[7] As a group, we took an expansive view of what constitutes an AEAB curriculum. It includes, for example, not only required and elective courses but also available high-impact practices (e.g., internships, study abroad, and research) and enrichment activities (e.g., club and competition teams and extension opportunities). It also includes various kinds of student support services (e.g., student recruitment, retention, academic advising, and career counseling). We envision that a survey would gather information about each program's curriculum—broadly conceived—and gather information about each program's perceived strengths, weaknesses, opportunities, and threats.

We think such a survey would improve understanding among program leaders and faculty who need evidence about the offerings and attributes of programs across institutions. Broad program information would bring to light the challenges and limitations to meet industry needs that can be addressed at the program or institutional level. The survey findings would potentially also draw

[7] Other members (alphabetical order) are Kate Brooks (U. of Nebraska-Lincoln), Stan Ernst (Pennsylvania State U.), Sierra Howry (U. of Wisconsin, River Falls), Mark Jenner (Greenville U.), Danielle Kaminski (Fort Hays State U.), Kristin Kiesel (U. of California, Davis), Katherine Lacy (U. of Nevada, Reno), Ross Pruitt (U. of Tennessee, Martin), James Sterns (Oregon State U.), Julianne Treme (North Carolina State U.), Yijing Wang (U. of California, Davis), and Na Zuo (U. of Arizona).

attention to curriculum gaps that programs need to address to meet the evolving needs of the industry and graduate programs that recruit AEAB graduates. These survey results, when combined with related information from the published literature, would serve as a useful summary framework (e.g., Figure 2) for programs as they engage in evidence-based curricular innovation.

4.2 The Award Solution

In this section, we first describe several existing curriculum-related awards offered by other institutions and disciplines. Next, we define what we think counts as "curricular innovation" to set some boundaries on the kinds of activities that would be eligible for an AEAB award recognizing excellence in this area. Last, we propose and describe six specific award criteria that we think would be, along with our proposed definition, useful for a call for award nominations.

4.2.1 Existing Awards

Existing curriculum-related awards focus on course-level or program-level innovations or sometimes on both. For example, the Association of Collegiate Schools of Planning (ACSP) and the Association of Public and Land-Grant Universities (APLU) each offer an annual curriculum innovation award, but these awards are for course innovations, not program-level curricular innovations.[8] Similarly, Georgia Tech (GT) offers an award, but it is open to individuals or teams of faculty, recognizing "innovation in their course or departmental curriculum." An award from Missouri State University (MSU), like the GT award, recognizes faculty "individually or as a team." An award from Northwestern University (NU) is perhaps most encompassing; it recognizes enhancements not only to a program curriculum but also "new courses, new course materials, or components for existing courses, and/or new approaches to instruction."

Criteria for most existing awards typically target some version of creative problem solving through inventive application of theoretical and research concepts in practical real-world scenarios, incorporating multidisciplinary knowledge, and providing evidence and documented assessment of student success. Awards usually require applicants to identify an initial curriculum-related problem and then describe or hypothesize how some evidence-based curricular change did or would remedy that problem. For example, the GT award requires nominees to describe the innovation, "including the problem or student learning issue it addresses, the objectives of the innovation, the learning outcomes for the intended audience, and the approach taken." The ACSP award requires nominees to explain how innovations "integrate expertise from multiple disciplines, connect theory and research practice, and incorporate insights from professionals in the field to fill essential knowledge and skills gaps and inspire new ways of thinking." Most awards also ask nominators to describe the innovation's significance, its transferability (i.e., potential for adoption or replication by others), and its sustainability through letters of support from students, observers (e.g., peers), and/or supervisors.

Some existing awards have additional criteria emphasizing emerging needs or pedagogical advancements. For example, the ACSP award explicitly but not exclusively invites nominations for innovative uses of distance learning in response to the global pandemic. Some institutions (e.g., MSU) offer awards for curricular advancements in certain specific areas (e.g., diversity, equity, and inclusiveness). The University of Iowa (UI) offers a curriculum innovation award only for faculty who successfully integrate international or global perspectives into a course. An award given by the

[8] Website URLs for each award mentioned in this section are: (ACSP) https://www.acsp.org/page/LincolnCurricAward, (APLU) https://www.aplu.org/members/awards/aps-innovative-teaching-awards, (GT) https://ctl.gatech.edu/faculty/awards/curriculum, (MSU) https://www.missouristate.edu/FCTL/CurriculumInnovationAwards.htm, (NU) https://www.northwestern.edu/provost/faculty-honors/alumnae-curriculum-award/about.html, (UI) https://international.uiowa.edu/faculty/ip-funding/global-curriculum-development-award, (AAMC) https://www.aamc.org/what-we-do/aamc-awards/curricular-innovation-awards.

Identified Industry Needs	Skills Gaps in Student Preparedness
• Knowledge of food and agricultural markets • Interpersonal characteristics • Communication skills • Business skills • Economics skills • Computer information • Quantitative information • Management information • Previous work experience • Culture awareness • International experience	• Recognize and deal constructively with conflict • Build professional relationships • Accept critique and direction in the workplace • Understand role and realistic career expectations • Deal with ambiguity and navigate change • Identify and analyze problems • Realize the effect of decisions • Transfer knowledge across situations • Listen effectively • Communicate accurately and concisely • Ask good questions and have the ability to work well in a diverse environment
Measurable Program Outcomes	**Ideas for Curricular Innovations**
• Regional and national conference and contest participation • Employer surveys • Undergraduate and graduate program enrollment • Industry and alumni satisfaction and job placement • Evidence in universal design for learning (UDL) and inclusion, diversity, equity, and accessibility (IDEA) initiatives • Student retention and graduation rates • Experiential and high-impact learning opportunities • Leadership roles and member participation in student organizations • Evidence of high-impact learning activities (HILA) • Participation in teacher education and instructional design opportunities • International travel, study abroad, and exchange programs	• Exposure to real-world learning environments to solve specific issues or problems (e.g., case study) • Opportunities to promote student confidence (e.g., perseverance, conflict, ambiguity, change) • High-impact learning opportunities (e.g., innovative projects, games) • Opportunities for discussion and exchange of ideas (e.g., seminar courses, industry speakers) • Emphasis on improving written communication (e.g., rubric innovation) • Foundational course enhancement preparing advanced skills (e.g., tools) • Enhancement to oral communication challenges (e.g., public speaking, professional networking) • Opportunities to develop technical writing (e.g., research, market reports) • Curriculum addressing data analytics (e.g., spreadsheets, database, programming software) • Emphasis on professional ethics and integrity (e.g., scenario, role-play) • Opportunities to explore global cultures and economies

Figure 2: Curricular Innovation Framework for AEAB Programs

A regular survey of agricultural economics and agribusiness (AEAB) programs coupled with summary information from the literature would help AEAB programs to identify industry skill needs, student skill gaps, curricular innovation ideas, and associated measurable program outcomes.

Note: Adapted from Carnevale, A.P., and N. Smith. 2013. "Workplace Basics: The Skills Employees Need and Employers Want." *Human Resource Development International* 16(5):491–501; Litzenberg, K.K., and V.E. Schneider. 1987. "Competencies and Qualities of Agricultural Economics Graduates Sought by Agribusiness Employers." *American Journal of Agricultural Economics* 69(5):1031–1036; and Gillespie, J.M., and M. Bampasidou. 2018. "Designing Agricultural Economics and Agribusiness Undergraduate Programs." *Journal of Agricultural and Applied Economics* 50(3):319–348.

Association of American Medical Colleges (AAMC) is similarly only for curricular innovations that advance education "about opioids, substance abuse disorder, and pain management."

Existing awards are presented either *ex-post*, recognizing completed efforts, or presented *ex-ante*, recognizing and often providing funding for planned innovations. The ACSP, APLU, and GT awards are examples of the former. The MSU and NU awards are examples of the latter. All awards described in this section, including the ex-post awards, include some monetary reward ranging from $2,500 (AAMC) to $12,500 (NU).

4.2.2 New Award: Purpose

A new AEAB award—like any award—should clearly define the award's purpose and evaluation criteria. We define a curriculum as a cohesive set of required learning experiences designed to develop in students a corresponding set of desired competencies. This definition encompasses both course-level and program-level curricula, though we recommend that the AEAB award be limited only to program-level innovations. At most institutions, faculty groups (e.g., the department faculty) have major deciding roles about changes to both types of curricula. Faculty decide, for instance, what the program's student learning objectives will be and how they will be embedded in various credit-bearing courses. While faculty typically make curricular decisions, these decisions are informed by input from other stakeholders (e.g., students and employers).

Thus, for the purposes of a new AEAB award, we envision that award for curricular innovation at the program level could be for any educational activity under the control of faculty decision makers that affects enrolled students' attainment of the program's learning outcomes. A list of these activities goes beyond deciding about program content and required courses. It also likely includes decisions about student recruitment, admissions, and retention and decisions about program delivery modes (e.g., in-person, online, and/or hybrid). It also likely includes decisions about co-curricular activities such as academic and career advising (e.g., Mu and Fosnacht 2019), student organization and competition team advising (e.g., Vetter and Wingenbach 2019, p. 39), and support for internships, study abroad, and undergraduate research (e.g., Johnson and St age 2018).

4.2.3 New Award: Evaluation Criteria

We suggest six evaluation criteria for a new AEAB award. Two of those criteria derive from our above definition of curriculum. We think this award should be for program-level (not course-level) innovations. That is, we think curricular innovations should be (1) *relevant* to programs (not individual courses), and those programs should be in our discipline, broadly inclusive of applied economics, agricultural economics, agribusiness, and related areas of study. We also think that this award should be for curricular improvements that were decided in a (2) *cooperative* fashion by the relevant faculty group that is responsible for the program with documented input from interested stakeholders. That is, we believe that this award should recognize the collective efforts of faculty and allied stakeholders (e.g., an entire department) rather than efforts by a lone innovator or administrative group (e.g., the provost's office). Allied stakeholders may include current, past, or prospective students and/or employers, program support staff, and others. The best ideas come from engaging many minds, and nominations for this award should document such cooperation.

We propose four additional award criteria (a total of six). The award should also target innovations that are responsive, interesting, promising, and useful. We think innovations should arise from and be (3) *responsive* to some assessed or perceived curricular weakness, opportunity, or threat, which nominations should document clearly. We also think innovations should be (4) *interesting*. To us, that means that curricular innovations should go beyond typical, standard, or prevailing responses and perhaps include novel and nonobvious developments or similar problem solving. Next, we think innovations should be (5) *promising*, meaning they should seem likely or reasonably to lead to improved student competency and/or more successful functioning of the program. Last, we think that the most

meritorious program-level curricular innovations should be those that are (6) *useful*, meaning they are broadly applicable and/or of benefit to other programs that do or might face similar program weaknesses, opportunities, or threats.

5 Conclusion

Academic programs in applied agricultural economics and agribusiness must be structured as more than a collection of courses. Programs must include coordinated and integrated niche experiences that develop industry-specific knowledge and foster deep critical thinking and diversity of thought. Programs must partner with industry and potentially with each other to empower our graduates to deal with an increasingly broad set of future public policy, macroeconomic, and international realities.

As we consider the changing economic and business operating environment of agricultural food and fiber systems, we also reflect on the alignment of academic programs and workforce needs. We reflect on innovations in the learning environment where interpersonal and intrapersonal skills and attributes are embedded within instructional programs to promote deeper learning. We think about moving beyond easily measurable metrics like test scores and GPA to employment competencies that include higher levels of collaboration, communication skills, reported self-efficacy, critical thinking, and motivation to learn. We think about how we can better translate these values for our students to incentivize their retention and strengthen their performance in our academic programs.

To do this, we need collective action to make curricular planning easier by considering the incentives associated with marginal costs and benefits of creating transformative educational innovations. We need to do more to recognize collective groups of AEAB programs who have assumed an opportunity cost of invested resources in designing and delivering program change. Regularly inventorying the range of curricular diversity can identify emerging issues within the discipline and serve a broad array of educational programs. Recognizing AEAB program innovations through an innovation award increases the marginal benefits associated with institutional efforts by publicly acknowledging “property rights” of invested resources. These two ways of centrally facilitating correction to this public goods problem of sharing how we are improving our academic programs address the current dilemma of suboptimal social welfare within our discipline. In short, we need to talk more about curricular innovation.

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